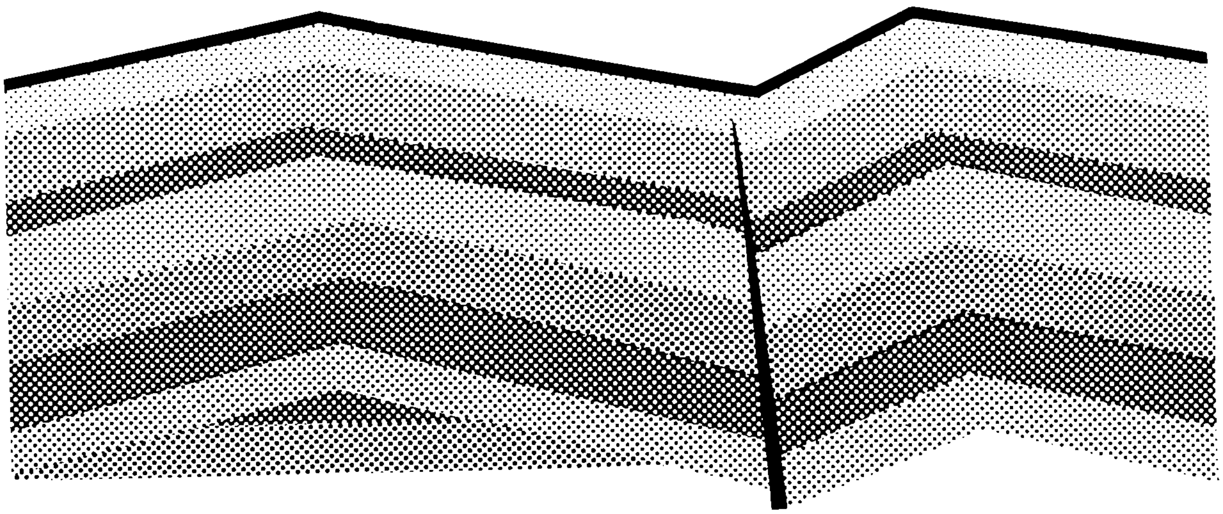
CANADIAN MINERALS YEARBOOK 1973



Mineral Report 23

Energy, Mines and Resources Canada — Énergie, Mines et Ressources Canada

Minerals — Minéraux

Available by mail from Information Canada, Ottawa, K1A 0S9
and at the following Information Canada bookshops:

HALIFAX
1683 Barrington Street

MONTREAL
640 St. Catherine Street West

OTTAWA
171 Slater Street

TORONTO
221 Yonge Street

WINNIPEG
393 Portage Avenue

VANCOUVER
800 Granville Street

or through your bookseller
Price: Canada $7.50 Catalogue No. M38-5/23
Other Countries $9.00

Price subject to change without notice

Information Canada
Ottawa, 1975

Contract No. 03KX 23230-75-6577
Thorn Press Limited

Foreword

This issue of the Canadian Minerals Yearbook is a report of developments in the industry for 1973. The 54 chapters dealing with specific commodities were issued in advance under the title Preprints, Canadian Minerals Yearbook 1973 to provide information as soon as possible to interested persons. The Statistical Summary written specifically for the Yearbook each year, deals with the overall position of the industry in its national and international perspective; it is supported by 72 statistical tables not readily available from other sources. The Index to Companies provides full and accurate company names and a complete cross reference to corporate activities in the Canadian industry, supported again by pocket map 900A, Principal Mineral Areas of Canada.

The Yearbook is the permanent official record of the growth of the mineral industry in Canada and is preceded by similar reports under various titles dating back to 1886. Those wishing to refer to previous reports should consult departmental catalogues, available in most libraries.

The basic statistics on Canadian production, trade and consumption were collected by Statistics Canada, unless otherwise stated. Company data were obtained directly from company officials or corporate annual reports by the authors. Market quotations were mainly from standard marketing reports.

The Department of Energy, Mines and Resources is indebted to all who contributed the information necessary to compile this report.

October 1974

Editor: G.H. Meldrum

Graphics and Cover: N. Sabolotny

Set by IBM 8 on 9 point and reproduced by offset lithography.

Readers wishing more recent information than that contained in the present volume should obtain the 1974 series of preprints: a complete set costs $5.00; individual copies sell for 25¢ each and may be obtained from Information Canada, Ottawa.

Front End Leaf

The Cassiar mine extracts its ore from 7,800-foot McDame Mountain, shown in colour in its setting in the rugged Cassiar range in northern British Columbia. After milling, the asbestos fibre is transported 357 miles by truck up the Alaska Highway to Whitehorse, then by rail to Skagway, Alaska, and finally by container ship to Vancouver. When the British Columbia Railway extension is completed from Prince George to Dease Lake, B.C., 80 miles south of the mine, the fibre will be shipped by this less expensive route. High transportation costs are only one of the factors which hinder the development of Canada's northern resources. Remoteness, extreme weather conditions and rough terrain make it difficult to bring new resource-extraction industries into production. (Cassiar Asbestos Corporation Limited photo)

Frontispiece

The casing through which an electrode will be fed into the furnace chamber is being positioned during installation of a new ferromanganese electric furnace at Union Carbide Canada Limited's plant at Beauharnois, Quebec. (Alan Bowering photo)

Contents

General Review

S.P. MALHOTRA

The state of the Canadian economy 1973

The year 1973, except for price stability, was very good for the Canadian economy. At the end of 1973 gross national product (GNP) at market prices, rose to a level of $118.7 billion. This was 14.8 per cent higher than a year earlier. After discounting the rise in the overall implicit price index during 1973, the growth in GNP, in real terms was 7.1 per cent. This growth rate was well in excess of that experienced in any year since 1966. By comparison, real growth amounted to 5.8 per cent in both 1971 and 1972. Figure 1 shows the GNP and the GNP per capita from 1955 to 1973.

Corporation profits before taxes rose by 36.9 per cent in 1973 compared with 20.6 per cent in 1972 and 16.2 per cent in 1971. This pushed the profit share of GNP in 1973 to 12.5 per cent – the highest in more than 22 years. On the other hand, labour income, which represents over one half of GNP, rose by 12 per cent in 1973 compared with 10.7 per cent in 1972.

During 1973, nearly all industries had profit increases; especially strong growth was recorded in manufacturing and mining. Within manufacturing particularly large gains were recorded in textiles, wood, paper and allied industries, primary metals, metal fabricating, nonmetallic minerals and refined petroleum products. All mining groups – base metal mining, oil and gas mining and other mining – increased substantially.

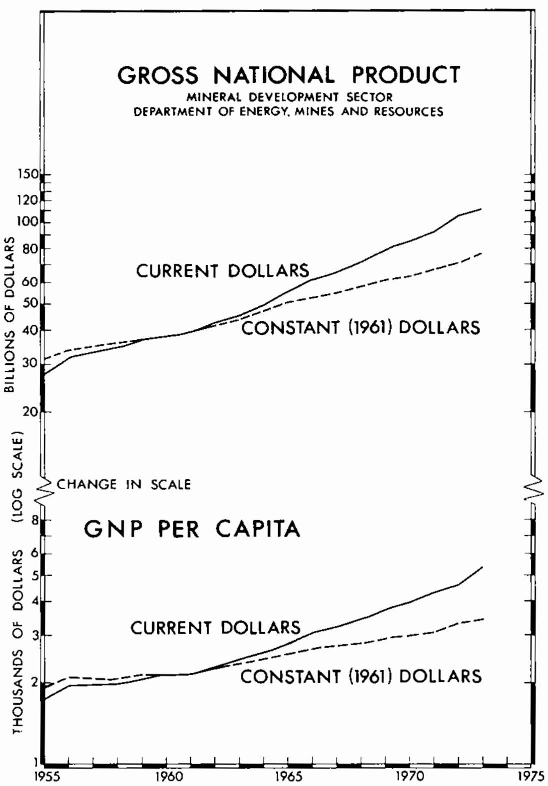


Figure 1

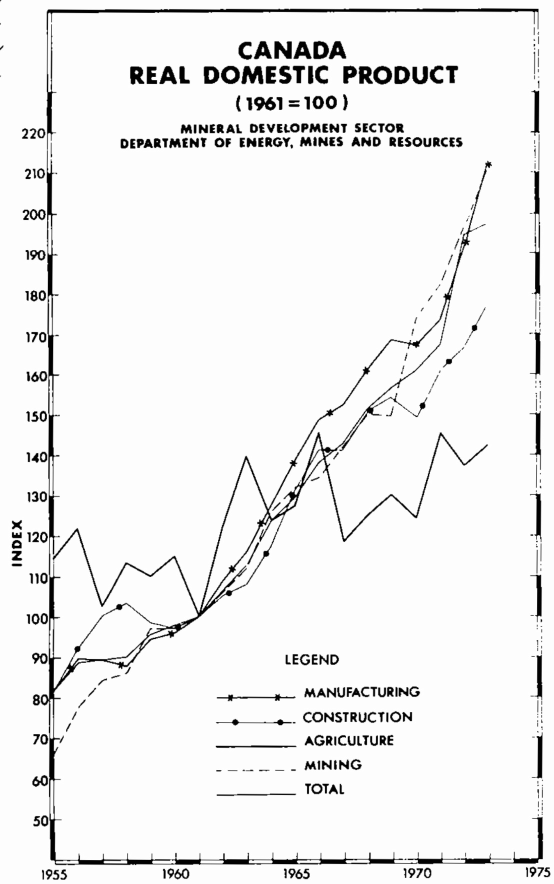


Figure 2

Statistical data were compiled from information provided by Statistics Canada by the Information Systems Division Staff.

As in the previous year, a significant part of the rise in corporation profits and in non-farm unincorporated business income was due to inventory gains resulting from the turnover of goods at rising prices. This was indicated by the inventory valuation adjustment, intended to remove from income those profits which do not reflect current production; this adjustment rose by over a billion dollars in 1973.

Real domestic product (RDP). Figure 2 indicates the growth in RDP for selected Canadian industries since 1955. The RDP measures the country's output of goods and services and it differs from the GNP in that it is a measure of production rather than of the income of Canadians. The RDP index (1961=100) for all Canadian industries in December 1973 was 197.5 compared with 184.3 a year ago – a rise of 7.2 per cent.

Manufacturing production in 1973 increased 8.1 per cent from the previous year with durable manufacturing up 9.2 per cent and non-durable manufacturing up 6.9 per cent. Among durables, output by transportation equipment industries rose 9.9 per cent, primary metal products increased 8.3 per cent and wood industries rose 7.9 per cent. Among non-durables, output in the chemical and chemical products industries rose 9.8 per cent, printing, publishing and allied industries rose 8.4 per cent, foods and beverages industries increased 4.9 per cent and paper and allied industries were up 4.4 per cent.

Labour force and unemployment. The year 1973 was slightly better than 1972 on the Canadian labour scene. In December 1973, the unemployment rate, seasonally adjusted, decreased to 5.6 per cent from 6.3 per cent a year ago, see Figure 3. This represents a drop of 72,000 in the number of people unemployed to 512,000. Also, at the end of 1973, the nation's total labour force was estimated at 9.29 million, up from 8.93 million a year earlier.

All regions shared in the growth of employment in 1973. The increase in British Columbia was 6.6 per cent (41,000 new jobs), Quebec 5.8 per cent (128,000 new jobs), Ontario 4.6 per cent (148,000 new jobs) and the Prairies 3.9 per cent (54,000 new jobs).

A major contribution to the growth in employment was made by the goods-producing sector. Employment in this sector grew by 155,000 or 5.1 per cent during 1973, almost five times the increase recorded in either 1971 or 1972. Among industries in this sector, agriculture showed a continued decline, while mining employment was virtually unchanged from 1972.

Employment in manufacturing was up by 6 per cent (111,000 new jobs), compared with a 3.5 per cent increase a year earlier. Construction employment was up by 9.6 per cent (48,000 new jobs) as a result of

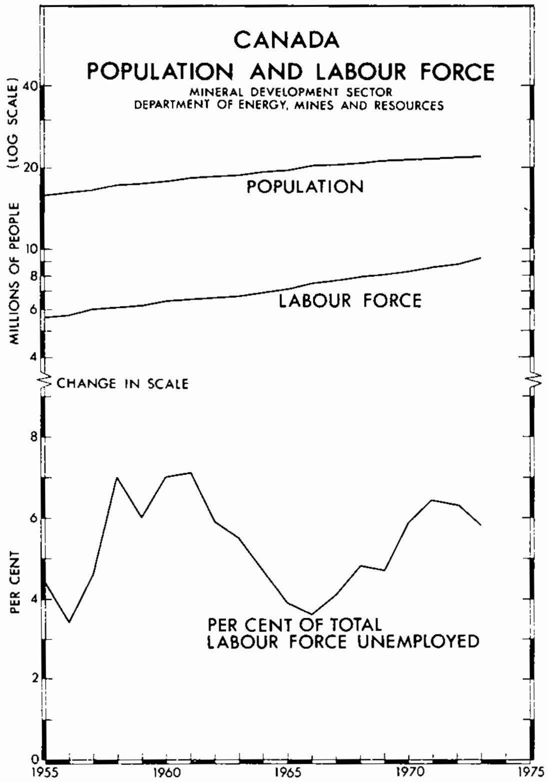


Figure 3

a year relatively free of the industrial disputes that plagued the construction industry in 1972, coupled with expansive investment and increasing growth in the demand for construction.

Prices. Prices, at both the retail and wholesale levels, continued to rise very sharply, in line with general inflation which became increasingly evident during 1973 in the industrialized countries. According to Statistics Canada, inflation* rose at a 7.1 per cent rate in 1973. The price increases were mostly due to worldwide demand pressures together with supply shortages, especially in the case of commodities such as raw materials and food products.

The Consumer Price Index (1961=100) which is designed to measure typical family living costs, went up to 156.4 in December 1973. This was a rise of 9.1 per cent over 1972. During 1973, food went up by 17 per cent, housing 7.2 per cent, clothing 7.3 per cent, and health-personal care 6.1 per cent.

The purchasing power of the consumer dollar, in terms of the 1961 prices, stood at 64 cents at the end of 1973.

*Measured by the differences between overall GNP and real GNP.

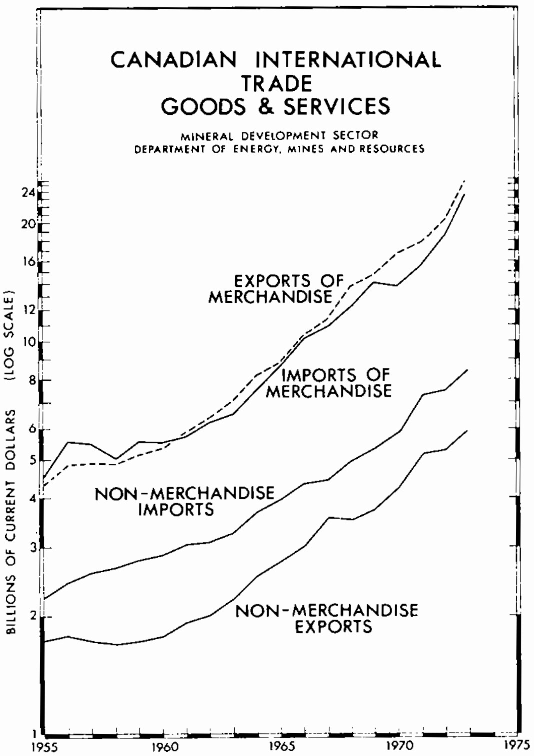


Figure 4

Canada's seasonally adjusted wholesale price index (1935-39=100) was 412.0 in December 1973, a rise of 25.5 per cent over the last 12 months. During this period the price of vegetable products went up 50.8 per cent, textile products 38.3 per cent, nonferrous metals 30 per cent, non-metallic minerals 18.1 per cent, and iron products 12.8 per cent.

Balance of international trade. Canada's current account was in deficit by $335 million at the end of 1973. This represented a gain of $288 million over the deficit of $623 million recorded in 1972. The gain in the current account was brought about by an increase in the surplus of merchandise trade of $500 million outpacing the deficit of non-merchandising transactions of over $200 million. Trends in the merchandise and non-merchandise trade and current account from 1955 to 1973 are illustrated in Figures 4 and 5.

During 1973, merchandise exports increased to $25,409 million, a gain of 26 per cent over 1972 – the largest growth in any year since 1951. Major price increases for some of Canada's most important export commodities accounted for more than one half of the total rise in the value of Canadian exports. There were substantial gains in shipments to most of Canada's principal markets; with the more notable being

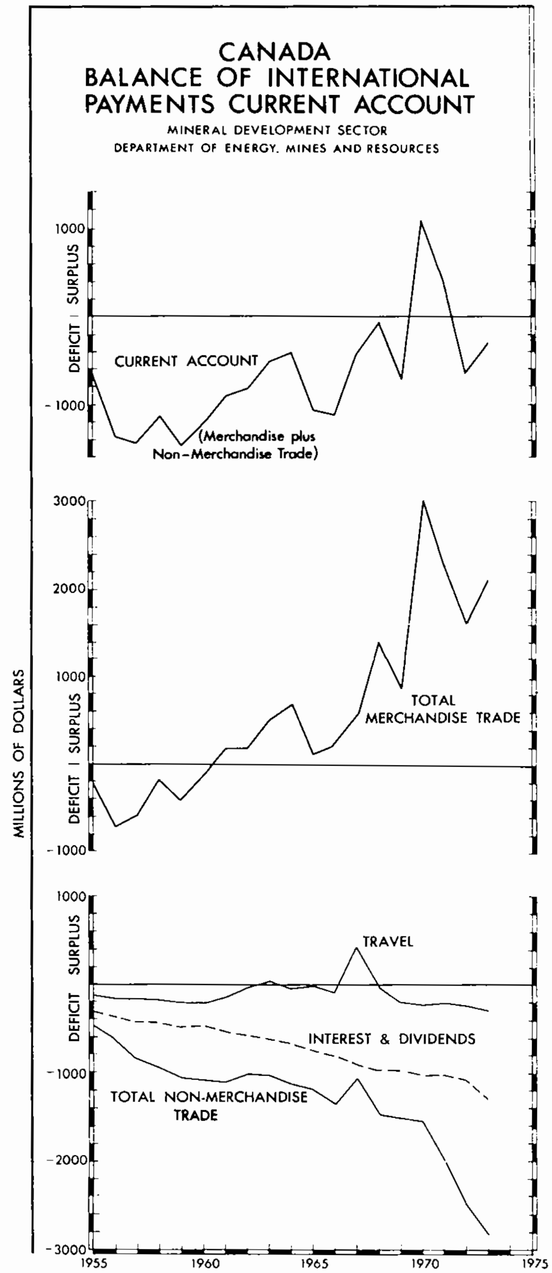


Figure 5

recorded to the United States, Japan, United Kingdom, West Germany, Italy, and Belgium and Luxembourg. The United States market received about 68 per cent of total shipments in 1973. On a commodity basis, the largest increases in exports were recorded in the fabricated and crude materials sections. Important increases were recorded for shipments of crude petroleum, lumber, wheat, crude copper, wood pulp, newsprint, petroleum and coal products, copper and alloys, iron ores and rape-seed.

Major currency realignments and the higher costs of petroleum in 1973, contributed to the rising prices of imports into Canada. The largest increases in imports were recorded from the United States, Venezuela, West Germany, France, Iran and the United Kingdom. The major commodities accounting for the expansion in imports included automotive products, crude petroleum, aircraft, live animals, telecommunications and related equipment, other transportation equipment, meat, and electronic computers.

The deficit on non-merchandise transactions continued to rise in 1973. At $2,466 million, it was $235 million greater than in 1972. With the exception of freight and shipping, the net balances on all the service items worsened. The largest change occurred on the interest and dividends account, with a $212 million expansion in the deficit to $1,252 million. More than two thirds of the growth in this deficit was due to net dividend payments. The deficits on travel and "other services" increased by $56 million and $36 million respectively, while the deficit on freight and shipping fell by $30 million to $52 million.

During 1973, there were increases in the prices of both exports and imports. These increases were associated with sharply rising world commodity prices for many major commodities, caused by world-wide inflation as well as rising primary commodity demand and developing shortages in supply. Canadian import prices have also tended to rise because of the depreciation of the Canadian dollar vis-a-vis European and Japanese currencies.

The rise in export price index (1968=100) in 1973 was led by a 72.7 per cent increase in the index for food, fuel, beverages and tobacco; while the export price indexes for crude materials rose 31.6 per cent and fabricated materials 28.2 per cent. Export price indexes for commodities showing particularly strong increases were those of barley, up 230 per cent; wheat, up 110 per cent; wood pulp, up 44 per cent; and crude petroleum, up 42 per cent.

On the import side, the largest increases were in the import price indexes (1968=100) for natural rubber, up 132 per cent; cotton, up 104 per cent; Indian corn, up 97 per cent; copper, up 74 per cent; and crude petroleum, up 66 per cent.

Figure 6 illustrates the behaviour of Net Capital Movement in the Canadian Balance of International Payments for 1955 to 1973. The net capital outflow in 1973 amounted to $132 million, a swing of almost $1 billion from the net inflow of $842 million recorded in 1972. Inflows of long-term capital in 1973 fell sharply by almost $1.1 billion to $667 million. This reflected reduced sales both of Canadian new and outstanding issues abroad and of outstanding foreign securities, and increased direct investment abroad. Short-term capital movements in 1973 led to a net capital outflow of $799 million, a decline of over $100 million from 1972. This was mainly due to increased non-resident holdings of Canadian dollar claims during the year.

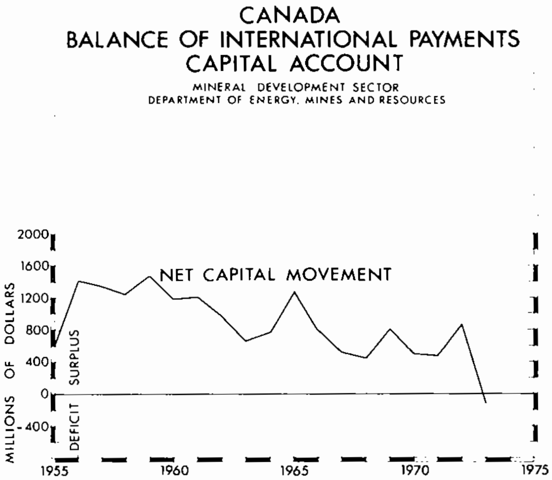


Figure 6

Capital and repair expenditures. Total investment, including both capital and repair expenditure on plant, machinery, equipment and construction in Canada during 1973, at current prices, was $33.4 billion. This was $4.6 billion or 15.9 per cent higher than 1972.

Investments for 1973 were more substantial in the business sector than in spendings for the non-business sector. Sectors showing the largest percentage increases in 1973 compared with 1972 were forestry 39.8 per cent; agriculture and fishing 24.3 per cent; finance, insurance and real estate 20.1 per cent; and manufacturing 15.1 per cent.

Trends in the total investment in major Canadian industrial sectors from 1955 to 1973 and a forecast for 1974 are illustrated in Figure 7. The total investment forecast for 1974 is $38.4 billion, a rise of 15.0 per cent over 1973.

In 1974, plans for acquisition of new machinery and equipment are somewhat more buoyant than intended outlays on new construction. A particularly strong demand for machinery and equipment expenditures is anticipated in natural gas processing plants and for the equipment needed in the extraction of oil from shales and sand. In manufacturing, large expenditures are expected for the acquisition of production machinery in chemicals and primary metals.

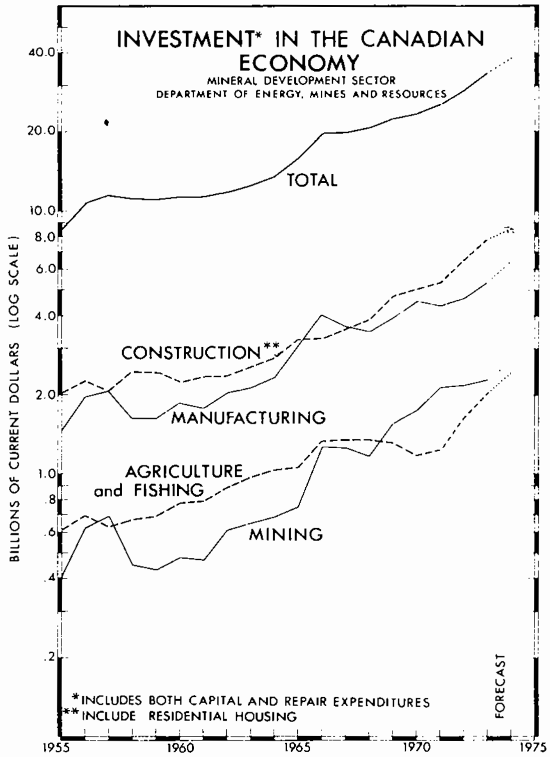


Figure 7

International Background

Internationally, the year 1973 saw fluctuations in international exchange rates and an accelerating rate of inflation accompanied by the soaring price of gold, a boom in commodity prices, a surge in stock exchange values, and a sharp rise in interest rates in most countries.

The pattern of exchange rates, which emerged as a result of the 1971 Smithsonian currency realignment, could not be sustained and it gave way in February 1973, when the second devaluation of the U.S. dollar occurred. Despite this, foreign exchange markets remained unsettled and, as a result, the Finance Ministers and Central Bank Governors of OECD countries agreed to a joint float against the U.S. dollar by a number of European countries, while allowing Britain, Italy, Switzerland and Japan to float independently. At the end of 1973 this crises was not yet over and there was talk of reforming the world's monetary system by phasing gold out of its major reserve position and replacing it with SDR's (special drawing rights) or "paper gold."

In November 1973, the European and the United States Finance Ministers abolished the 1968 agreement which banned central banks from dealing in gold on the open market and also pegged the gold price at $42.22 U.S. an ounce in official monetary transactions. This amounted to devaluation of the dollar and several other currencies in relation to gold.

During 1973, both the United States and Japan had a major reversal in their balance of payments. The United States balance of payments recorded a $6.4 billion surplus in 1973. This was a swing of about $11 billion from the 1972 deficit of $4.6 billion. This improvement was largely attributable to a substantial rise in the merchandise trade, a rise of foreign purchases of the U.S. securities and a positive swing in non-liquid capital flows from the U.S. banks. On the other hand, Japan recorded a balance of payments deficit of $10.1 billion for 1973, a sharp contrast with a surplus of $4.8 billion a year ago. This deficit was partly due to the floating and substantial appreciation of the yen during 1972-73 and partly due to the flow of Japanese capital into investments abroad, including mineral industry investment.

At the end of 1973 the free world faced a fuel crisis of massive proportions as a result of the Arab oil boycott of the United States and a gradual reduction in their oil shipments to most other countries. As a result, the United States called for an average reduction of 10 per cent of heating oil for industrial use, 15 per cent for home use, and 25 per cent for commercial use. This meant a reduction of highway speeds to 50 miles an hour, the use of car pools, the lowering of thermostats by 6 to 10 degrees and the closing of gasoline stations on Sundays. Likewise, Canadians were urged by the federal government to cut back in home heating, car driving, highway speeds, and in the use of electrical Christmas decorations. Furthermore, Canada set up a five-member Energy Supplies Allocation Board to determine the desirability of a mandatory fuel rationing program at the wholesale level early in 1974.

Mineral Industry

Mineral production. In 1973 the total output of the Canadian mineral industry, including metallics, non-metallics, structural materials and mineral fuels, reached a record level of $8.2 billion, compared with $6.4 billion the previous year. This was in the wake of strengthening world demand for minerals and also accelerating prices of most nonferrous metals.

The highest production value was in the fuels sector, including coal, natural gas, natural gas byproducts and crude petroleum, which rose to $3.25 billion in 1973 from $2.37 billion in 1972. Alberta output increased to $2.67 billion in 1973 from $1.91 billion in 1972.

Metal mining production had a value of $3.79 billion in 1973, up from $2.95 billion in 1972. Ontario was the leading province in metals output, with production value of $1.48 billion, up from $1.25

billion in 1972.

In non-metals, production value was $589.6 million in 1973, compared with $513.5 million in 1972. Leading minerals in the group were: asbestos at $241 million in 1973, up from $206.1 million in 1972, and potash at $151.1 million, up from $135.5 million in 1972.

Total value of structural materials rose to $609 million in 1973, up from $569.9 million in 1972. Leading materials were: cement at $228.1 million, up from $209.2 million; sand and gravel at $187.5 million, up from $178.1 million; and stone at $107 million, up from $103.3 million in 1972.

Figure 8 illustrates growth of the three major sectors of the Canadian mineral industry between 1955 and 1973. The value of mineral production has grown at about 9 per cent a year during the period with metallics and mineral fuels growing at a much higher rate than the industrial minerals. During this period, the per capita value of mineral production went up by $79.2 to $372.9, while the mineral production as a percentage of GNP from 6.2 to 6.9.

Figure 9 shows mineral production by commodity and by province for 1973 in percentage terms. As in the past year, petroleum was the dominant mineral commodity in terms of value of output in 1973, with 27.3 per cent of the total. In terms of provincial mineral production, Alberta made the largest single contribution, 33.3 per cent of the total, followed by Ontario which contributed 21.6 per cent.

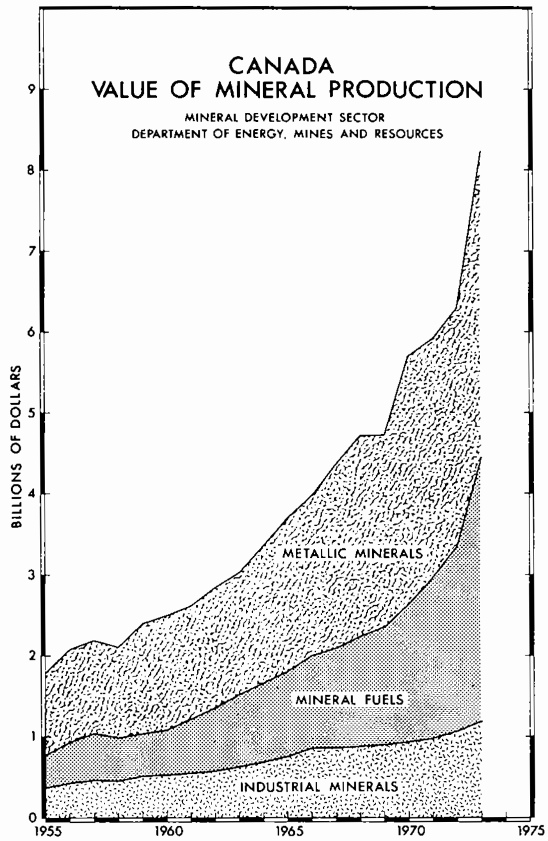


Figure 8

Mineral prices. The trends in general wholesale price indexes of mineral products since 1951 are shown in Figure 10. The iron product index, which has been the highest mineral industry price index in recent years, reached 376.3 in December 1973. This was a 12.8 per cent increase over 1972, compared with the nonferrous metals index which went up 30.0 per cent, the non-metallic minerals which rose 18.1 per cent and the general wholesale index which rose 25.5 per cent.

The prices of most minerals, especially the nonferrous metals went up in 1973. This is partly due to inflation and partly as a result of a greater than anticipated economic expansion in the United States, Japan and Europe. At year-end, Canadian producer price* for copper was 74 cents a pound, up from 50 cents at the end of 1972; zinc 31 cents to 32 cents a pound, up from 20 cents; and lead 18 to 19 cents a pound, up from 15 cents.

Mineral trade. Canada exported $7.3 billion worth of crude and fabricated minerals during 1973, with the United States buying the bulk of mineral exports, 61.8 per cent, while Japan took 12.5 per cent, Britain 8.1 per cent, and the European Economic Community** (EEC) 7.8 per cent. Figure 11 illustrates the declining share of mineral exports to Britain and the EEC in the last decade and the fact that, in the case of Japan, they have increased in value and volume. Canadian mineral exports to the United States were 2.2 per cent lower in 1973 than in 1972.

Trends in Canadian mineral trade since 1964 are given in Figure 12. At the end of 1973, the value of mineral exports, including both crude and fabricated mineral products, was $7,335.6 million, 33.4 per cent higher than a year ago. In terms of share of mineral exports of crude and fabricated materials as a percentage of total Canadian trade, which has been falling slowly between 1964-1972, it improved slightly during 1973. It increased to 29.1 per cent compared with 28.5 per cent a year ago. During this period, mineral fabricated products, which were running at an average of about 14 per cent, fell to 10.9 per cent at

*Applicable to North American markets.

**It includes only six old members of the present EEC; i.e. Belgium, France, Italy, Luxembourg, the Netherlands and West Germany.

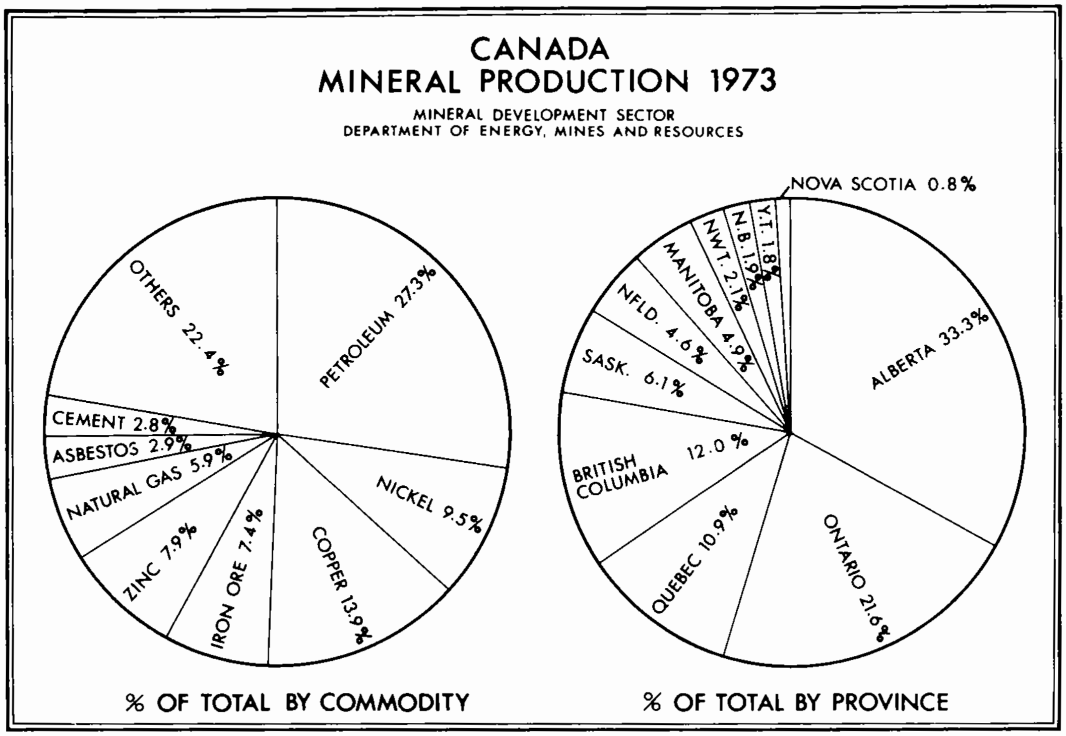


Figure 9

the end of 1973, while crude minerals moved up from an average of 16.6 per cent to 18.2 per cent.

Mineral investment. Trends in mineral investment in durable physical assets, including both capital and repair expenditures, for six major mineral sectors from 1951 to 1973 are illustrated in Figures 13 and 14. In mining, investment in mineral fuels in 1973 at $1.1 billion was 15.3 per cent higher than 1972, compared with non-metal mines at $267.7 million that rose 1.5 per cent and metal mines at $894 million that fell 3.5 per cent. Similarly, in mineral manufacturing, investment in non-metallics at $389 million was 29 per cent higher than 1972, compared with petroleum and coal products at $388.5 million that rose 21.5 per cent and primary metals at $16.4 million that rose 3.3 per cent.

Return on invested capital. Figure 15 compares the average 1962-1973 rate of return on invested capital* percentage ratios of various sectors in the Canadian mineral industries with the total of all Canadian industries. Among the various sectors presented, metal mines show the highest average rate of return at 12.0 per cent and mineral fuels the lowest at 6.5 per cent

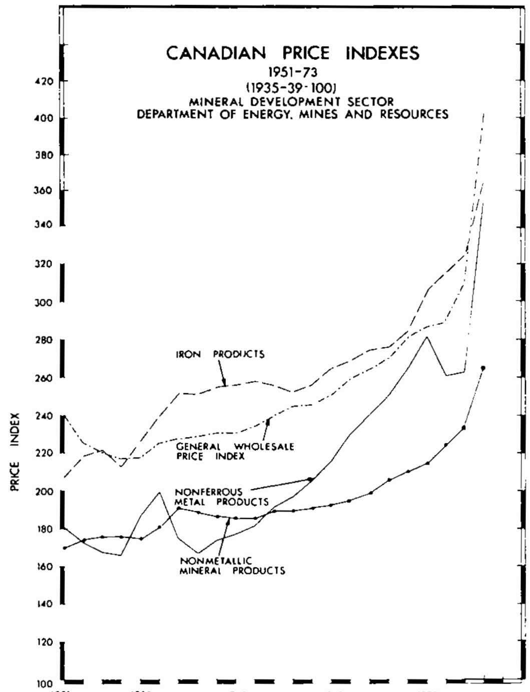


Figure 10

*Pre-tax profit/total assets minus total current liabilities.

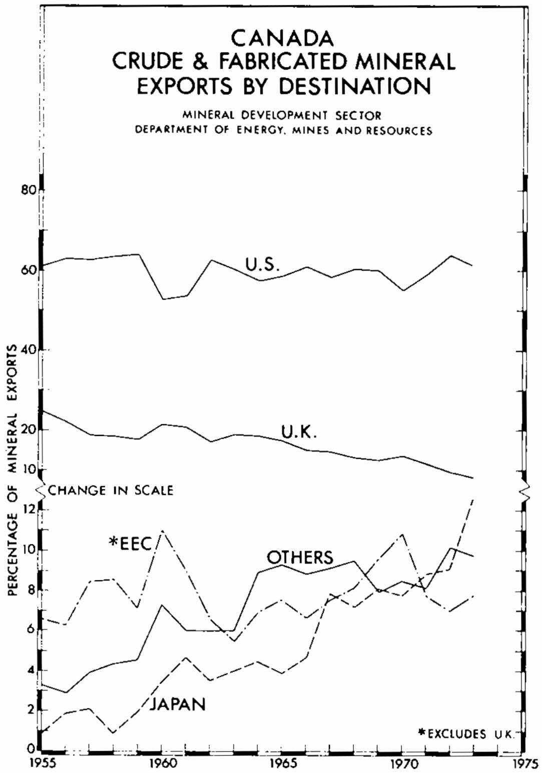


Figure 11

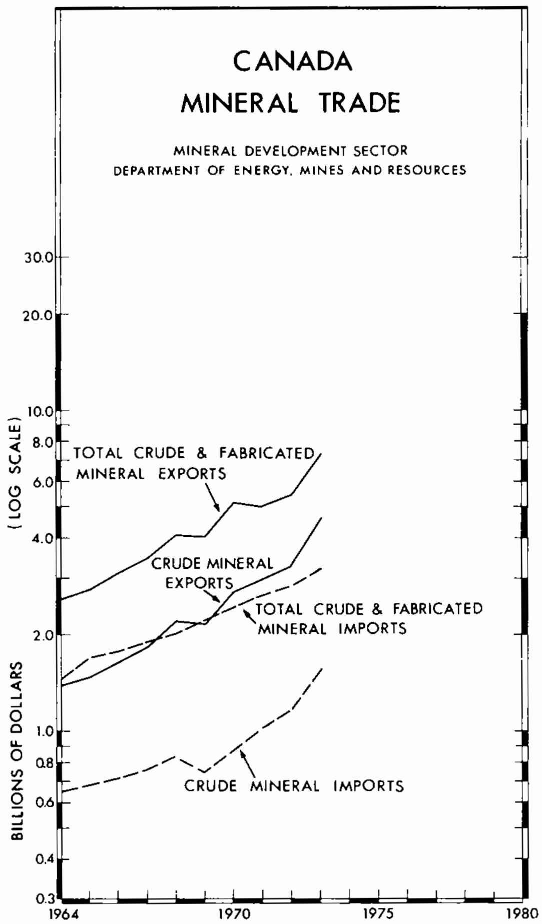


Figure 12

compared with the total of all Canadian industries at 9.6 per cent. The relevant values in 1973 were higher than the average values. The rate of return in metal mines for 1973 was 14.0 per cent, in mineral fuels 11.7 per cent, and in all industries 10.1 per cent.

In the mining industries* the rate of return in 1973 was 13.3 per cent. This is much higher than the rate of return in the past ten years when the highest level was achieved at 11.6 per cent in 1965 and the lowest 7.9 per cent in 1972. In the mineral-based manufacturing industries** the 1973 rate of return was 14.5 per cent. This rate is much higher than that experienced in the past ten years when it moved upward to 10.3 per cent in 1965 and then fluctuated in the period from 1966 to 1972 between 7.9 and 9.8 per cent.

Outlook

The Canadian economy. Although a deceleration in growth appears to be under way in a number of countries with a return to lower and more sustainable rates of expansion, the outlook for the Canadian economy in 1974 seems to be for continued healthy growth, particularly in manufacturing, and in the oil and gas industries. The stimulus for Canadian growth is likely to come from the rapidly expanding capital investment in new plant and equipment which will increase productive capacity and employment opportunities.

The expected expansion in 1974 is also associated with strong current sales in Canada and abroad and also with rising profits because of corporate tax concessions. According to the latest annual survey by the Department of Industry, Trade and Commerce the capital spending by 200 large Canadian companies will increase by 46.5 per cent in 1974. The spending

*Includes metal mines, non-metal mining and mineral fuels.

**Includes primary metals, non-metallics and petroleum and coal products.

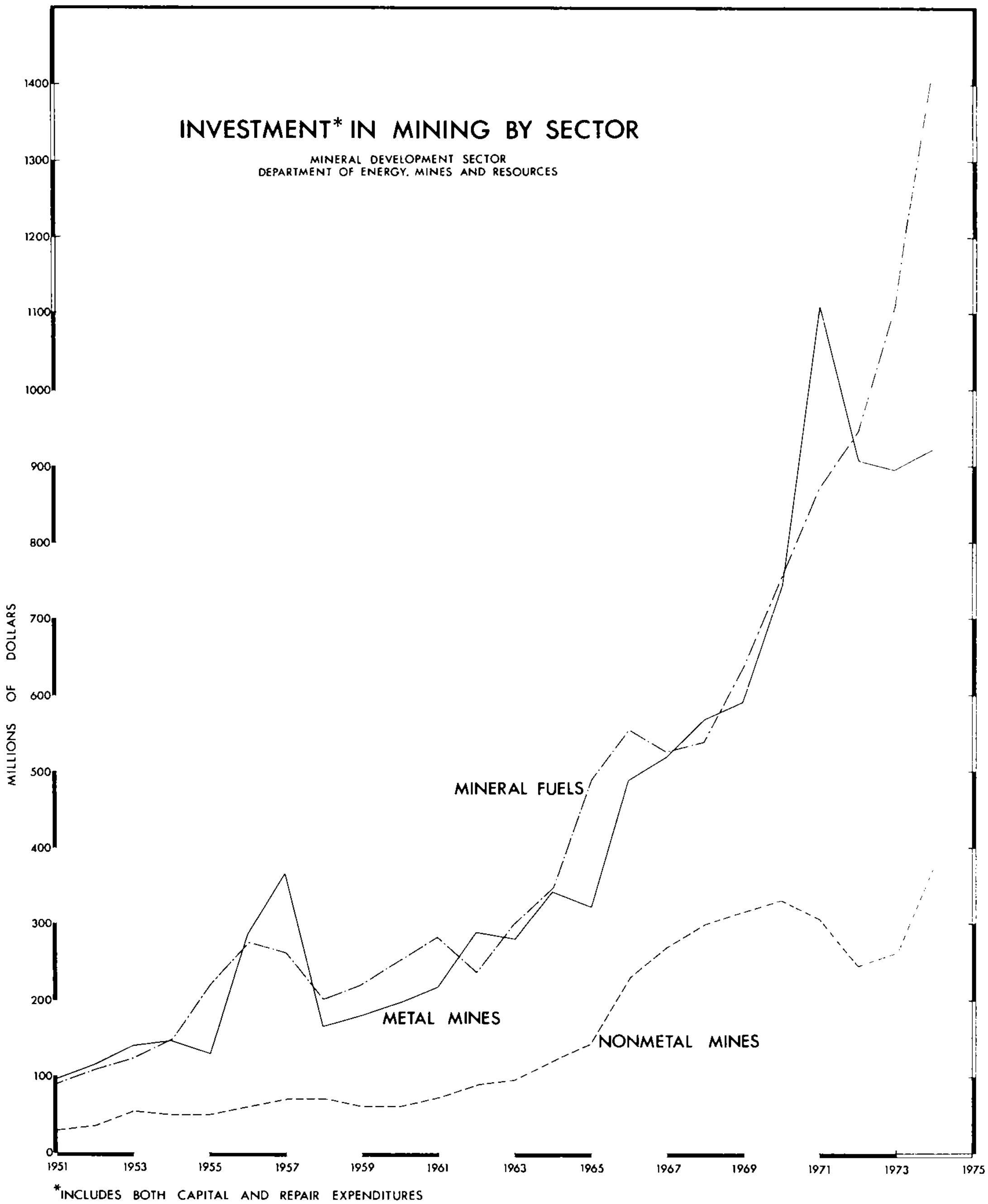

INVESTMENT* IN MINING BY SECTOR
MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES
MILLIONS OF DOLLARS
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
MINERAL FUELS
METAL MINES
NONMETAL MINES
1951
1953
1955
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
*INCLUDES BOTH CAPITAL AND REPAIR EXPENDITURES

Figure 13

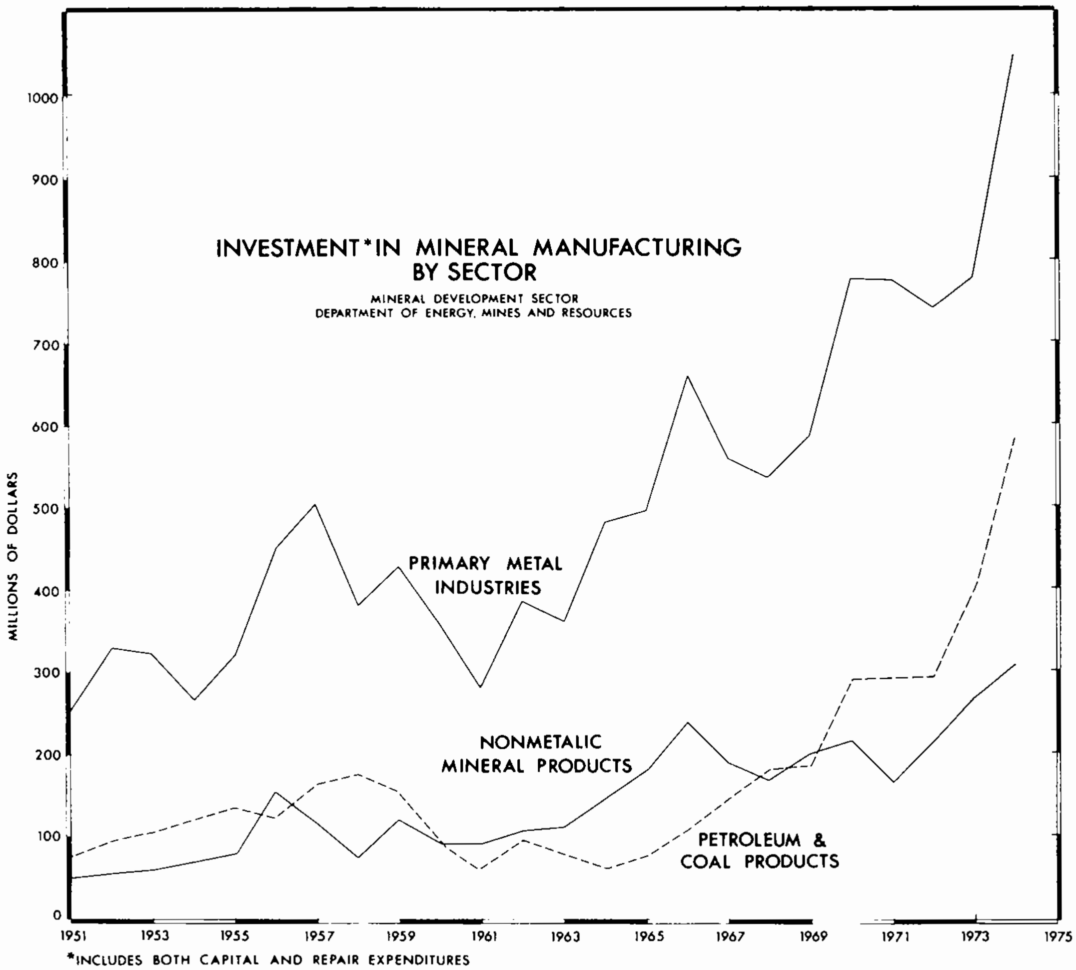


Figure 14

program includes large projects such as the construction of new steel mills by The Steel Company of Canada Limited who will be spending $490 million on the first phase of its $2 billion steelmaking complex at Nanticoke on Lake Erie, chemical plants and pulp and paper plants. The planned investments in oil and gas industries is likely to show an increase of 28.3 per cent, while transportation and communication, including oil and gas pipelines and storage is likely to increase by 15.8 per cent, and electric utilities by 11.9 per cent.

Canada's exports of resource materials are likely to continue to increase in 1974 although oil shortages could have a depressing effect on customers for Canadian raw materials in the United States, Europe and Japan. Plant shut-downs in these countries means less demand for Canadian goods.

Canada is not likely to be directly much affected by the world energy crisis as Canada produces more oil than it consumes. But, if the energy situation becomes severe in eastern Canada because of difficulties in shipping oil to this region from western Canada, the production levels in 1974 are not expected to be materially lower than 1973. The Canadian economy's main thrust will come from the buoyancy of business investment, exports and private consumption. In the absence of significant and prolonged oil supply cuts a real growth in GNP for 1974 is forecast between 4 and 5 per cent, compared with 7 per cent advance in 1973. This means the Canadian economy will likely slow in 1974 to a pace just under the full capacity rate of growth.

RETURN ON INVESTED CAPITAL AVERAGE 1962 - 1973

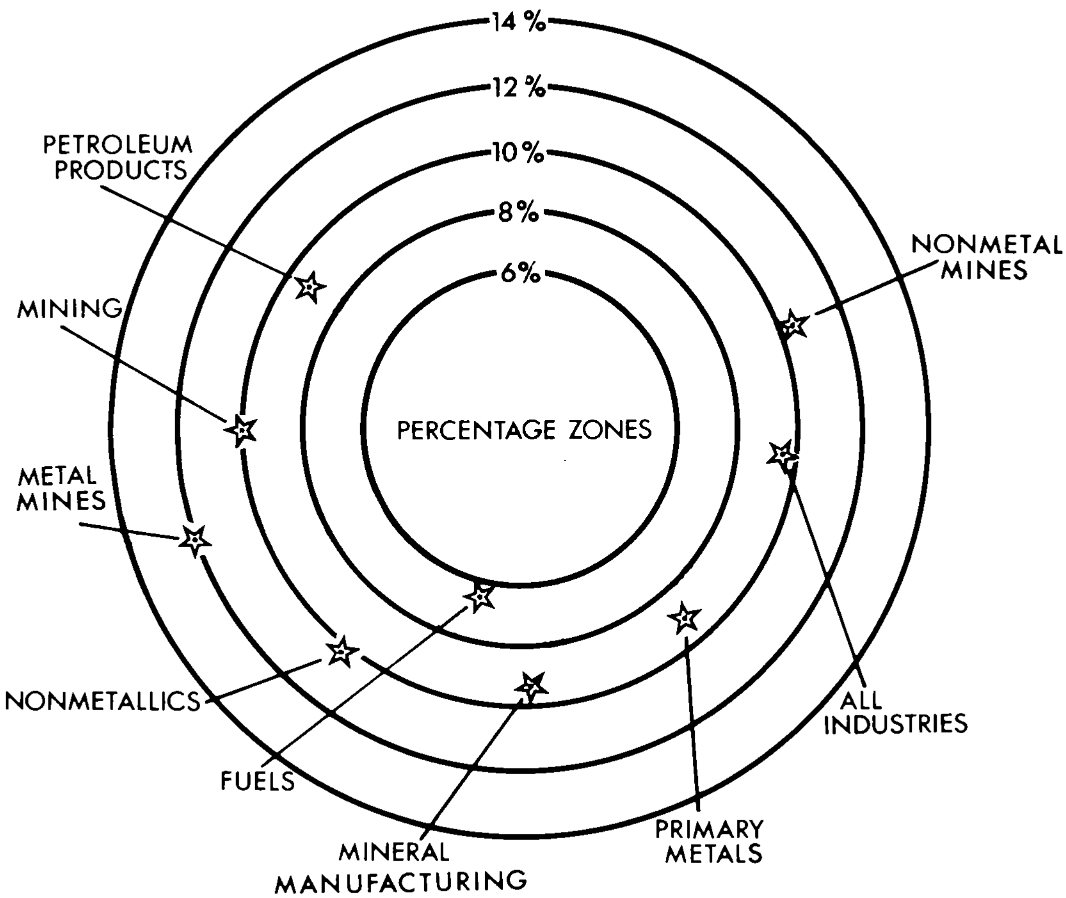


Figure 15

The mineral industry. The outlook for each major mineral commodity is given under its own review. Here an attempt is made to give an overall outlook for the Canadian mineral industry. The future course of the Canadian mineral industry depends upon many factors. They include, among others, the current government policies at home and the ever-changing politico-economic conditions abroad. It is difficult to be specific about the outlook for the Canadian mineral industry, but the following events may indicate the direction in which we are likely to go in the near future.

At home, after the expansionary 1972-1973 budgets, which included a substantial cut in corporate income tax, the outlook for the next few years is for further rapid growth in most sectors of the economy, with non-residential fixed investment and stockbuilding contributing heavily to a rise in total demand. This should make further inroads into unused capacity, although the capacity utilization in several sectors of the mineral industry is already running very high.

Another factor which is likely to influence the future development of the Canadian mineral industry is the recently declared mineral policy goal and objectives. With reference to the objectives, the Honourable Donald S. Macdonald suggested as a basis for discussion a priority emphasis whereby future policy would seek domestic economic diversification and financial returns from exportable mineral surpluses. However, policy must also ensure minerals for domestic needs and reflect other elements of the objectives. As a major component of Canada's economic base, the mining industry, excluding oil, gas and coal, accounts directly for 4 per cent of total GNP. Indirectly, a further 8 per cent of GNP is dependent on the activities of the mineral industry.

Furthermore, there are several indicators which point towards an increasing future activity in the mineral industry. For example, there is a likelihood of the development of mining technology for conducting deep-sea mining. This will open further many yet untapped mineral resources for human exploitation and use. Similarly, the potential of the Athabasca oil sands and offshore and Arctic mineral deposits for utilization in the next few years is under consideration. Recently, it was announced that Syncrude Canada Limited will proceed with development at the Athabasca oil sands. This project is likely to cost $800 million and will provide jobs for about 3,000 during construction and 1,600 during operations which are expected to begin early 1978.

During the past five years the search for new oil and gas resources has been gradually shifting from the Prairie provinces to Canada's frontier areas; and this trend is expected to continue in the future. These high-potential areas include the Mackenzie Delta-Beaufort Sea region, the Arctic Islands and offshore from the east coasts of Canada. To date some oil and gas discoveries have been made in the Arctic Islands and the Mackenzie Delta region.

Again, the trend toward large, low-grade orebodies has changed some of the variables in mine development. Larger initial investments with longer lead times and longer payback have led to more joint ventures, and other forms of financing; e.g., Japanese financing in coal and copper in British Columbia. This will further enhance mining growth in Canada.

A major factor in the strength of the Canadian economy is provided by crude and fabricated mineral products exports. These normally contribute about 28 per cent of total Canadian exports. The growth in mineral exports depends largely upon the expansion in the economies of our trading partners, especially the United States. The United States economy has been expanding rapidly recently, but it is likely to turn a "growth recession economy"* in 1974 because of inflation, the energy shortage and less spending on items like cars and homes. Similarly, the economies of Japan and Europe may likely face a sluggishness during 1974 because of energy shortage. As a result, the Canadian mineral industry may experience a slightly difficult time in the immediate future.

The official entry of Britain into the European Economic Community (EEC) came into effect on January 1, 1973, and this may have a detrimental affect on certain areas of the Canadian mineral economy as Britain represents a very important, although decreasing portion of Canadian trade. Canada not only loses the old Commonwealth preferences, but also faces "reverse preferences" which Britain grants to its new partners behind the EEC's common tariff wall. The principal nonferrous metal products, in order of value, likely to be affected by the British entry into the EEC are zinc, lead and aluminum.

Canada also faces increased competition as a major mineral supplier in the world. The rise of Australia as a major supplier of iron ore and nickel and the discovery of large copper deposits in the Pacific Rim countries are likely to affect Canadian markets. Similarly, discovery of extremely large high-grade iron ore in Brazil may provide stiff competition for export of Canadian iron ore to the U.S.A. and Europe.

Taken together, the above developments indicate a significant growth in new production, employment and exporting opportunities for Canadian minerals in the next few years, although an energy-based recession affecting our major trading partners may also hurt our economy in 1974. Looking ahead, there is every reason to believe that the Canadian mineral industry will continue to be both internationally competitive and an important means for enhancing national and regional development.

*An economy performing below capacity and growing at less than its long-term average rate but not back-tracking, as in classical recession.

Regional Review

KEITH J. STEWART

Increases in the value of mineral production in 1973 occurred in all of Canada's provinces and territories. As in recent years, all contributed to Canada's mineral production with over 78 per cent of the value coming, in decreasing order, from Alberta, Ontario, British Columbia and Quebec. Slightly more than half of the total was produced in Alberta and Ontario. About 95 per cent of the value of Alberta's output resulted from crude petroleum, natural gas and natural gas byproducts, whereas 80.7 per cent of the value of Ontario's output resulted from the production of metallic minerals and their byproducts.

Alberta continued to be Canada's leader in mineral production value, a position reached for the first time in 1971. Alberta increased its proportion of a considerably expanded value of national mineral output to 33.1 per cent as compared with its lower proportion of 30.9 per cent for 1972. Most of the increase was due to an expansion in output in the fuels sector including coal, natural gas, natural gas byproducts and crude petroleum. The decline in the value of Ontario's mineral production from 23.9 per cent in 1972 to 22.2 per cent in 1973 resulted principally from the higher production values achieved by Alberta and British Columbia. The third leading producer, British Columbia, increased its proportion of total production value from 10.6 per cent in 1972 to 11.7 per cent in 1973. Quebec, the fourth leading producer, experienced a continuing decline in its proportion of national mineral production and accounted for 11.1 per cent of the total in 1973, down from 12.3 per cent in the previous year. The proportion of total production values for Saskatchewan (6.1 per cent), Newfoundland (4.4 per cent), New Brunswick (1.9 per cent) and Nova Scotia (0.7 per cent) were all less than for 1972. The proportion of total production values of Manitoba (4.9 per cent), Northwest Territories (2.0 per cent) and Yukon (1.8 per cent), either remained the same or increased slightly over 1972.

Review by provinces

British Columbia. In 1973 the value of mineral production reached a record of $975.7 million, a gain of 43.9 per cent over $677.9 million for the previous year. Copper continued to be the leading commodity. Its production value increased significantly by 87.8 per cent and it attained its largest proportion of the total output, 45.8 per cent. It was followed by coal production value which increased 27.9 per cent and represented 9.5 per cent of the total. The value of structural materials production increased by 13.2 per cent representing 7.7 per cent of the total value. Zinc production accounted for 7.5 per cent of the total and it was in fourth place in mineral production value. Petroleum production value increased 3.0 per cent and represented 6.7 per cent of the total value. Natural gas production value increased 7.0 per cent accounting for 4.7 per cent of the total value of mineral production. Molybdenum production increased by 19.9 per cent and lead production increased by 0.3 per cent in terms of value of production.

Three mines suspended operations and closed during 1973. These closures included the Invincible Mine of Canex Placer Ltd., a 75-ton-a-day tungsten mine, Mt. Copeland Mine of KRC Operators Ltd., a 200 ton-a-day molybdenum mine, and the Bradina Joint Venture of Nadina Explorations, a 500 ton-a-day lead, zinc, copper and silver mine. These losses were compensated by the opening of four mines, one each for copper, gold, zinc-lead, and silver-gold. In addition, a gold placer operation at Eight Mile Lake, and a limestone quarry on Aristagabal Island commenced operation.

1973 was the first full year of production of four major mining operations in the province. Gibraltar Mines Limited, a subsidiary of Placer Development Limited, operated its copper-molybdenum mine at McLeese Lake in the Cariboo district. Lornex Mining Corporation Ltd. operated its copper-molybdenum mine, 33 miles south of Ashcroft. Also during the year the copper mine of Similkameen Mining Company Ltd. at Princeton and the Bell copper deposit of Noranda Mines Limited were in full production.

Production of natural gas and crude petroleum continued at about the same level as last year. The quantity of crude petroleum produced dropped to 21.3 million barrels from 23.9 million barrels in 1972. Natural gas production rose from 432.1 million cubic feet in 1972 to 469.3 million cubic feet in 1973.

Zinc production increased by 34.5 million pounds. This increase, along with price increases, accounted for an increase of 42.9 per cent in the total value of zinc production over 1972. Cominco Ltd. mined most of the province's zinc and lead, and this production, along with concentrates from other mines throughout Canada, is converted at the company's metallurgical plants to refined zinc, lead and silver and the byproducts antimony, bismuth, cadmium, tin, and sulphur compounds. Cominco's H.G. mine, a zinc-lead mine closed since 1965, was brought back in production in February and has a rated capacity of 1,000 tons a day.

The coal mining industry of the province continued to increase its productivity during the year. The quantity of coal mined in the province increased by 11.9 per cent over the previous year. Most of the province's coal output will continue to be exported to Japan for metallurgical purposes. The continuing development of coal mining and its related transportation facilities will have a long-term buoyant effect on the economy of western Canada.

Yukon Territory and Northwest Territories. The value of mineral production in the Yukon Territory increased to $150.7 million from $106.8 million recorded in 1972. Almost 92 per cent of the value of production was provided by the metallic mineral sector, and most of that through the output of zinc and lead which increased 45.7 per cent in value. There are two zinc and lead producers in the Yukon, Anvil Mining Corporation Limited at Ross River and United Keno Hill Mines Limited at Elsa. Copper production became significant again with a full year of production from Whitehorse Copper Mines Limited which had closed in 1971 and reopened late in 1972. Offsetting this gain was the closure of the nickel-copper Wellgreen mine of Hudson-Yukon Mining Co. Ltd. Nonmetallic mineral production was represented by asbestos shipped from the Clinton Creek operation of Cassiar Asbestos Corporation Limited. Shipments of asbestos increased in total value by $0.9 million, but declined in quantity by about 1,000 tons.

In the Northwest Territories, mineral output increased in value to $165.5 million from $120.3 million in 1972. Metallic minerals accounted for almost all the production. Zinc and lead, the leading commodities, comprised 72.4 per cent of the total output value and were produced in increased amounts from the Pine Point area south of Great Slave Lake by Pine Point Mines Limited, a subsidiary of Cominco Ltd. Shipments of zinc, at $87.5 million, accounted for 52.9 per cent of the total value of minerals. During the year the Northwest Territories advanced its position to second place among the lead producing regions of Canada and also recorded an increase in shipments of about 19.4 million pounds. Gold output from mines in the Yellowknife area was down about 58.4 thousand ounces, but with increases in the price of gold, the value of production was up to $24.3 million from $17.7 million in 1972. The value of silver production increased to $13.7 million from $6.8 million in 1972.

The fifth leading commodity, natural gas, represented 2.6 per cent of the production value. Petroleum and natural gas have spurred considerable exploration activity on the Arctic Islands and near the Arctic coast. Significant discoveries were made in 1973. The Dome Arctic Ventures Wallis K-62 well on King Christian Island, encountered a gas-bearing sandstone at 6,430 feet. On test, the sandstone yielded gas at a rate of 12.4 million cubic feet a day accompanied by condensate. This well is considered to be a major gas discovery.

Canada Tungsten Mining Corporation Limited is preparing for underground production from the new "E" zone near its open-pit mine site in the Flat River area of the Mackenzie District. Preliminary estimate of the "E" zone reserves is 4 million tons 1.60 per cent tungsten trioxide (WO_3) and 0.22 per cent copper.

Alberta. In terms of value of production, this province maintained its position as the leading mineral producing region in Canada in 1973. It increased the value of mineral output by 39.7 per cent over that of 1972 to a total of 2,764.1 million. It continued as the leading producer of crude petroleum, natural gas and its byproduct and elemental sulphur. Those commodities accounted for 95.9 per cent of the total value with crude petroleum leading the list at $1,894.7 million and providing 68.6 per cent of the total. Natural gas and natural gas byproducts were next in importance and experienced substantial gains to $388.7 million and $340.4 million, respectively. The value of coal, the fourth commodity of importance, increased 14.8 per cent and, in terms of tonnage, Alberta continued as the largest national producer of this commodity. The production value of structural materials increased by 9.0 per cent in 1973. The value of sulphur shipments reversed its downward trend in 1973 registering an increase of 28.2 per cent indicating an easing of the international over-supply situation.

Petroleum exploration activity in Alberta increased, but the success ratio continued to decline as no significant petroleum or natural gas was found during the year. Alberta's reserves-production ratio is declining indicating a consumption rate greater than the discovery rate. It is estimated that Alberta's reserves of liquid petroleum will last another 12 years at 1973 rates of production. Reserves of natural gas are sufficient to last 17 years at 1973 levels of use.

Saskatchewan. Saskatchewan's mineral production reached $510.3 million in 1973, up 24.6 per cent from 1972. Most mineral commodities experienced significant advances as compared with the previous year. Crude petroleum, the leading commodity, advanced in value to $264.1 million and represented 51.7 per cent of the total. Potash followed in order of value and increased 30.5 per cent over its 1972 output value, to account for 34.7 per cent of the provincial total. This province provides all of Canada's potash and is responsible for this country being the leading world producer.

Copper, the next commodity in importance, increased 2.1 per cent in value and accounted for 2.6 per cent of the provincial total. Structural materials followed copper, accounting for 2.8 per cent of the total value. The value of natural gas production increased slightly, accounting for 1.8 per cent of the total value of mineral production. Coal production accounted for 1.7 per cent of the provincial total, an increase of 29.7 per cent from the previous year. Zinc production value increased by 2.2 per cent, accounting for 1.3 per cent of the provincial total.

Manitoba and Saskatchewan Coal Company (Limited) developed a new lignite mine at Estevan. Start up of production was scheduled for January 1974 at an annual rate of about 1.7 million tons. All the coal produced from this mine will be sold to the nearby power plant of Saskatchewan Power Corporation.

Gulf Minerals Canada Limited continued with development work at its Rabbit Lake property, near the west end of Wollaston Lake. Construction of a 4.5-million-pound-U_3O_8-a-year mill was commenced in 1973. Production is scheduled for 1975.

The Jolu gold property, 75 miles north of La Ronge, was brought into production in July by Decade Development Ltd. at a rate of 50 tons a day.

Manitoba. The value of mineral output from Manitoba reached $419.2 million in 1973, an increase of 29.7 per cent over the previous year. The two leading commodities, nickel and copper, which were valued at $228.2 million and 91.0 million respectively, accounted for 76.1 per cent of the total mineral value. Nickel production value increased 21.3 per cent and copper production value increased 55.3 per cent. There was an increase of 7.5 per cent in the output of structural materials and an increase of 84.3 per cent in the value of zinc output, the two commodities next in importance. The value of crude petroleum production increased 17.6 per cent to account for 4.1 per cent of the total value of mineral production. Other mineral commodities such as gold, cobalt and tantalum contributed in that order, but to a minor extent, to the value of provincial mineral output.

The International Nickel Company of Canada, Limited (Inco) operated three nickel mines, the Thompson, Pipe, and Brichtree, a smelter and refinery in the Thompson area. Sherritt Gordon Mines, Limited continued to ship nickel and copper from its Lynn Lake operation and copper-zinc from its Fox Lake operation. Production at 10,000 tons a day commenced at Sherritt's Ruttan Lake copper-zinc deposit about 140 miles northeast of Flin Flon.

Hudson Bay Mining and Smelting Co., Limited operated nine copper-zinc mines in the province. The mineral concentrates shipped from these mines are smelted and refined, along with concentrates received on a custom basis, at the company's copper-zinc smelter at Flin Flon.

Ontario. The value of Ontario's mineral production increased by $318.1 million in 1973, reaching a total of $1,185.9 million. During 1973, nickel and copper accounted for 50.7 per cent of the total value of the province's mineral output. The value of nickel production increased 10.6 per cent to $574.8 million, and the value of copper increased 79.5 per cent to $365.3 million. In decreasing order of value, the other leading mineral commodities were structural materials, zinc, iron ore, gold, silver and platinum.

During 1973, five small mining operations commenced. Kanichee Mining Inc. commenced mining copper-nickel ore in Strathy township, Temagami area, at a rate of 500 tons a day. Kingbridge Mines Ltd. commenced mining five to ten tons a day of gold-silver-copper ore 12 miles southwest of Gogama. Lynx-Canada Explorations Ltd. commenced zinc production at its Long Lake mine near Parham at a rate of 200 to 300 tons a day. New Joburke Explorations Ltd. commenced mining gold-copper ore at a rate of 200 to 250 tons a day in Keith township, northern Ontario. Noranda Mines Limited commenced nickel production at its Langmuir project, 20 miles southeast of Timmins, at a rate of 700 tons a day.

The International Nickel Company of Canada, Limited formally opened its new nickel refinery at Copper Cliff. It has an annual capacity of 100 million pounds of nickel pellets and 25 million pounds of nickel and iron-nickel powders. Inco has also announced that the Crean Hill mine in the Sudbury district will be reopened for production in 1974. Mid-1974 production will be 4,000 tons a day.

Texasgulf, Inc. announced a two-phase expansion plan for its Kidd Creek mine. The first phase consists of mine and mill expansion to increase annual ore production from 3.6 million to 4 million tons by mid-1974. The second phase is to increase to 5 million tons and to build a smelter.

Canada Cement Lafarge Ltd. began start-up procedures at its new plant at Bath. It will officially open in the spring. The company closed its Belleville plant at the end of October, 1973.

Many other mineral commodities are produced in Ontario which supplies a greater variety than any other province. The northern part of this province continues to provide significant exploration activity and additional new discoveries are being explored or developed for production.

Quebec. The production value of minerals in Quebec rose by 18.3 per cent. Copper continued to be the most dominant commodity and its value provided 21.8 per cent of the province's total value, or $201.4 million. This was an increase of 12.1 per cent from the 1972 value. Contributing to this increase was the commencement of mining of the Bouzan copper deposit, a joint venture of Kerr Addison Mines Ltd., and Patino Mines (Quebec) Ltd. in the Chibougamau district. At Ellis Lake Falconbridge Copper Ltd. commenced production of copper-gold at a rate of 300 tons a day at the Cooke mine. Some production was lost with the closing of the Weedon copper-zinc mine by the Sullivan Mining Group, 20 miles south of Thetford Mines.

Asbestos was the second mineral commodity in importance and provided 19.2 per cent of the province's value of mineral production. Expansion activity continued at the operations of Canadian Johns-Manville Company, Limited, Bell Asbestos Mines, Ltd. and at the King-Beaver operation of Asbestos Corporation Limited. Canadian Johns-Manville Company, Limited officially inaugurated its new Mill 6 crusher-dryer-concentrator complex at its Jeffrey mine. The opening culminated nearly five years of work, with expenditures of $75 million. The new facilities are designed to ensure that an annual production of 600,000 tons of high-quality fibre will be maintained "well into the 21st century." Expansion of the open pit will now be allowed with removal of the old crusher-dryer building, relocation of part of the townsite and relocation of the asbestos manufacturing plant near the northern limit of the present pit. The pit, now one mile in diameter, will be taken to a depth of 1,400 feet from the present 900 feet. Ore reserves have been placed nominally at 500,000,000 tons.

Structural materials increased substantially over last year and accounted for 18.5 per cent of the province's value of mineral production.

Iron ore output accounted for 13.6 per cent of the value of mineral output. This was an increase of 23.8 per cent from the previous year. Iron Ore Company of Canada brought on stream its 6 million ton-a-year concentrator and pellet plant at Sept-Iles during the year. Construction of Quebec Cartier Mining Company's huge Mt. Wright concentrator continued with some major elements being completed. Expected to be put into production in early 1975, it will provide some 16 million tons a year of concentrate for export. Quebec Cartier Mining is also developing the Fire Lake mine, some 50 miles from Gagnon. It will supply raw ore to the Gagnon concentrator by 1975-76 to partially replace ore from the Lac Jeannine mine, which is expected to be depleted by then.

Other leading commodities were zinc, gold, titanium dioxide, and iron remelt, in that order. Quebec produces many other mineral commodities and has pioneered such industries as those relating to titanium dioxide, columbium and lithium. A new gold producer commenced production in October with the opening of the Eagle mine by Agnico-Eagle Mines Ltd. in Joutel township at a rate of 1,000 tons a day.

New Brunswick. The mineral output of New Brunswick is closely related to the production of zinc and its coproducts. In 1973 the total value of mineral production increased substantially by 35.4 per cent from the previous year to a total of $162.4 million. Zinc accounted for 57.3 per cent of the total and, along with its coproducts lead, copper, silver, bismuth and gold, it represented 80.2 per cent of the overall mineral value. The value of zinc was up 36.7 per cent. The value of structural materials, the second leading commodity, was up 56.6 per cent. The production of lead, the third leading commodity, was up 1.2 per cent accounting for 8.8 per cent of the total value. Copper production increased 25.3 per cent and silver production increased 41.3 per cent, both in terms of value. Coal output from the Minto coal fields decreased by 4.6 per cent in value to account for 2.1 per cent of the provincial total.

Brunswick Mining and Smelting Corporation Limited is the provinces largest producer of base metals and operated two zinc-lead-copper mines and two mills near Bathurst. A related company, East Coast Smelting and Chemical Company Limited, operates a lead blast furnace at Belledune with a capacity of 60,000 tons of lead metal a year. Brunswick Mining and Smelting announced at $16.5 million expansion of the No. 12 mine to keep production at the same level after the expected closure of No. 6 mine in 1976. The expansion includes a second shaft to 4,300 feet.

Anaconda Canada Limited and Cominco Limited announced the reopening of their Caribou mine, a silver-lead-zinc property near Bathurst. Mining commenced in September at a rate of 5,000 tons a week. The operating company is Caribou-Chaleur Bay Mines Ltd.

Another important base metals producer is Heath Steele Mines Limited with mines located northwest of Newcastle. During the year Heath Steele increased its capacity to 4,000 tons a day.

The Sullivan Mining Group Ltd. plans to reopen the lead-zinc-copper-silver mine and 1,000-ton-a-day mill of Nigadoo River Mines Limited near Bathurst. This mine became strike-bound in 1971 and closed in 1972. The Sullivan Mining Group is also conducting exploration on other properties. A decline is being driven at the copper-lead-zinc Chester Mines property, Clearwater Stream, Newcastle district, and a decline is being driven at the Mount Pleasant multimineral prospect 37 miles south of Fredericton.

Antimony production at the Lake George mine of Consolidated Durham Mines and Resources Ltd. continues. The value of 1973 production more than doubled the value of the previous year.

Exploration drilling for potash near Sussex is being conducted by Potash Company of America. The discovery of potash in this area was made in 1971 as a result of drilling which was part of the mineral-exploration program funded by the federal Department of Regional Economic Expansion. DREE programs are continuing in the province.

Nova Scotia. Nova Scotia's mineral output was valued at $61.7 million in 1973, representing an increase of 7.3 per cent from 1972. Most of the total production was provided by structural materials, fuels and nonmetallic minerals. Structural materials became the leading commodity in terms of value replacing coal in that position. Structural materials increased 16.5 per cent in value to account for 35.5 per cent of the provincial total.

Coal production value decreased 3.4 per cent to account for 25.2 per cent of the value of provincial mineral output. Cape Breton Development Corporation's No. 12 colliery at New Waterford was closed by a fire March 3, 1973, and was still closed at the end of the year. With the current world energy crisis, the immediate future bodes well for Nova Scotia coal production.

Gypsum retained its position in third place in terms of value and provided 23.4 per cent of the overall value. Nova Scotia provides about 73.6 per cent of Canada's gypsum and is one of the leading gypsum producing areas in the world.

Salt production value decreased 2.8 per cent providing 13.5 per cent of the province's value of production. Salt is produced by the Canadian Rock Salt Company Limited at Pugwash and Domtar Chemicals Limited at Nappan.

Barite is produced at Walton by Dresser Minerals a Division of Dresser Industries, Inc. Barite production value increased 87.7 per cent, accounting for 1.2 per cent of the total mineral value.

Peat moss is produced at Berwick by Annapolis Valley Peat Moss Co. Ltd. Peat moss production value increased 19.1 per cent to account for 0.6 per cent of the total mineral value.

Celestite is mined at Loch Lomond, Cape Breton Island, by Kaiser Celestite Mining Limited. Mining by open pit commenced in 1971. Mining is now going underground with the driving of an incline.

The highlight of the year in Nova Scotia was the discovery of extensive lead-zinc mineralization in the Gays River area about 30 miles north-northeast of Halifax by Imperial Oil Enterprises on ground held by Cuvier Mines Limited. Extensive diamond drilling has been completed to date and this operation is continuing. The lead-zinc mineralization occurs in a porous reefal formation in limestones. A recent estimate of reserves places them at 20.7 million tons assuming 75 per cent of the tonnage will be minable. Average grade of these reserves is 6.14 per cent combined lead-zinc. However, it has been stressed by Cuvier Mines that at the present time neither the full strike length nor the full width have been determined, and therefore the mineralized area is open in all four directions.

Prince Edward Island. Historically, Prince Edward Island's mineral production has been confined to structural materials. The value of production increased 53.2 per cent to $1,680,000 from a total of $1,097,000 for the previous year. Production was confined solely to the output of sand and gravel.

Newfoundland and Labrador. Newfoundland's total mineral production was valued at $374.5 million in 1973, an increase from $290.6 million in 1972. Iron ore continued to play a major role in the mineral industry of Newfoundland, accounting for 84.1 per cent of the total value of provincial mineral production. Newfoundland is by far the largest producer of iron ore in Canada, the mines and concentrators being operated by Iron Ore Company of Canada Limited and Wabush Mines.

Asbestos, the mineral commodity second in value of output, increased in value by 61.7 per cent, to account for 4.7 per cent of the provincial total. The province's only asbestos producer is Advocate Mines Limited, located at Baie Verte.

Structural materials, the mineral commodity third in value of production, increased 29.3 per cent to account for 3.6 per cent of the provincial total. Copper production increased 13.9 per cent accounting for 3.0 of the value of mineral production. Zinc production declined 58.6 per cent, to account for 1.1 per cent of the provincial total. Likewise, lead production value declined 27.6 per cent accounting for 0.7 per cent of the provincial total. The declines registered by copper, zinc and lead were due to labour problems that resulted in a strike at the operations of the Buchans Unit of American Smelting and Refining Company between March 15 and October 3, 1973.

Exploration and development continues at a good pace in the province. During the year Teck Corporation Limited and Amax Exploration, Inc. announced a new zinc find on the Newfoundland concession of Newfoundland Zinc Mines Limited. Reserves were estimated at 3,700,000 tons of 11.4 per cent zinc. Near Springdale, Notre Dame Bay, Green Bay Mining Co. Ltd. plans to open the Little Deer copper deposit near the former producing Whalesback mine of British Newfoundland Exploration Ltd. (Brinex).

Lightweight Aggregates

D. H. STONEHOUSE

Traditional aggregates for use in concrete and concrete products have been sand and gravel. As concrete technology advanced, the need for clean, sharp aggregate with a designed particle size distribution was emphasized and the use of crushed stone aggregate as well as crushed, screened and washed gravel became standard procedure. The methods of mixing, transporting, placing and curing of concrete are the subjects of ongoing studies and research in conjunction with the use of various types of cement as the binding media. Until the mid-forties, comparatively little attention was paid to designing concrete products to meet a specific requirement other than a certain predetermined strength and setting time. At that time increased housing demand accentuated the need for prefabricated structures. Techniques of construction were developed using structural sections and panels of much lighter unit volume, with no sacrifice of strength, by utilizing lightweight aggregates which also incorporated the added advantage of insulation from heat, fire, sound and moisture. The use of lightweight concrete in commercial and institutional projects has facilitated the construction of much taller buildings and the use of longer clear spans. Normal aggregates are becoming increasingly scarce in many consuming regions such that the possibility of lightweight aggregate utilization for reasons other than the derived physical benefits could develop in these particular areas.

Four categories generally used to classify the lightweight aggregates combine elements of source, processing methods and end use. Natural lightweight aggregates include materials such as pumice, scoria, volcanic cinders and tuff. Manufactured lightweights are bloated or expanded products obtained by heating certain clays, shales, or slates. Ultralightweights are made from natural mineral ores, such as perlite and vermiculite, which are expanded or exfoliated by the application of heat and used mainly as plaster aggregate or as loose insulation. Fly ash, obtained from the combustion of coal and coke, and slag, obtained from metallurgical processes, are classed as byproduct aggregates.

All types are used in Canada but only expanded clays, shale and slag are produced from materials of domestic origin. Vermiculite is imported mainly from Montana, U.S.A., although a small amount is brought in from South Africa; perlite is imported mainly from New Mexico and Colorado and pumice is imported from the State of Oregon and from Greece.

Canadian industry and developments

With total construction spending in Canada showing continued increases and with the general trend towards higher buildings, larger precast shapes and greater clear spans, the application of lightweight aggregates in concrete should increase greatly. The advantages of location and cost enjoyed by the normal heavy aggregates are becoming less of a factor as land-use conflicts are more evident and transportation costs continue to increase.

Perlite. Perlite is a variety of obsidian or glassy volcanic rock that contains 2 to 6 per cent of chemically combined water. When the crushed rock is heated rapidly to a suitable temperature it expands to between four and twenty times its original volume. Expanded material can be manufactured to weigh as little as 2 to 4 pounds a cubic foot, with attention being given to preblending of feed to the kiln and retention time in the flame.

In Canada, imported perlite is expanded and used mainly by gypsum products manufacturers. In 1973, about 67 per cent of consumption was in plaster products such as wallboard or drywall, where its value as a lightweight material is augmented by its fire-resistant qualities. It is also used as a loose insulation (24 per cent) and as an insulating medium in concrete products. Perlite, as well as vermiculite and expanded shale and clay, is becoming more widely used in agriculture as a soil conditioner and fertilizer carrier.

Imports of crude perlite for consumption in Canada are from New Mexico and Colorado deposits worked by such companies as Johns-Manville Corporation, United States Gypsum Company, United Perlite Corp. and Grefco Inc. In 1973 nine companies at eleven locations in Canada reported production of expanded perlite.

Perlite occurs in British Columbia but no commercial deposits have as yet been located.

Table 1. Canada, production of lightweight aggregates, 1972-73

	1972		1973	
	(cu yd)	($)	(cu yd)	($)
From domestic raw materials				
Expanded clay, shale and slag	739,074	3,989,611	742,964	4,491,769
From imported raw materials				
Expanded perlite and exfoliated vermiculite	680,464	6,133,521	661,448	6,598,429
Pumice	6,100	35,948	60,250	436,800
Total	1,425,638	10,159,080	1,464,662	11,526,998

Source: Company data.

Pumice. Pumice is a cellular, glassy lava, the product of explosive volcanism, usually found near geologically recent or active volcanoes. It is normally found as a loosely compacted mass composed of pieces ranging in size from large lumps to small particles. It is not the lightest of the lightweight aggregates, but when utilized as a concrete aggregate, particularly for the manufacture of concrete blocks, it exhibits strength, density and insulating values that have made it a preferred material.

In Canada a number of concrete products manufacturers use pumice imported from Greece or from northwestern United States mainly in the manufacture of concrete blocks. A major use for pumice, as yet unexplored in Canada, has been in highway construction where lightweight aggregate surfaces have been shown to have exceptional skid resistance.

Pumicite, distinguished from pumice by its finer size range (usually minus 100 mesh), is used in concretes mainly for its pozzolanic qualities. (A pozzolan is a siliceous material possessing no cementitious qualities until finely ground, in which form it will react with calcium hydroxide in the presence of moisture to form insoluble calcium silicates.)

Table 2. Canada, consumption of expanded perlite

	1971	1972	1973
	(per cent)		
Insulating plaster	64	60	67
Insulation	22	19	24
Insulating concrete	3	2	1
Agriculture, horticulture	11	12	5
Other uses fillers	–	7	3

Source: Company data.
– Nil.

Extensive beds of pumicite have been noted in Saskatchewan and in British Columbia.

Vermiculite. The term vermiculite refers to a group of micaceous minerals, hydrous magnesium-aluminum silicates, that exhibit a characteristic lamellar structure and that expand or exfoliate greatly upon being heated rapidly. Mining is normally by open-pit methods; and beneficiation techniques include the use of hammer mills, rod mills, classifiers, screens, dryers and cyclones. Exfoliating is done in oil- or gas-fired, vertical or inclined furnaces, usually close to the consuming facility to obviate the higher costs associated with shipping the much bulkier expanded product. The expansion process has advanced technologically to permit production of various grades of expanded vermiculite as required. The uses to which the product is put depend on its low thermal conductivity, its fire-resistance and, more recently, on its lightweight qualities.

Canadian consumption is mainly as loose insulating material, with smaller amounts being used as aggregate in insulating plaster and concrete. In 1973, building construction accelerated to the point where producers of expanded vermiculite were hard pressed to meet demands even before the energy crisis. At the year-end, operating at capacity, the industry was six months behind in orders.

The major producer of vermiculite is the United States. The principal company supplying Canada's imports is W. R. Grace and Company from operations at Libby, Montana. Canada also imports crude vermiculite from South Africa where Palabora Mining Co. Ltd. is the major producer. At both the Grace and Palabora operations process milling limitations have necessitated new mill installations during 1973 in an effort to keep up with demand.

Vermiculite occurrences have been reported in British Columbia and a deposit near Perth, Ontario has been investigated but, as yet, no commercial deposits have been developed in Canada.

Table 3. Canada, consumption of exfoliated vermiculite

	1971	1972	1973
		(per cent)	
Loose insulation	72	72	73
Insulating plaster	9	5	3
Insulating concrete	10	15	7
Minor uses			
Fireproofing, agriculture, underground pipe insulation, horticulture, barbecue base	9	8	17

Source: Company data.

Clay and shale. Common clays and shale are used throughout Canada as raw material for the manufacture of lightweight aggregates. Although the Canadian industry began in the 1920's in Ontario, it did not evolve significantly until the 1950's when it grew in support of demands from the construction industry. The raw materials are usually quarried adjacent to the plant sites at which they are expanded. Clay receives little beneficiation other than drying before being introduced to the kiln. Shales are crushed and screened before burning. Ten plants in Canada currently produce lightweight aggregates from clay and shale, using a rotary kiln process.

One company produces an aggregate material from slag as a byproduct of a blast furnace operation. In the steel-making process, iron ore, coke and limestone flux are melted in a furnace. When the metallurgical process is completed, lime has combined with the silicates and aluminates of the ore and coke and formed a nonmetallic product (slag) which can be subjected to controlled cooling from the molten state to yield a porous, glassy material. Slag has many applications in the construction industry. The statistics relative to expanded slag production are included in those of clay and shale.

Although Canada does not produce large amounts of fly ash, the technology of fly ash processing and utilization is well advanced. The largest single use for fly ash is as a cementitious material where its pozzolanic qualities are utilized. Use of fly ash as a lightweight aggregate could become of increasing importance. International Brick and Tile Ltd. of Edmonton, Alberta, which produces brick using fly ash and bottom ash as raw material, was taken over by Great West Steel Industries Ltd. of Vancouver in 1972.

About half of the 400,000 tons a year of fly ash collected at Ontario Hydro's Lakeview thermal generating plant is to be utilized in the production of pozzolan, iron oxide and lightweight aggregate pellets.

There are as yet no Canadian Standards Association (CSA) specifications for the lightweight aggregates. Production and application are based on American Society for Testing and Materials (ASTM) designations as follows: ASTM Designations C 332-56 T – Lightweight Aggregates for Insulating Concrete; C 330 – Lightweight Aggregates for Structural Concrete; C 331 – Lightweight Aggregates for Concrete Masonry Units.

Table 4. Canada, consumption of expanded clay and shale

	1971	1972	1973
		(per cent)	
Concrete			
block	69	70	67
precast structural	3	3	6
cast-in-place structural	27	24	25
Minor uses			
sand blasting, horticulture refractories, insulation brick grog, flexible pavement	1	3	2

Source: Company data.

Outlook

Demand for all lightweight aggregates will continue to increase as use in structural concrete and for insulation purposes becomes more popular. In view of increased costs of energy the amount of insulation which can be economically installed in new housing, and indeed in older housing, has about doubled during the past couple of years thereby placing great demand pressure on the suppliers of these materials. The four main lightweight materials – perlite, pumice, vermiculite and expanded clays – are interchangeable for many applications and can, along with some synthetic materials, be considered substitutes or alternates for each other.

The United States is the source of most of the lightweight raw materials consumed in Canada, exclusive of clay, shale and slag. The U.S. reserves are sufficient both for its domestic requirements and for exports to meet Canada's projected needs for many years.

World review

The United States and Greece are the main producers of perlite with smaller quantities mined in Algeria, Turkey, the Philippines and New Zealand. The last country could become a major producer if huge deposits owned by Consolidated Silver Mining Co. are developed for export markets.

The major producers of pumice include the United States, Italy, West Germany and Greece although production is recorded from other countries. As with

Table 5. Lightweight aggregate plants in Canada, 1973

Company	Location	Product
Atlantic provinces		
Avon Aggregates Ltd.	Minto, N.B.	Expanded shale
Quebec		
F. Hyde & Company, Limited	Montreal	Vermiculite
Laurentide Perlite Inc.	Charlesbourg West	Perlite
Masonite Canada Ltd.	Gatineau	Perlite
Miron Company Ltd.	Montreal	Pumice[1], shale
Perlite Industries Reg'd.	Ville-St-Pierre	Perlite
Vermiculite Insulating Limited	Lachine	Vermiculite
Ontario		
Canadian Gypsum Company, Limited	Hagersville	Perlite
Canadian Johns-Manville Company, Limited	North Bay	Perlite
Domtar Construction Materials Ltd.	Caledonia	Perlite, shale
	Cornwall	Perlite
	Mississauga	Expanded shale
Grace Construction Materials Ltd.	St. Thomas	Vermiculite
	Ajax	Vermiculite
Holmes Insulations Limited	Sarnia	Perlite
National Slag Limited	Hamilton	Slag
Prairie provinces		
Cindercrete Products Limited	Regina, Sask.	Expanded clay
Consolidated Concrete Limited	Calgary, Alta.	Expanded shale
Domtar Construction Materials Ltd.	Calgary, Alta.	Perlite
Echo-Lite Aggregate Ltd.	St. Boniface, Man.	Expanded clay
Consolidated Concrete Limited Edcon Block Division	Edmonton, Alta.	Expanded clay
Grace Construction Materials Ltd.	Winnipeg, Man.	Vermiculite
	Regina, Sask.	Vermiculite
	Edmonton, Alta.	Vermiculite
Kildonan Concrete Products Ltd.	St. Boniface, Man.	Expanded clay
Northern Perlite & Vermiculite Limited	St. Boniface, Man.	Perlite Vermiculite
British Columbia		
British Columbia Lightweight Aggregates Ltd.	Saturna Island	Expanded shale
Grace Construction Materials Ltd.	Vancouver	Vermiculite
Ocean Construction Supplies Limited	Vancouver	Pumice[1]
Westroc Industries Limited	Vancouver	Perlite

Source: Company data.
[1] Pumice is used in concrete block manufacture.

other low-cost lightweight material, transportation costs are the main factors in determining the competitiveness of pumice. Prices have not varied greatly in recent years.

In the United States, W. R. Grace and Company, Zonolite Division is by far the largest producer of vermiculite with mines in Montana and South Carolina. Through the Palabora Mining Co. Ltd. the Union of South Africa remains the second largest producer.

The unit price has shown a steady but unspectacular rate of increase during the past few years and is likely to continue to do so in pace with moderate increase in demand.

W. R. Grace and Company completed a $7 million, 1,000-tons-a-day wet-processing plant near Libby, Montana in 1973. The company continues to develop its network of processing and storage facilities. Palabora has installed provisions for the treatment of much finer grades than formerly, allowing a higher degree of utilization of available reserves. Most of its product is shipped to European markets.

The use of fly ash should increase with the added incentives provided by environmental control. Two cement companies in the United States have begun to blend fly ash with portland cement at three plants to produce portland-pozzolan cement for general construction use. Using only about 20 per cent of ash production, industry in North America falls far short of European enterprises, which use as much as 80 per cent of production.

Table 6. Value of construction in Canada, 1972-74

	1972	1973	1974[1]	Change 1973-74
	(millions of dollars)			(%)
Building construction				
Residential	5,870.6	7,133.0	7,863.6	+ 10.2
Industrial	926.7	1,075.8	1,275.3	+ 18.5
Commercial	1,706.2	2,089.1	2,598.1	+ 24.4
Institutional	1,249.3	1,151.5	1,240.1	+ 7.7
Other building	574.7	680.1	833.7	+ 22.6
Total	10,327.5	12,129.5	13,810.8	+ 13.9
Engineering construction				
Marine	145.6	149.9	181.9	+ 21.4
Highways, aerodromes	1,670.8	1,872.1	2,110.2	+ 12.7
Waterworks, sewage systems	714.3	831.5	1,002.6	+ 20.6
Dams, irrigation	77.9	87.0	110.6	+ 27.1
Electric power	1,235.2	1,609.3	1,834.8	+ 14.0
Railway, telephones	666.1	795.0	939.7	+ 18.2
Gas and oil facilities	1,385.7	1,531.2	1,833.0	+ 19.7
Other engineering	1,065.8	1,132.8	1,329.7	+ 17.4
Total	6,961.4	8,008.8	9,342.5	+ 16.7
Total construction	17,288.9	20,138.3	23,153.3	+ 15.0

Source: Statistics Canada.
[1] Intentions.

October 1974

aluminum rose significantly in 1973 to an estimated 240,000 tons, about 14% more than in 1972. Progressively rising domestic consumption has resulted in more semifabricating plants being constructed. Alcan's subsidiary, Alcan Canada Products Limited, opened its $4,000,000 LaPointe rod mill at Arvida, which utilizes molten aluminum from Alcan's nearby smelter. Alcan Canada Products also announced a $14,000,000 expansion of its Kingston, Ontario works, where a second cold mill will be added, more than doubling sheet and

Table 1. Canada, aluminum production and trade, 1972-73

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Production	1,012,132	–	1,037,859	–
Imports				
Bauxite ore				
Guyana	1,760,739	14,495,000	1,559,635	12,280,000
Surinam	338,690	5,317,000	464,703	7,576,000
Sierra Leone	385,442	2,692,000	393,668	2,982,000
Guinea	–	–	112,805	1,068,000
People's Rep. of China	–	–	42,610	983,000
Indonesia	148,844	691,000	162,723	815,000
United States	28,915	787,000	21,541	716,000
Other countries	228,881	1,222,000	149,698	852,000
Total	2,891,511	25,204,000	2,907,383	27,272,000
Alumina				
Australia	239,139	15,739,000	367,829	24,182,000
United States	273,238	18,586,000	312,522	21,921,000
Jamaica	228,299	15,878,000	237,156	16,319,000
Guinea	–	–	15,983	1,055,000
Surinam	–	–	4,228	272,000
Guyana	654	41,000	2,298	147,000
Other countries	112	33,000	74	23,000
Total	741,442	50,277,000	940,090	63,919,000
Aluminum and aluminum alloy scrap	8,179	1,082,000	11,339	2,138,000
Aluminum paste and aluminum powder	2,029	1,261,000	5,147	3,306,000
Pigs, ingots, shots, slabs, billets, blooms and extruded wire bars	38,300	18,899,000	49,535	25,889,000
Castings	705	1,436,000	651	1,385,000
Forgings	474	1,594,000	752	2,388,000
Bars and rods nes	5,715	3,643,000	4,490	3,501,000
Plates	16,027	9,675,000	17,201	11,631,000
Sheet and strip up to .025 inch thick	16,945	12,084,000	28,591	20,324,000
Sheet and strip over .025 inch up to .051 inch thick	6,382	5,115,000	9,131	7,893,000
Sheet and strip over .051 inch up to 1.25 inch thick	34,771	18,993,000	19,052	11,821,000
Sheet over 1.25 inch thick	19,156	11,236,000	25,444	15,440,000
Foil or leaf	1,103	1,143,000	1,069	1,078,000
Converted aluminum foil	. .	2,931,000	. .	3,777,000
Structural shapes	2,596	5,330,000	3,506	7,524,000
Pipe and tubing	991	1,648,000	1,266	2,115,000
Wire and cable excluding insulated	1,222	1,319,000	1,814	1,995,000
Aluminum and aluminum alloy fabricated materials nes	. .	7,379,000	. .	11,580,000
Total aluminum imports		180,249,000		224,976,000

Table 1 (cont'd)

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Exports				
Pigs, ingots, shot, slab, billets, blooms and extruded wire bars				
United States	487,609	220,508,000	423,684	187,002,000
Japan	76,881	31,089,000	93,044	41,448,000
Britain	80,523	42,382,000	69,716	33,151,000
West Germany	20,261	9,299,000	22,524	11,235,000
Netherlands	4,346	1,859,000	21,044	9,980,000
Italy	8,879	3,877,000	18,304	8,984,000
Turkey	8,872	3,585,000	16,447	7,439,000
People's Rep. of China	6,617	2,404,000	16,539	6,543,000
Belgium and Luxembourg	6,195	3,166,000	12,007	5,994,000
Brazil	13,201	5,714,000	12,960	5,616,000
Israel	7,485	3,097,000	11,086	4,515,000
Hong Kong	5,939	2,967,000	8,317	4,238,000
Other countries	43,345	21,313,000	44,258	21,283,000
Total	770,153	351,533,000	769,930	347,428,000
Castings and forgings				
United States	1,522	3,410,000	1,927	4,569,000
France	17	355,000	31	490,000
Japan	149	40,000	79	28,000
West Germany	2	32,000	9	24,000
Other countries	25	32,000	13	37,000
Total	1,715	3,869,000	2,059	5,148,000
Bars, rods, plates, sheets and circles				
United States	3,381	2,266,000	11,288	6,366,000
Mexico	2,431	1,194,000	1,176	806,000
Portugal	6,940	4,204,000	1,302	606,000
Jamaica	952	695,000	622	467,000
El Salvador	2	3,000	781	440,000
Netherlands	102	92,000	656	327,000
Panama	388	307,000	337	253,000
Trinidad-Tobago	170	123,000	265	197,000
Switzerland	–	–	186	191,000
Indonesia	223	107,000	338	187,000
Other countries	6,010	4,082,000	1,652	1,258,000
Total	20,599	13,073,000	18,603	11,098,000
Foil				
United States	42	52,000	51	77,000
United Kingdom	...	1,000	15	12,000
Jamaica	8	9,000	7	8,000
Guyana	–	–	2	3,000
Other countries	21	25,000	5	5,000
Total	71	87,000	80	105,000
Fabricated materials, nes				
United States	4,744	4,109,000	5,905	4,849,000
United Kingdom	251	415,000	736	1,069,000
Argentina	5,345	2,786,000	1,110	538,000
Ivory Coast	934	947,000	299	286,000
Guyana	72	61,000	314	251,000
Israel	4	8,000	125	209,000
Other countries	6,313	5,496,000	2,168	1,865,000
Total	17,663	13,822,000	10,657	9,067,000

Table 1 (Concl'd)

	1972		1973	
	(short tons)	($)	(short tons)	($)
Ores and concentrates				
United States	17,828	1,986,000	24,696	2,515,000
France	2,887	401,000	1,536	222,000
Italy	1,313	170,000	1,525	207,000
Republic of South Africa	–	–	608	188,000
United Kingdom	744	105,000	1,008	170,000
Spain	1,076	148,000	844	120,000
Other countries	479	63,000	1,741	343,000
Total	24,327	2,873,000	31,958	3,765,000
Scrap				
United States	45,326	14,531,000	40,622	13,957,000
Japan	3,738	1,092,000	4,006	1,677,000
West Germany	1,826	413,000	3,701	643,000
Spain	1,259	364,000	1,989	593,000
Italy	5,160	1,543,000	1,752	452,000
South Korea	1,290	397,000	1,270	381,000
Brazil	222	56,000	1,055	352,000
Taiwan	86	26,000	539	213,000
Other countries	616	178,000	1,944	534,000
Total	59,523	18,600,000	56,878	18,802,000
Total aluminum exports		403,857,000		395,413,000

Source: Statistics Canada.
^{p}Preliminary; – Nil; nes Not elsewhere specified; . . Not available; . . . Less than one short ton.

Table 2. Canada primary aluminum production, trade and consumption, 1964-73

	Production	Imports	Exports	Consumption[1]
	(short tons)			
1964	842,640	3,996	627,992	172,443
1965	830,505	6,945	707,512	213,094
1966	889,915	16,923	716,382	243,301
1967	963,343	8,176	760,649	217,484
1968	979,171	15,043	862,634	242,390
1969	1,078,717	11,531	886,688	269,027
1970	1,061,020	13,425	839,598	275,743
1971	1,120,951^r	17,527	890,022	322,081^r
1972	1,012,132	38,300	770,153	333,550
1973^p	1,037,859	49,535	769,930	. .

Source: Statistics Canada.
[1]Excluding aluminum metal used in the production of secondary aluminum.
^{p}Preliminary; ^{r}Revised; . . Not available.

plate capacity to 175,000 tons a year. Reynolds Aluminum Company of Canada Ltd., another Reynolds subsidiary, is progressing with a $5,000,000 expansion of its Cap-de-la-Madeleine, Quebec, sheet and foil mill which will be completed in 1975.

After an interval of several years, Canadian primary smelting capacity will be increased. Aluminum Company of America (Alcoa) is planning to build a smelter in the Valleyfield area of Quebec. Its capacity is expected to be about 60,000 tons a year and to cost about $60,000,000.

Tentatively, production is to begin in 1976. Alcan has started construction of a $17,000,000 expansion of its Arvida smelter to add some 38,000-ton-a-year-capacity by stages in 1974 and 1975.

Canadian exports of aluminum, mainly in the form of ingot but also including some further fabricated materials, should be about the same in 1973 as in 1972, when 810,201 tons were exported. Their value was $382,384,000, but the value of 1973 exports should be somewhat higher because of rising prices. Exports to the United States and Britain were expected to be lower in 1973, but were counterbalanced by sales to other countries, such as Japan, where currency revaluation favours Canada. An important detriment to Canadian trade was averted when the United States Tariff Commission ruled that aluminum ingot imported from Canada had not injured United States producers. A positive finding would have resulted in extensive antidumping duties being assessed, to the disadvantage of Canadian producers.

World review

Australia surpassed Jamaica as the largest producer of bauxite in 1972 and it retained this position in 1973, and should for the foreseeable future. World bauxite production was about 69 million tons in 1973, up from 62 million tons the previous year. In 1973, the world inventory of bauxite was further reduced, but bauxite and alumina were not in short supply as was aluminum metal. Kaiser Aluminum & Chemical Corporation, Revere Copper and Brass, Inc. and New Zealand Aluminium Smelter Ltd. were exposed to labour strikes affecting their raw materials supply and were able to arrange alternative sources without undue difficulty.

Raw material producing facilities were expanded. Bauxite mining from the Boke deposit in Guinea, mentioned previously, was started. Output in 1973 was about 950,000 tons scheduled to increase to 5,600,000 tons next year, and 9,000,000 tons in 1979. Queensland Alumina Limited in Gladstone, Australia, which operates the world's largest alumina refinery, completed its expansion from 1,400,000 to 2,000,000 tons a year. In West Germany, the 660,000-ton-a-year alumina plant of Oxid Stade GmbH began production. Bharat Aluminium Company began production at its 200,000-ton-a-year alumina refinery at Korba, India.

Future developments include the proposed Trombetas bauxite deposit in Brazil to be mined at the rate of 1,000,000 tons a year in 1977, increasing to 3,300,000 tons, thereafter. The operators, ten companies in all, include three Brazilian companies and Alcan. Increased production is not being overlooked in the established producing countries, Jamaica and Australia. Reynolds Jamaica Mines Ltd. is boosting its annual bauxite capacity from 2,500,000 to 3,250,000 tpy. Alcoa Minerals of Jamaica Inc. is raising capacity of its alumina plant by 110,000 tpy to 550,000 tons, with further possible expansion to 880,000 tons. Expansion of the Alcoa of Australia Ltd. Pinjarra alumina refinery, from 700,000 to 1,000,000 tons a year will be completed in 1975. It is considering a further increase of 300,000 tons a year for 1976. In the Virgin Islands, Martin Marietta Aluminum Inc. continued enlarging its alumina plant. Its capacity will be raised by 100,000 tons to 450,000 tons a year in 1974 and to 1,000,000 tons in 1976. A state-owned Yugoslavian refinery at Zvornik will come on stream in 1976, commencing at 660,000 tons of alumina a year with later expansion to 1,600,000 tons. Further in the future are plans for an 880,000-ton-a-year alumina refinery in Spain and one of 600,000 tons in Ireland. However, some raw material projects received setbacks.

Australian expansion was affected by the upward revaluation of their currency as well as government restrictions on foreign borrowings. Thus, there have been delays to plans in Western Australia for a Pacminex Pty. Ltd. alumina refinery of 880,000 tons at Muchea, and an Alwest Pty. 350,000-ton-a-year plant at Worsley. Comalco Limited has cancelled its plans for a huge 4,800,000-ton-a-year capacity alumina refinery at Weipa, Queensland. The Vanua Levu bauxite mine in Fiji was closed down because of rampant inflation. The mine was to ship 275,000-tons a year to its Japanese owners.

After producing at under capacity to balance supply and demand in 1972, producers rapidly increased their output of aluminum metal in 1973, attempting to keep pace with rising markets. In the second half of the year a shortage developed despite all available capacity being utilized. Noncommunist production of aluminum in 1973 was an estimated 11,100,000 tons, 9 per cent more than 1972 output of 10,157,000 tons. Yugoslavia has been included with the noncommunist countries throughout this review because of its extensive trading with the noncommunist world.

Some factors combined to accentuate the supply shortage. The northwestern region of United States, which depends upon hydro power for much of its electrical output, experienced low precipitation. Electric power generation was reduced in the spring of 1973, and aluminum producers were forced to curtail operations. The result was a loss of about 250,000 tons of output during the year. Labour disputes at Alcan's Quebec smelters caused a loss of some 50,000 tons of ingot production, and a 53-day strike at Pechiney Ugine Kuhlmann Development Inc.'s Noguerres, France, smelter caused a loss of about 44,000 tons.

The aluminum supply shortage in the United States would have been extremely acute in 1973 if the United States government had not provided for accelerated disposal of ingot from its General Services Administration stockpile. From about 1,263,000 tons of ingot in the stockpile at the start of 1973, almost all but 450,000 tons was sold during the year. Another 207,440 tons was authorized for sale at the year-end. Japanese aluminum production was the first to be affected by oil export reductions by Arab countries. Commencing in December, a 10 per cent cutback of electric power to the Japanese aluminum industry is expected to result in a 12-13 per cent reduction in output.

Aluminum producers raised their output to about 95 per cent of rated capacity at the end of 1973. Aside from loss of production due to power shortages and labour disruptions, one might question why producers are not operating at higher capacity in the light of a supply shortage. During 1971 and 1972, many producers operated well below capacity and let their plant run down to some extent. Now these producers must replace some obsolete equipment, particularly to satisfy increasingly stringent pollution controls.

New primary ingot capacity which came on stream in 1973 is estimated to be 548,000 tons a year, to raise installed aluminum capacity to about 12,700,000 tons at the end of the year in the noncommunist world. The largest addition to capacity was the new 120,000-ton-a-year smelter of Anaconda Aluminum Company in Sebree, Kentucky. Japan continued to enlarge its aluminum output, starting up production in

Table 3. Canada, consumption of aluminum at first processing stage

	1970	1971	1972	1973p
	(short tons)			
Castings				
Sand	1,596	1,486	1,468	. .
Permanent-mould	11,574	15,468	13,351	. .
Die	19,546	23,573r	28,120	. .
Other	73	117	182	. .
Total	32,789	40,644r	43,121	. .
Wrought products				
Extrusions including tubing	64,145	79,179	87,588	. .
Sheet, plate, coil and foil	80,598	92,941	104,400	. .
Other wrought products (incl. rod forgings and slugs)	87,923	98,680	87,630	. .
Total	232,666	270,800	279,618	. .
Destructive uses				
Non-aluminum-base alloys, powder and paste deoxidizers and other	10,288	10,637r	10,811	. .
Total consumed	275,743	322,081r	333,550	. .
Secondary aluminum[1]	30,035	33,007r	35,209	. .

Receipts and Inventories at Plants	Metal Entering Plant		On Hand December 31	
	1972	1973	1972	1973
Primary aluminum ingot and alloys	284,899	. .	66,004	. .
Secondary aluminum	33,922	. .	2,139	. .
Scrap originating outside plant	47,806	. .	6,781	. .
Total	366,627	. .	74,924	. .

Source: Statistics Canada.
[1] Aluminum metal used in the production of secondary aluminum.
p Preliminary; r Revised; . . Not available.

some previously delayed projects. The Lynemouth smelter of Alcan (U.K.) Limited approached its full productive capacity of 132,000 tons a year after lengthy delays in starting up its power source. Electric power limitations have adversely affected other smelting projects in India, Yugoslavia, and Turkey, retarding the start up of completed production facilities. Six new smelters began operation in 1973, however many of these smelters started up late in the year at much below their rated capacity.

In future, the largest aluminum smelter expansion may occur in Brazil, where a plant of up to 660,000 tons a year may be built by the state-owned Cia Vale do Rio Doce and five Japanese companies in the Trombetas River region, although planning is still in the early stages.

Venezuela also may have its present capacity greatly expanded, with feasibility studies underway for up to 325,000 tons of additional smelting facilities. Norway is considering adding to its large smelting capacity, an additional 320,000 tons being planned by 1981. Spain anticipates a 260,000-ton expansion of its smelting industry being completed by 1982 by a state-owned company with Pechiney and Alcan interests also taking part. Japan has forecasted a vast expansion of 800,000 tons a year but these plans may be considerably reduced by a shortage of electric power and pollution control regulations.

Future Unites States capacity additions are not extensive. Amax Aluminum Corporation Inc. will enlarge the Eastalco smelter at Frederick, Maryland, by 86,700 tons a year by 1975, but its plans for a Warrenton, Oregon smelter are still in doubt. Alcoa will add 55,000 tons a year to the capacity of its Massena, New York smelter. Two long-planned projects, Asahan in Indonesia, and Alcoa's in Megara, Greece have been delayed, electric power supply being a major drawback.

Increased demand for primary aluminum was widespread in noncommunist countries and consumption is estimated to be 12,300,000 tons in 1973, a 19% gain over the previous year. Prominent in this extensive increase were the U.S. with a 20% rise and Japan with 26%. One might note that in the accompanying table, consumption in noncummunist countries is estimated to be 1,200,000 tons more than production in 1973. This production deficit was made up from a draw-down of government stockpiles and producer inventories, and imports from communist countries.

There are two new fields which are promising for increased consumption of aluminum. One is housings for the Wankel rotary engine, the other is cryogenic tanks for holding liquified natural gas, both in ships and on shore.

Technology

Early in 1972 Alcoa unveiled its new smelting process, in which aluminum is combined with chlorine to form aluminum chloride which, in turn, is separated into molten aluminum and chlorine at relatively low temperatures. Advantages claimed are 30 per cent less power consumption than for the conventional smelting process, less risk of metal freezing in furnaces if power is interrupted, and no harmful emissions to pollute the atmosphere. Alcoa is constructing a 30,000-ton-a-year pilot plant in Palestine, Texas, which may be expanded to a 300,000-ton-a-year smelter if the process proves commercial. Another new process, discovered by Charles Toth, may result in production of aluminum at half the cost of conventional Bayer alumina and Hall-Heroult smelting processes. His method utilizes aluminum-bearing ore, instead of alumina, which is combined with chlorine gas to form liquid aluminum chloride. The aluminum chloride is passed through crushed manganese metal to form manganese chloride and pure aluminum. A pilot plant is to be built in Europe, but financing problems may delay start up.

In the raw materials field, construction has started on a pilot plant to test a clay known as alunite, as an alternative to bauxite, in the production of alumina. The plant is located at Golden, Colorado and is a joint venture of Earth Sciences Incorporated, National Steel Corporation and Southwire Aluminum Company. The group is negotiating with the Soviet Union which already produces alumina from non-bauxite ores, to incorporate some Soviet processes into its own technology.

Uses

Characteristics such as lightness combined with strength, pleasing appearance, corrosion resistance, conductivity and heat reflectivity provide many advantages favouring the use of aluminum. It may be cast,

Table 4. World primary aluminum production and consumption, 1972 and 1973

	Production		Consumption	
	1972	1973	1972	1973[e]
	(thousand short tons)			
United States	4,122	4,530	4,736	5,596
Europe[1]	2,756	3,135	3,066	3,433
Japan	1,113	1,216	1,315	1,676
Canada	1,012	1,038	268	261
Australia and New Zealand	324	357	140	172
Asia (excluding Japan and China)	346	383	384	410
Africa	256	274	109	113
America (excluding United States and Canada)	234	233	311	325
Sub-total	10,163	11,166	10,329	11,986
Communist countries[2]	2,523	2,601	2,383	2,382
Total	12,686	13,767	12,712	14,368

Source: World Bureau of Metal Statistics.
[1]Includes Yugoslavia. [2]Excludes Yugoslavia.
[e]Estimated.

Table 5. Canadian primary aluminum smelter capacity, 1973

Smelter location	Annual capacity
	(short tons)
Aluminum Company of Canada, Limited	
Quebec	
Arvida	458,500
Isle-Maligne	130,000
Shawinigan	95,000
Beauharnois	51,500
British Columbia	
Kitimat	300,000
Total Alcan capacity	1,035,000
Canadian Reynolds Metals Company, Limited	
Quebec	
Baie-Comeau	175,000
Total Canadian capacity	1,210,000

Table 6. Estimated world production of bauxite in 1973

	Production (millions of short tons)
Australia	15.8
Jamaica	13.9
Surinam	6.9
Guyana	3.6
France	3.1
Republic of Guinea	3.0
Greece	2.6
United States	1.8
Other noncommunist countries[1]	10.5
Total noncommunist countries	61.2
Communist countries	8.3
World total	69.5

Source: United States Bureau of Mines Commodity Data Summaries, January 1974.
[1] Production of Yugoslavia included.

rolled, extruded and forged with ease compared with many of its competitive materials. In the United States, by far the world's largest market, the construction field continued to be the largest consumer in 1972, accounting for 27 per cent of shipments, according to the Aluminum Association. Transportation, another major user, was in second place with 18 per cent, followed by containers and packaging 15 per cent, electrical uses 13 per cent, consumer durables 9 per cent, and machinery and equipment 6 per cent. It might be noted that in many of the other main consuming countries transportation ranks first.

In the construction field in 1972, new housing remained buoyant in the United States, but the level of nonresidential building did not keep pace. It is doubtful if the rapid increase in residential construction can be maintained in 1973, although the market for mobile homes is accelerating significantly in contrast to an expected fall-off in conventional housing. The importance of housing construction to the aluminum industry is obvious when one considers that the average new conventional or mobile home in the United States contains about 1,000 pounds of aluminum. Transportation reflects very high manufacturing activity in trailers, semitrailers, trucks and buses. The increasing use of aluminum cans for beer and soft drinks continues to be a major growth factor, aided by public acceptance of the efforts of aluminum manufacturers, brewers, and soft-drink bottlers to recycle the used cans.

There are two fields which have prospects of greatly increased consumption of aluminum. One is automotive, where the average use of aluminum in a standard size 1973 model car manufactured in North America rose to a record 76 pounds. The need to reduce vehicle weight because of the addition of increased safety and pollution control devices is apparent. Housings for the much-heralded Wankel rotary engine should contain considerable quantities of aluminum if this engine is mass-produced. With the advent of better joining techniques, aluminum radiators are a distinct possibility. The other major field is cryogenic tanks for holding liquified natural gas (LNG). There are extensive plans to ship this form of energy from overseas natural gas producers to areas experiencing an energy shortage, such as the United States, Europe and Japan. Aluminum is expected to be used in both the ships transporting LNG and for onshore storage vessels.

Prices

Published prices for 99.5 per cent primary aluminum ingot in the United States were 25¢ a pound in 1973 until December, when the Cost of Living Council permitted a rise to 29¢. Canadian prices are not published but follow United States prices fairly closely. World market prices fluctuated much more, being as low as 20 1/2 – 21¢ a pound in January, rising to 36 – 38¢ in the latter part of the year in Europe and Japan. However, many producers were selling at prices well under 25¢ a pound under long-term contracts which lasted throughout most of 1973. To attract any substantial investment in new smelting facilities in North America, aluminum prices must rise above 30¢ a pound.

Outlook

The rapid rise in world aluminum consumption in 1973 will not be sustained and a lesser increase of about 4 per cent is forecast for 1974. The long-term growth pattern of 7 or 8 per cent a year should continue over the next five years. On the other hand, a prolonged reduction of oil shipments by the Arab producing nations would make such forecasts meaningless. Obviously, a chronic oil shortage would have dire effects on the automobile and aircraft industries, whereas a resultant economic recession would severely restrict home construction, all being major users of aluminum.

Although only a modest increase in demand is anticipated in 1974, the current supply shortage should continue over the short-term as limited new smelter facilities are coming on stream. This shortage will be accentuated if 1974 labour negotiations in the United States result in work stoppages. Overseas prices are expected to stabilize but those in the United States would certainly move higher when price controls are removed. Although recent rains have aided hydroelectric power generation in the northwestern United States, power consumption for uses other than aluminum production is growing rapidly in the area and power shortages may be extended. It is unlikely that smelter overexpansion will take place to the same extent as in the early years of this decade because of more expensive energy and increasing pollution controls. As for the impact of a petroleum shortage, most smelters, with Japanese producers a notable exception, are not particularly dependent on this commodity for their operations, although bunker oil for ocean shipping of raw materials would be affected. It is possible that an oil-induced recession would reduce consumption of aluminum much more than production with a reversal of the present undersupply situation taking place.

Canada still has unused hydro-power resources from which electricity could be transmitted to smelters constructed near ocean shipping points. This electric power potential should attract more aluminum smelters over the long-term.

Tariffs

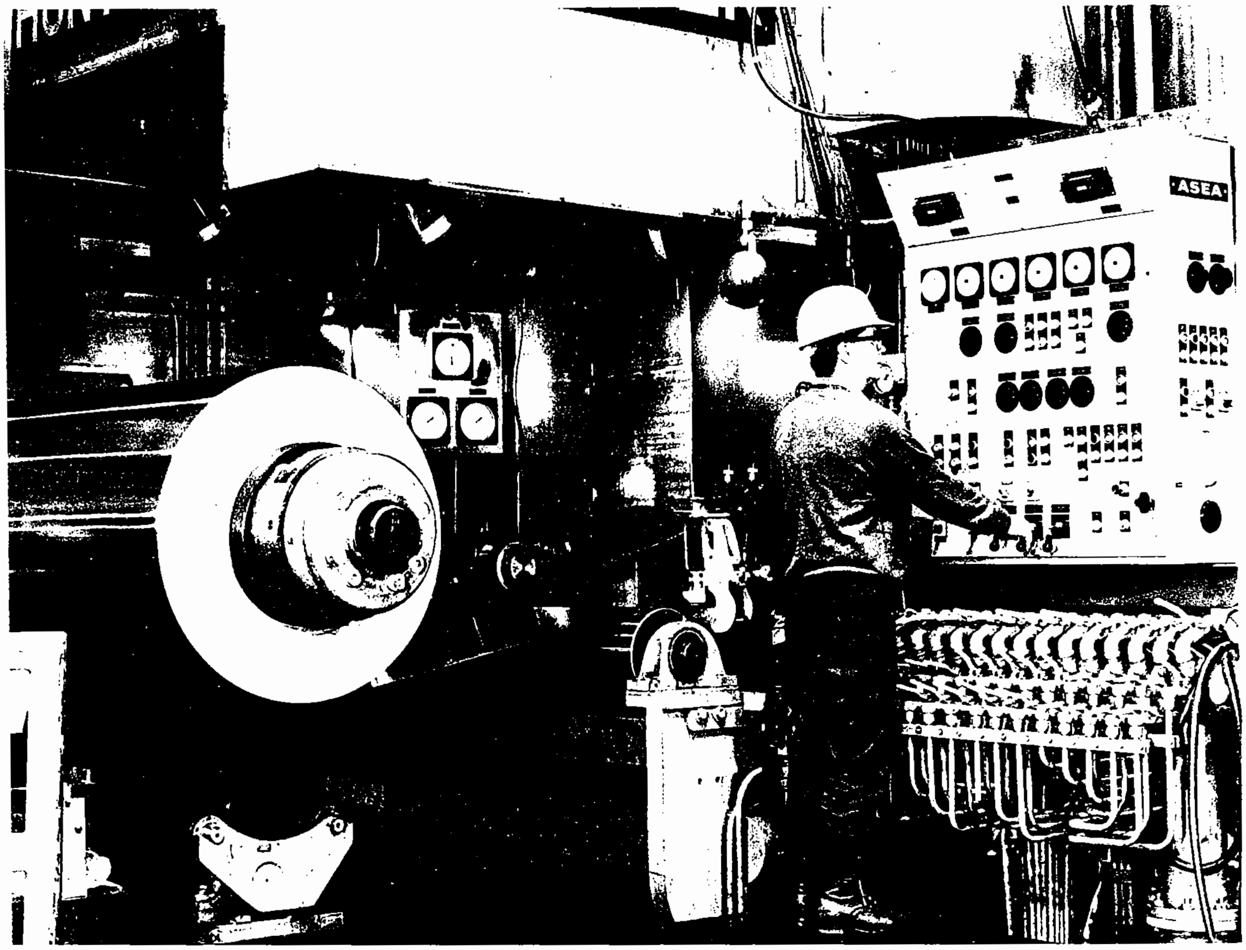
Canada

Item No.		British Preferential	Most Favoured Nation	General
32910-1	Bauxite	free	free	free
92820-1	Aluminum oxide and hydroxide; artificial corundum (this tariff includes alumina)	free	free	free
			(¢)	(¢)
35301-1	Aluminum, pigs, ingots, blocks, notch bars, slabs, billets, blooms, and wire bars, per lb	free	1	5
35302-1	Aluminum bars, rods, plates, sheets, strips, circles, squares, discs and rectangles, per lb	free	2	7.5
			(%)	(%)
35303-1	Aluminum channels, beams, ties and other rolled, drawn or extruded sections and shapes	free	12½	30
35305-1	Aluminum pipes and tubes	free	12½	30
	Various tariffs are in effect on more advanced forms of aluminum			

United States

Item No.		On and After January 1 1971	1972
601.06	Bauxite	10¢ per lt*	free
		(¢ per lb)	
417.12	Aluminum compounds: hydroxide and oxide (alumina)	0.15*	free
618.01	Unwrought aluminum, in coils, uniform cross section not greater than 0.375 inch	1.5	1.2
618.02	Unwrought aluminum, other, excluding alloys	1	1
618.04 618.06	Unwrought aluminum alloys, aluminum silicon and other aluminum alloys	1	1
618.10	Aluminum scrap (duty on scrap suspended until 30 June 1972)	0.9	0.7
	Various tariffs are in effect on more advanced fabricated forms of aluminum		

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1972) TC Publication 452.
*Declared free as of July 16, 1971 by Public Law 92-151.



An operator at the controls of a 58-in. cold-rolled aluminum sheet mill in the new Bracebridge, Ontario, plant of Canada Foils, a subsidiary of the Aluminum Company of Canada Limited. (Alcan photo).

Antimony

M. GAUVIN

Canada's production of antimony is derived as a by-product of lead smelting operations, principally in the form of antimonial lead but also as antimonial dross and, in much smaller quantities, as high-purity antimony metal. The value of the antimony content of primary antimonial lead produced in 1973 was, $1,912,000 compared with $419,042 in 1972. The value of antimony contained in ores and concentrates produced in 1973 was $3,375,000 compared with $824,500 in 1972. The quantities of antimonial lead alloy and antimony contained in ores and concentrates are withheld to protect the confidentiality of the producers.

Canadian requirements of antimony metal, antimony oxide and antimony salts are imported. Regulus (metal) import statistics were discontinued in 1964, but in earlier years the main suppliers were the People's Republic of China and Yugoslavia which mine and refine antimony ores, and western European countries which import antimony ores and concentrates and export refined metal and salts. Imports of antimony oxide in 1973 totalled 1,437,400 pounds of which 78.1 per cent came from Britain and 21.9 per cent from the United States.

Cominco Ltd., which operates a lead smelter and refinery at Trail, British Columbia, is the main producer of primary antimonial lead in Canada. Its antimonial lead has a variable antimony content up to 23 per cent, depending on the customers' requirements. The only other primary producer of antimonial lead is Brunswick Mining and Smelting Corporation Limited, Smelting Division, which operates a lead smelter at Belledune, New Brunswick. Secondary smelters recovered antimonial lead from scrap metal but no recent information is available concerning this production. In 1969 these smelters reclaimed 30,685 short tons* of antimonial lead from scrap compared with 26,815 tons in 1968.

In 1972, 81,200 tons of lead scrap in all forms was handled by secondary smelters. It is estimated that close to 60 per cent of this scrap was in the form of antimonial lead.

*All tons are short tons of 2,000 pounds avoirdupois unless otherwise stated.

Domestic sources and occurrences

Most of the antimonial lead produced at Trail is a by-product of the lead concentrate obtained from ores of Cominco's Sullivan mine at Kimberley, British Columbia. Other sources are the lead-silver ores and concentrates shipped to Trail from other Cominco mines and from custom shippers. The lead bullion produced from the smelting of these ores and concentrates contains about 1 per cent antimony, which is recovered in anode residues from the electolytic refining of the lead bullion and in furnace drosses produced during purification of the cathode lead. These residues and drosses are treated to yield antimonial-lead alloy to which refined lead may be added to produce marketable products of the required grade. At Belledune, the Brunswick Mining and Smelting plant recovers antimony as an antimonial dross which is then purified and used to produce antimonial lead alloys of whatever grade the market demands.

Consolidated Durham Mines & Resources Limited is Canada's only antimony mine. It mines low-angle-dipping veins containing stibnite (Sb_2S_3) at its Lake George property near Fredericton, New Brunswick. The mine has four levels, with the bottom level 450 feet below surface. The mill, with an operating rate at the end of 1973 of between 150 and 200 tons a day, produces concentrates averaging over 65 per cent antimony, which are shipped to smelters outside of Canada.

World review

World mine production of antimony in 1973, as estimated by the United States Bureau of Mines, totalled 78,650 tons, 3,850 tons more than in 1972.

Antimony is produced from ores and as a smelter byproduct in about 25 countries. The major sources of ore are the Republic of South Africa, the People's Republic of China, Bolivia, U.S.S.R., Mexico, Turkey and Yugoslavia. Prior to 1935, China, which reputedly has over 50 per cent of the world's reserves, produced two thirds of the annual world output of antimony, but during the Chinese-Japanese War the centre of production shifted to the Americas. The United States, Mexico and Bolivia were the leading world suppliers of antimony during and immediately after The Second World War. In the years following the Korean War, the Republic of South Africa, the People's Republic of China and Bolivia became the dominant suppliers of antimony.

Table 1. Canada, antimony production, imports and consumption, 1972-73

	1972		1973^p	
	(pounds)	($)	(pounds)	($)
Production				
Antimonial lead alloy	..	419,042	..	1,912,000
Antimony in ores and concentrates	..	824,500	..	3,375,000
Total	..	1,243,542	..	5,287,000
Imports				
Antimony oxide				
Britain	777,300	451,000	1,122,400	728,000
United States	98,100	62,000	315,000	273,000
People's Republic of China	154,500	73,000	-	-
Total	1,029,900	586,000	1,437,400	1,001,000
Consumption				
Antimony regulus (metal) in production of:				
Antimonial lead alloys	1,377,353		593,087	
Babbitt	235,282		144,173	
Solder	116,952		32,106	
Type metal	132,676		35,138	
Other commodities[1]	164,037		175,062	
Total	2,026,300		979,566	

Source: Statistics Canada; Company reports.
[1] Includes foil, bronze, lead-base alloys, drop shot and other minor commodities.
^{p} Preliminary; – Nil; .. Not available.

Table 2. Antimony, Canadian production, imports and consumption, 1964-73

	Production[1] all forms	Imports regulus	Consumption[2] regulus
		(pounds)	
1964	1,591,523	..	558,091
1965	1,301,787	..	659,637
1966	1,405,681	..	1,098,162
1967	1,267,686	..	1,190,179
1968	1,159,960	..	1,169,631
1969	820,122	..	1,305,742
1970	726,474	..	1,142,009
1971	323,525	..	1,461,763
1972	..	..	2,026,300
1973^p	..	..	979,566

Source: Statistics Canada.
[1] Antimony content of antimonial lead alloy.
[2] Consumption of antimony regulus (metal), as reported by consumers. Does not include antimony in antimonial lead produced by Cominco Ltd.
^{p} Preliminary; .. Not available.

In South Africa, Consolidated Murchison Limited operates the world's largest antimony mine in the vicinity of Gravelotte in northeast Transvaal. It has a mining and milling plant with a capacity of 660,000 tons a year of stibnite ore averaging 3 per cent antimony. The company, in partnership with Chemetron Corporation, started construction of an antimony oxide plant which, when completed in 1974, will have an annual capacity of 7.2 million pounds of crude oxide.

With Czechoslovakian backing, Bolivia is building a new antimony smelter scheduled for completion in 1975 and will emerge as a fully-integrated mine to smelter antimony producer. The smelter, located near Oruro, will have an annual capacity of 5,500 tons of metallic antimony and 1,100 tons of antimony alloys. The Empressa National de Fundiciones, Bolivia's national smelting company, is planning a second antimony smelter to be located in southern Bolivia.

NL Industries, Inc. operates the world's largest antimony smelter for ores and concentrates at Laredo, Texas, where it produces antimony metal and oxide, mainly from imported Mexican, South African and

Table 3. Canadian consumption of antimonial lead alloy[1], 1971-73

	1971	1972	1973
		(pounds)	
Batteries	1,791,469	1,886,320	1,912,526
Type metal	238,000	222,000	201,182
Babbitt	131,781	56,767	1,913
Solder	6,103	223	6,518
Other uses	7,732	3,515	1,000
Total	2,175,085	2,168,825	2,123,139

Source: Statistics Canada.
[1]Antimony content of primary and secondary antimonial lead alloy.

Table 4. Canadian consumption of antimonial lead alloy[1], 1964-73

	(pounds)		(pounds)
1964	2,506,454	1969	2,321,770
1965	2,775,241	1970	1,400,402
1966	2,593,733	1971	2,175,085
1967	2,496,032	1972	2,168,825
1968	2,124,903	1973	2,123,139

Source: Statistics Canada.
[1]Antimony content of primary and secondary antimonial lead alloys.

Table 5. World mine production of antimony, 1971-73

	1971	1972	1973[e]
		(short tons)	
Republic of South Africa	15,704	16,062	18,000
Bolivia	12,861	14,472	15,000
People's Republic of China[e]	13,000	13,000	*
U.S.S.R.[e]	7,600	7,700	*
Thailand	2,529	5,234	*
Mexico	3,705	4,700	4,800
Yugoslavia	3,204	3,171	3,400
Turkey	2,435	2,500	*
Australia	1,061	1,467	*
Italy	1,295	1,300	*
Morocco	2,174	929	*
Czechoslovakia	660	660	*
United States	1,025	489	650
Canada	162	. .	. .
Other countries	3,476	3,116	36,800
Total	70,891	74,800	78,650

Sources: For Canada, Statistics Canada. For other countries, U.S. Bureau of Mines *Minerals Yearbook* Preprint 1972; Commodity Data Summaries, January 1974 for 1973.
*Included in "Other countries".
[e]Estimated; . . Not available.

Bolivian ores and concentrates. The United States' mine production of antimony in 1973 was 33 per cent above that of 1972 with the resumption of production at the major producer of antimony, the Sunshine mine of Sunshine Mining Company, whose production was interrupted by a major fire in 1972. Recovery of antimony in antimonial lead scrap is a major source of supply. This secondary supply represents a substantial portion, up to 60 per cent, of total antimony supply in the United States and other highly industrialized countries.

The antimony industry responded to the favourable economic conditions in 1973 with higher production and consumption. Antimony prices rose sharply during the year. The antimony market is very sensitive to changes in supply and demand, and the periodic absence of Chinese offerings of metal contributes to the upward push on prices. The price increases during the year encouraged mine development and the expansion of production facilities.

The United States was again the noncommunist world's largest consumer of antimony and continued to depend on foreign suppliers for much of its requirements. Its consumer requirements in 1973 were about 21 per cent of the world primary supply.

The General Services Administration (G.S.A.) of the United States government sold 5,947 tons of antimony during 1973 from the government stockpile. This reduced the stockpile to 40,700 tons at the end of 1973, exhausting that portion of the stockpile which Congress had given G.S.A. authority to sell.

Uses

Antimony is used principally as an ingredient in many alloys and in the form of oxides and sulphides.

Antimony hardens and strengthens lead and inhibits chemical corrosion. The use of antimonial lead in storage batteries remains its major outlet, but the antimony content in such batteries has been progressively reduced in recent years, dur to technological developments, from about 12 per cent to current levels which vary from 3 to 6 per cent of the antimonial lead contained. Antimonial lead alloys are also used for power transmission and communications equipment, printing metal, solder, ammunition, chemical pumps and pipes, tank linings, roofing sheets and antifriction bearings.

Antimony oxide, Sb_2O_3, usually produced directly from high-grade sulphide ore, is used extensively in plastics and in flameproofing compounds.

Antimony trioxide or trichloride in an organic solvent has long been recognized as having significant flame-retardant properties and is now used extensively in carpets, rugs and carpet underlay. The trioxide is also a glass former, and is sought for its ability to impart hardness and acid resistance to enamel coverings for bathtubs, sinks, toilet bowls and refrigerators. The pentasulphide, Sb_2S_5, is used as a vulcanizing agent by the rubber industry. Burning antimony sulphide creates a dense white smoke that is used in visual control, in sea markers and in visual signaling.

Antimony is valuable for paint formulation since its high hiding power and various chemical compounds produce a wide range of pigments. High-purity metal is used by manufacturers of indium-antimony and aluminum-antimony intermetallic compounds as a semiconductor in transistors and rectifiers.

Outlook

The major use of antimony is expected to continue to be as antimonial lead for storage batteries. Battery usage continues its steady growth in Europe, North America and Japan and there has been rapid growth in countries such as Spain and Brazil where automobile populations are rising fast. As less developed countries become more industrialized and advance economically we can expect a rapid increase in their demand for batteries. The advent of a popular and economical battery-powered electric vehicle could sharply increase the consumption of antimony. Attractive battery-powered cars and buses that have been test driven in the United States average from 35 to 55 miles per charge depending on the type of driving done. The United States Postal Service has ordered 350 electric-powered delivery trucks with a 500-pound payload. In Europe the use of electric road vehicles is spreading and it is estimated that they are economically competitive with gasoline powered delivery vans.

Antimony has been replaced by calcium in the manufacture of sealed maintenance-free batteries.

The use of antimony oxide as a flame retardant, especially for plastics, is expected to grow and should more than offset any decline in some of the metal's historic uses or its substitution by other metals. In the United States, regulations for flammability standards for childrens' sleepwear came into force in July 1973. New flammability standards for motor vehicle interiors apply to the 1974 models of cars, trucks, buses and passenger carriers, all of which bodes well for antimony usage in flame retardants. Substitutes for antimony oxide are available, but they are not as effective.

The outlook for antimony appears favourable, with a steady demand expected during the next few years. Antimony prices have been subject to wide fluctuations over the years dependent on general economic conditions and are expected to continue to fluctuate for this reason.

Prices

Prices of all antimony products rose during 1973. The United States domestic price of antimony as quoted in Metals Week, in bulk, 99.5 per cent, fob Laredo, Texas was 57 cents a pound at the beginning of the year. It was increased to 60 cents on February 16 and to 66 cents on April 20. This price was maintained un-

Table 6. Industrial consumption of primary antimony in the United States, by class of material produced

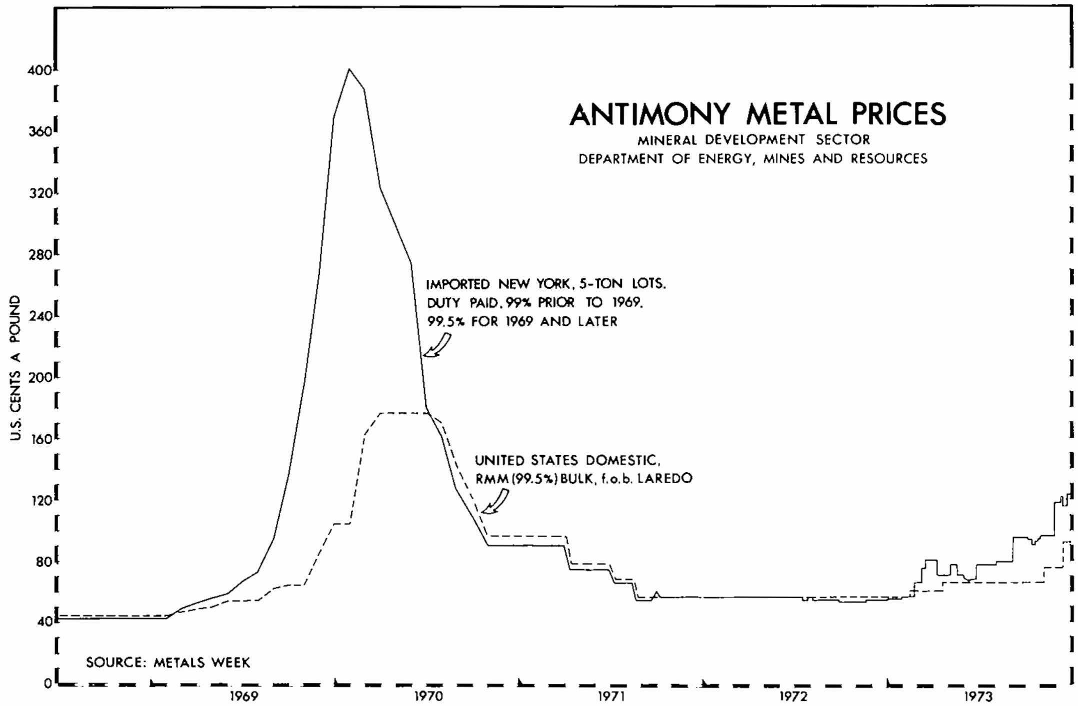
Product	1971	1972	1973^p	Product	1971	1972	1973
	(short tons, antimony content)				(short tons, antimony content)		
Metal Products							
Ammunition	67	64	*	**Nonmetal Products**			
Antimonial lead	5,430	6,149	5,016	Ammunition primers	23	23	15
Bearing metal and bearings	515	559	463	Fireworks	4	4	–
Cable covering	36	19	13	Flameproofing chemicals and compounds	1,524	2,280	2,083
Castings	20	39	6	Ceramics and glass	1,840	1,695	1,830
Collapsible tubes and foil	22	20	12	Matches	–	–	–
Sheet and pipe	74	108	96	Pigments	592	644	356
Solder	178	177	134	Plastics	1,810	2,391	973
Type metal	177	142	87	Rubber products	525	587	440
Other	102	105	176	Other	768	1,118	2,065
				Total	7,086	8,742	7,762
Total	6,621	7,382	6,003	Grand total	13,707	16,124	13,765

Sources: United States Bureau of Mines, *Minerals Yearbook* Preprint 1972, and Mineral Industry Surveys.
*Included in "Other".
^{p}Preliminary; – Nil.

til November 9 when it was increased to 70 cents. On December 14 the price rose to 92 cents a pound and this price was still in effect at the end of the year.

The United States price of imported antimony metal, as quoted in Metals Week, in 5-ton lots, 99.5-99.6 per cent, fob New York, duty paid was 55 cents a pound from January 1 to January 26 when it was raised to 57 cents. It then rose steadily during the year and, at the end of December, was quoted by dealers at \$1.10-\$1.35 a pound.

Similarly, antimony lump-ore prices, based on a 60 per cent antimony content as quoted in Metals Week, were \$7.60-\$8.60 per short-ton unit at the beginning of the year and rose steadily to \$17.65-\$18.05 by year-end.



Tariffs

Canada Item No.		Most Favoured Nation	United States Item No.		Most Favoured Nation
33000-1	Antimony, or regulus of, not ground, pulverized or otherwise manufactured	free	601.03	Antimony ore	free
			632.02	Antimony metal unwrought on and after Jan. 1, 1972	1¢ per lb.
33502-1	Antimony oxides	12½%			

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States annotated (1972), T.C. Publication 452.

Asbestos

G.O. VAGT

Canadian production (shipments) of asbestos fibre was 1,862,963 tons valued at $229.4 million in 1973 compared with 1,687,051 tons valued at $206.1 million in 1972. All of the Canadian production consisted of chrysotile. Approximately 80 per cent of total production came from Quebec, over 6 per cent from British Columbia, a similar percentage from the Yukon, 5 per cent from Newfoundland and about 2 per cent from Ontario.

Exports of fibre represented approximately 95 per cent of production. The United States continued as our major market, consuming approximately 41 per cent of total asbestos fibre exports.

Fibre shipments to nearly all countries increased; United States and some European Economic Community markets exhibited the largest increase. The value of exports of manufactured asbestos products remained essentially the same at $5.3 million while the value of imports of manufactured asbestos products increased 11 per cent to $16.5 million.

Canadian developments

The major developments at the producing mines are summarized in Table 2.

In Ungava, Quebec, production of partially milled fibre at the Putuniq (Asbestos Hill) mine, owned by Asbestos Corporation Limited, was at about 60 per cent of capacity. Full productive capacity of 300,000 tons of concentrate a year is anticipated by 1974 or 1975. The final milling process, which is carried out in West Germany, will result in production of 100,000 tons of fibre a year at full capacity. The fibre is mainly in groups 4 and 5.

Canadian Johns-Manville Company, Limited (CJM) completed a plant expansion and relocation program as part of a $75 million project at the Jeffrey mine and mill. An annual output of at least 600,000 tons of fibre is expected to be maintained.

In Carpentier township, 12 miles northeast of Barraute, Quebec, CJM commenced with clearing for an open-pit and primary milling operation to process ore from the Bolduc deposit containing 1.2 million tons of ore. A two- to three-year life is expected for the operation. Final milling will be done in the Eastern Townships to produce a total of about 60,000 tons of fibre.

In Ontario, total production by Hedman Mines Limited and Johns-Manville Mining and Trading Limited's Reeves mine remained approximately the same as in 1972. The name of the Johns-Manville operation was changed to Canadian Johns-Manville Company, Limited and is now a part of the Canadian rather than part of the parent American corporate structure of Johns-Manville Corporation. The Reeves mill was shut down in December to permit a redesign and overhaul of the crushing plant. Waste removal at the open pit will continue and will provide for deeper pit mining. Ore mining and milling is scheduled to commence at a future date.

Advocate Mines Limited, Newfoundland's only asbestos producer, increased fibre shipments substantially above the 1972 level.

Cassiar Asbestos Corporation Limited, Cassiar, B.C. shipped a record 108,981 tons. Mill expansion and general modernization, estimated to cost approximately $9 million, will continue in 1974 and 1975.

In the Yukon Territory, over 100,000 tons of fibre was shipped from Cassiar's Clinton Creek mine. Diamond drilling and ore reclassification resulted in a moderate net increase in probable ore reserves. Reserves in the possible category are to be further evaluated.

Prospective producers

United Asbestos Inc. (resulting from the merger of United Asbestos Corporation Limited and Allied Mining Corporation) proposed to bring into production its asbestos property located 17 miles southwest of Matachewan, Ontario. Drilling has indicated 31 million tons of ore averaging 9 per cent fibre content distributed in grades 5, 6 and 7. Production objectives are 100,000 tons of fibre a year from the open-pit mine through a 4,000-tons-a-day mill. Start-up is scheduled for mid-1975, and the estimated cost of the project is now $26 million.

At the Abitibi Asbestos Mining Company Limited property, 52 miles north of Amos, Quebec, underground bulk sampling and pilot plant studies proceeded under management and financing by Brinco

Table 1. Canada, asbestos production and trade, 1972-73

	1972		1973p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
By type				
Crude groups, 1, 2 and other milled	101	121,000	..	..
Group 3, spinning	36,508	14,497,000	..	..
Group 4, shingle	499,234	96,660,000	..	..
Group 5, paper	271,585	38,770,000	..	..
Group 6, stucco	236,105	22,835,000	..	..
Group 7, refuse	642,625	33,184,000	..	..
Group 8, sand	893	22,000	..	..
Total	1,687,051	206,089,000	1,862,963	229,376,000*
By province				
Quebec	1,377,950	156,965,000	1,518,798	170,652,000
British Columbia	105,807	20,870,000	108,981	22,357,000
Yukon	101,888	13,007,000	100,242	15,035,000
Newfoundland	63,846	10,842,000	99,014	17,264,000
Ontario	37,560	4,405,000	35,928	4,068,000
Total	1,687,051	206,089,000	1,862,963	229,376,000
Exports				
Crude				
United States	17	15,000	12	14,000
Italy	14	15,000	6	10,000
Japan	17	14,000	10	8,000
France	7	6,000	4	4,000
West Germany	–	–	3	3,000
Total	55	50,000	35	39,000
Milled Fibre (groups 3, 4 and 5)				
United States	211,100	47,148,000	223,482	51,573,000
West Germany	68,967	13,812,000	105,525	20,396,000
Britain	59,801	13,984,000	75,383	18,199,000
France	42,246	9,365,000	58,436	13,384,000
Japan	36,318	6,573,000	52,997	9,686,000
Spain	28,031	6,090,000	40,438	8,936,000
Belgium and Luxembourg	24,631	5,713,000	36,470	8,604,000
Mexico	21,318	4,870,000	28,087	7,735,000
Australia	43,265	8,766,000	35,766	7,141,000
India	24,946	5,927,000	21,259	5,264,000
Italy	14,618	3,403,000	22,326	5,146,000
Netherlands	13,191	3,035,000	19,811	4,800,000
Other countries	179,284	37,954,000	202,314	43,034,000
Total	767,716	166,640,000	922,294	203,898,000
Shorts (groups 6, 7, 8, 9)				
United States	503,552	35,499,000	548,412	41,428,000
Japan	75,138	6,841,000	105,366	9,688,000
Britain	39,180	2,422,000	52,168	3,739,000
West Germany	28,639	2,057,000	37,164	2,787,000
France	25,735	1,549,000	29,972	2,009,000
Netherlands	15,436	1,214,000	26,146	1,946,000
Belgium and Luxembourg	16,727	1,424,000	20,751	1,710,000
Spain	11,872	1,255,000	11,981	1,239,000
Australia	10,530	786,000	17,770	1,062,000
South Korea	27,522	3,154,000	5,705	671,000
Denmark	3,478	396,000	5,995	640,000

Table 1 (cont'd)

	1972		1973p	
	(short tons)	($)	(short tons)	($)
Milled Fibre (cont'd)				
Thailand	6,577	723,000	5,395	589,000
Malaysia	2,328	279,000	4,581	568,000
Argentina	8,844	678,000	6,626	553,000
Other countries	55,327	4,845,000	54,426	4,955,000
Total	830,885	63,122,000	932,458	73,584,000
Grand total, crude, milled fibres and shorts	1,598,656	229,812,000	1,854,787	277,521,000
Exports				
Manufactured products				
Brake linings and clutch facings				
United States		453,000		468,000
Ecuador		43,000		52,000
Guatemala		63,000		34,000
Thailand		25,000		34,000
Lebanon		40,000		16,000
Honduras		8,000		13,000
Britain		8,000		10,000
El Salvador		21,000		10,000
Syria		28,000		9,000
France		15,000		9,000
Other countries		143,000		40,000
Total		847,000		695,000
Asbestos and asbestos cement building materials				
United States		1,527,000		1,346,000
Australia		117,000		192,000
Netherlands		151,000		189,000
Switzerland		35,000		135,000
Britain		141,000		50,000
Saudi Arabia		3,000		24,000
Chile		–		17,000
Leeward and Windward Islands		–		15,000
Italy		4,000		12,000
Israel		32,000		11,000
Other countries		143,000		76,000
Total		2,153,000		2,067,000
Asbestos basic products nes				
United States		2,193,000		2,352,000
Australia		9,000		60,000
Switzerland		33,000		54,000
France		22,000		27,000
Israel		4,000		18,000
Britain		14,000		13,000
Belgium and Luxembourg		5,000		9,000
Bermuda		1,000		6,000
West Germany		10,000		4,000
Other countries		75,000		27,000
Total		2,366,000		2,570,000
Total Exports asbestos manufactured		5,366,000		5,332,000

Table 1 (concl'd)

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Imports				
Asbestos unmanufactured	6,561	1,291,000	4,959	992,000
Asbestos manufactured				
Cloth dryer felts, sheets woven or felted		1,115,000		1,646,000
Packing		1,130,000		1,392,000
Brake linings		4,920,000		4,788,000
Clutch facings		644,000		1,024,000
Asbestos cement shingles and sidings		160,000		112,000
Board and sheets		842,000		838,000
Asbestos and asbestos cement building materials, nes		3,846,000		3,678,000
Asbestos and asbestos cement basic products, nes		1,918,000		3,000,000
Total asbestos manufactured		14,575,000		16,478,000
Total asbestos unmanufactured and manufactured		15,866,000		17,470,000

Source: Statistics Canada.
* Value of containers not included.
^p Preliminary; – Nil; nes not elsewhere specified.

Limited. Proven ore reserves are reported at about 100 million tons with 4 per cent fibre content distributed in groups 4, 5 and 6. Earlier plans were to mine by open pit and to recover approximately 155,000 tons of fibre a year.

Evaluation of the McAdam Mining Corporation Limited property, located about 20 miles east of Chibougamau and under option to Rio Algom Mines Limited, continued. The main, or "C" zone, was calculated to contain a geological reserve of 105 million tons of material grading 3.92 per cent fibre to a depth of 700 feet. Three other zones consist of total drill-indicated reserves of 86,371,000 tons with a fibre content of 3.55 per cent.

Pathfinder Resources Ltd. continued with a feasibility study of the Lili asbestos property, 80 miles east of Montreal and 2½ miles from the Canadian Johns-Manville mine. Recent drilling has indicated approximately 49 million tons of ore in three zones. Earlier tonnage and grade estimates were 18.6 million tons grading 4.68 per cent asbestos fibre and 20.0 million tons grading 3.87 per cent.

World developments

In Australia, Woodsreef Mines Limited, situated near Barraba, New South Wales, did not reach its rated annual capacity of 70,000 tons of fibre because of production and financial problems. Negotiations for reorganization of the company were made and continued operation will be based on reappraisals of present conditions.

The Zidani mine in northern Greece, jointly owned by Cerro Corporation (90%) and The Hellenic Industrial Development Bank, S.A. is expected to be in operation by 1975. Estimated initial annual production will be 45,000 tons of fibre in groups 4 to 7.

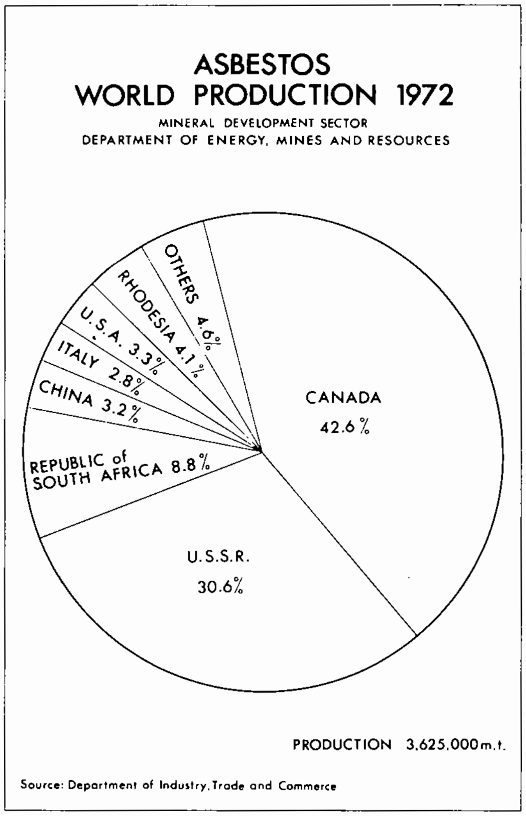
In the Cuicatlan district, Mexico, evaluation work was continued by Industries Penoles, S.A. at the Oxaca deposit. This deposit was last reported to have drill-indicated reserves of about 110 million tons of medium to short slip fibre.

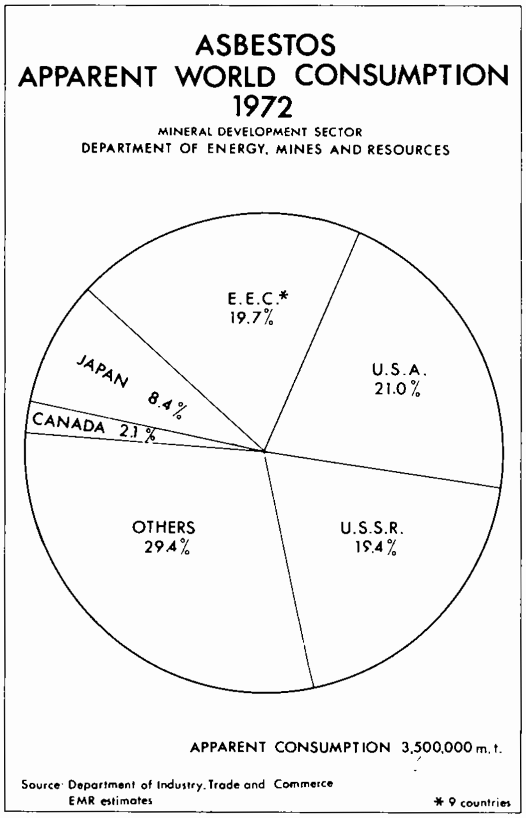
In Colombia, Nicolet Industries Incorporated (70%) along with a Colombian partner (30%) continued evaluation of the Las Brisas deposit at Campamento in the Province of Antioquia. The most recent estimates suggest that a plant will be in operation by 1977, considerably later than previously estimated.

Expansions over the past two years to production facilities in Brazil resulted in the production of over 40,000 metric tons of fibre in 1973.

World production and major markets

Chrysotile asbestos represents over 90 per cent of the annual world asbestos production which is approximately 4.5 million short tons. The two major producers of chrysotile are Canada and the U.S.S.R.





Russian production in 1973 was estimated at approximately 1.4 million short tons (excluding about one million tons of very low-grade short fibre) compared with Canadian production of over 1.8 million tons. South Africa is unique in that it is the only source of amosite in the world and the most important producer of crocidolite. The two major producers of anthophyllite are Finland and the United States.

As a percentage of world production, the following 1972 figures apply: Canada, 42.6; U.S.S.R., 30.6; Republic of South Africa, 8.8; U.S.A., 3.3; Italy, 2.8; Rhodesia, 4.1; China, 3.2; and others, 4.6.

Canada exports about 94 per cent of its fibre production to over 70 countries. The United States is Canada's major market, followed by Japan, Britain, West Germany and France. These countries receive about 70 per cent of Canadian fibre exports, which totalled over 1.8 million tons in 1973. Most of the production of the U.S.S.R. is consumed internally although exports now approaching 500,000 tons a year are shipped to eastern Europe, France, Japan and West Germany. South Africa exports to countries throughout the world and its major customers are Japan, Britain, Spain, Italy, and West Germany.

Fibre groups, uses and technology

To evaluate the quality of asbestos fibre there are five basic properties which must be considered: fibre length distribution, fibre bundle diameter distribution, harshness, tensile strength and surface activity. Other properties governing quality are iron content, colour and dust content. The major standard on a length basis is that developed by the industry in Quebec, whereby asbestos is classified and priced by groups from the longest fibre corresponding to No. 1, to the shortest, No. 9. Because there are more than 3,000 uses for asbestos, it is more appropriate to classify the groups in categories and describe the major purposes the fibres serve than to list the products in which they are used.

Long fibres, Crudes No. 1 and 2 and group 3 – used in the textile industry, as electrical insulation, as a filtration medium and as reinforcing fillers in asbestos-cement products where great strength is required.

Table 2. Canadian asbestos producers, 1973

Company	Mine Location	Mill Capacity	Remarks
		(st ore/day)	
Advocate Mines Limited	Baie Verte, Nfld.	7,500	Open pit.
Carey-Canadian Mines Ltd.	East Broughton, Que.	5,500	Open pit.
Asbestos Corporation Limited			World's major independent asbestos producer.
Asbestos Hill Mine	Putuniq, Que.	6,000	Expected to reach annual capacity of 300,000 tons of concentrate in 1974 or 1975. Final processing to 100,000 tons of fibre at Nordenham, W. Germany.
British Canadian mine	Black Lake, Que.	12,400	Open pit, two milling plants.
King Beaver mine	Thetford Mines, Que.	12,000	Underground and open pit.
Normandie mine	Black Lake, Que.	7,500	Open pit.
Bell Asbestos Mines, Ltd.	Thetford Mines, Que.	3,000	Underground. New shaft and surface installations completed.
Lake Asbestos of Quebec, Ltd.	Black Lake, Que.	9,000	Open pit. Purchased assets of National Asbestos Mines Limited.
National Mines Division	Thetford Mines, Que.	3,500	Open pit. Mill expansion to 80,000 tpy planned.
Canadian Johns-Manville Company, Limited			Western world's largest known asbestos deposit.
Jeffrey mine	Asbestos, Que.	33,000	Open pit. Expanded complex designed to maintain annual output at a minimum of 600,000 tons of fibre.
Reeves mine	Timmins, Ont.	5,000	Open pit. Closed temporarily at end of year.
Hedman Mines Limited	Matheson, Ont.	300	Open pit. The plant is designed to turn out Group 7 fibre.
Cassiar Asbestos Corporation Limited			
Cassiar mine	Cassiar, B.C.	3,300	Open pit.
Clinton mine	Clinton Creek, Yukon	4,000	Open pit.

Table 3. Canada, asbestos production and exports, 1964-73

	Crude	Milled	Shorts	Total
	(short tons)			
Production[1]				
1964	236	664,284	755,331	1,419,851
1965	163	659,598	728,451	1,388,212
1966	215	735,972	752,868	1,489,055
1967	288	705,295	746,521	1,452,104
1968	290	777,006	818,655	1,595,951
1969	7,017	687,924	916,227	1,611,168
1970	7,252	737,037	917,355	1,661,644
1971	2,029	753,241	879,309	1,634,579
1972	101	807,327	879,623	1,687,051
1973p	. .	. .	. .	1,862,963
Exports				
1964	214	630,515	702,747	1,333,476
1965	123	630,777	688,504	1,319,404
1966	172	732,585	713,405	1,446,162
1967	229	653,280	688,535	1,342,044
1968	202	723,136	736,330	1,459,668
1969	135	778,641	785,986	1,564,762
1970	101	824,324	738,007	1,562,432
1971	115	778,143	794,143	1,572,423
1972	55	767,716	830,885	1,598,656
1973p	35	922,294	932,458	1,854,787

Source: Statistics Canada.
[1] Producers' shipments.
p Preliminary; . . not available.

Medium-length fibres, Groups 4, 5, 6 – reinforcing fillers in asbestos-cement products, friction materials such as brake linings and clutch facings, paper and pipe coverings.

Short fibres, Groups 7, 8, 9 – reinforcing fillers in plastics, floor tile, asphalt, and in paints and oil-well muds.

Asbestos-cement building materials and asbestos-cement pipe together consume an estimated 70 per cent of world fibre production. Domestic consumption in the United States, based on a 1973 United States Bureau of Mines survey, indicated a consumption breakdown as follows: construction materials, 30 per cent; floor tile, 21 per cent; friction products, 8 per cent; paper, 10 per cent; asphalt felts, 5 per cent; packing and gaskets, 3 per cent; insulation, 1.5 per cent; textiles, 1.5 per cent and others 20 per cent.

The U.S. Environmental Protection Agency published asbestos emission regulations in April. All revisions to regulations were not finalized in 1973. Regulations of the U.S. Labour Department's Office of Safety and Health Administration (OSHA) have apparently not retarded overall consumption of asbestos in the manufacturing sector.

In Canada, specific regulations to control asbestos emissions into the air from mining and milling operations are expected to come into effect late in 1975. Regulations will be under the Clean Air Act and will be based on national air emission inventory surveys.

Outlook

The high world demand for asbestos is expected to continue, based on growth in the construction industry in North America and elsewhere. Average annual growth rates in consumption of 4 to 4.5 per cent are anticipated if strong demand continues in key western European markets and in the developing countries. Continued demand would suggest that over 500,000 metric tons of new production will be required to satisfy world demand in 1977 and 1.2 million metric tons by 1980.

Plans to increase output by improving productivity and by full utilization of capacity are expected to result in the continued upward trend in total shipments by several major Canadian producers. Present prospective producers in Canada are potentially capable of contributing over 300,000 metric tons to world markets in the near-term. Production problems and the apparent slow progress toward the realization of production in several countries suggest that there is good opportunity for Canada to maintain its share of total world production. With continued buoyancy in world demand and given the present trade patterns, it may be assumed that Canada will be called upon to supply an additional 400,000 to 500,000 metric tons of fibre by 1980.

Improving demand for fibre groups 4, 5 and 6, utilized in the construction materials industry, is expected to continue in the medium and longer-term. The use of group 7 fibre, primarily as a filler in floor tiles and insulating wallboard, is also expected to continue at a good growth rate. Escalating costs in all segments of the industry may provide further impetus for the use of substitute materials in the generally very competitive construction materials market.

In highly developed countries such as the United States and Britain, where large quantities of fibre are already used in construction materials, growth rates will probably be slow because of the highly competitive nature of the marketplace and modifying effects from the irregular nature of the construction cycle. Production in the U.S.S.R. is expected to continue its upward trend to satisfy domestic requirements and exports are not expected to increase greatly in the short-term except where specific trade agreements are concerned.

The outlook in the health and environmental field is uncertain, although significant progress has been achieved in establishing a trend toward lower threshold limits for dust concentrations in the air in mills and factories where asbestos fibre is processed.

The asbestos industry in Canada plans to spend about $20 million between 1970 and 1975 to ensure continuing and better environmental control.

Prices

Cassiar Asbestos Corporation Limited announced price increases ranging from 3 to 5 per cent in January 1973. Quebec asbestos prices were increased 8 per cent in May 1973. Both sets of increases remained unchanged throughout the year. The outlook in 1974 indicates that significantly greater increases will be forthcoming.

Canadian asbestos prices quoted in Asbestos[1]

	May 1, 1973
	($ a short ton)
Quebec fob mines	
Crude No. 1	1,745
Crude No. 2	945
Group	
No. 3 (spinning fibre)	445-730
No. 4 (asbestos-cement fibre)	246-414
No. 5 (paper fibre)	177-209
No. 6 (waste, stucco, plaster)	129.50
No. 7 (refuse, shorts)	54-105

	April 1973
Cassiar, fob North Vancouver, B.C. Canadian group	
Cassiar Mine	
C-1	1522
No. 3 (nonferrous spinning fibre)	
AAA Grade	$ 895.
AA Grade	711.
A Grade	541.
No. 4 AC	388.
No. 4 AK	276.
No. 4 AS	240.
No. 5 AX	219.
No. 5 AY	155.
No. 6 AZ	114.
Talus	233.
Clinton Mine	
No. 4 CP	$ 261.
No. 4 CT	235.
No. 5 CY	155.
No. 6 CZ	114.

1 *Asbestos* is a magazine published monthly by Stover Publishing Company.

Tariffs

Canada

Item No.	British Preferential	Most Favoured Nation	General
	(%)	(%)	(%)
31210-1 Asbestos, crude	free	free	25
31215-1 Asbestos, yarns, wholly or in part of asbestos, for use in manufacture of clutch facings and brake linings	7.5	7.5	25
31225-1 Asbestos felt, rubber impregnated for use in mcf floor coverings	free	free	25
31200-1 Asbestos, in any form other than crude, and all manufactures thereof, nop	12.5	12.5	25
31205-1 Asbestos in any form other than crude, and all manufactures thereof, when made from crude asbestos of British Commonwealth origin, nop	free	12.5	25
31220-1 Asbestos woven fabric, wholly or in part of asbestos for use in manufacture of clutch facings and brake linings	12.5	12.5	30

United States

Item No.	
518.11 Asbestos, not manufactured, crude, fibres, stucco, sand and refuse containing not more than 15 per cent by weight of foreign matter	free

Tariffs (Concl'd)

United States (cont'd)

	On or after January 1, 1972
	(%)
518.21 Asbestos, yarn, slivers, rovings, wick, rope cord, cloth, tape and tubing	4
518.51 Asbestos articles not specifically provided for	4
Articles in part of asbestos and hydraulic cement	(¢ per lb)
518.41 Pipes and tubes and fittings thereof	0.15
518.44 Other	0.1

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa, Tariff Schedule of the United States, Annotated (1972) TC Publication 452.

Barite and Celestite

G.O. VAGT

Total production of barite in Canada was 98,000 tons in 1973 and exports were nearly 30,000 tons greater than in 1972. Imports of barium carbonate in 1973 were 4,894 tons valued at $686,000 an increase of 1,022 tons over 1972 figures.

Barite ($BaSO_4$) is of value mainly because of its weight (specific gravity 4.5) and chemical inertness. Its dominant use is as a weighting agent in muds that serve to counteract high pressures under the substrata when drilling oil and gas wells.

Barite deposits are widespread throughout the world and it is mined in many countries, principally the United States, followed by West Germany, U.S.S.R. and Mexico. Canada is eleventh in world production and about 50 per cent of its output is exported, mainly as crude barite, to grinding plants in the United States.

Production and occurrences in Canada

Barite is found in a variety of geological environments: as the principal mineral in veins along with fluorite, calcite and quartz; as a gangue mineral in some lead-zinc-silver deposits; and as irregular replacement deposits in sedimentary rocks. Pure barite is white and is most common in veins; impure barite may be near white, grey, brown or light red. Barite was produced only in Nova Scotia and British Columbia in 1973.

At the Walton, N.S. mine, operated by Dresser Minerals, a division of Dresser Industries, Inc., most of the production was obtained from low-grade stockpiles, waste dumps and the tailings pond. Mud and water inflows to the underground workings have not been effectively controlled, however, limited quantities of ore are still mined. Prior to flooding, the barite ore was mined from a large replacement deposit by a block-caving method and hoisted through the same shaft as lead-zinc sulphide ore mined in conjunction with the barite. Most of the production was shipped in crude form to southwestern United States and the remainder was transferred to an affiliated company for use in offshore oil drilling in eastern Canada.

There were two barite producers in British Columbia in 1973. Baroid of Canada, Ltd., recovered barite from tailings at an abandoned lead-zinc mine near Spillimacheen, south of Golden. The tailings were fed as a slurry to separation tables and the barite concentrate dewatered and shipped by rail for further processing in a grinding plant at Onoway, Alberta. Mountain Minerals Limited mined barite underground from vein deposits near Parson and Brisco in the eastern part of the province, and recovered crude barite from the tailings at the Mineral King mine near Invermere. The crude barite was shipped to the company's plant at Lethbridge, Alberta, for grinding.

In Ontario, Extender Minerals of Canada Limited, a subsidiary of L. V. Lomas Limited, completed construction of a mill building and storage buildings. The plant site, located in Powell township near Ryan Lake, about four miles northwest of Matachewan, was formerly owned by Geo-Pax Mines Limited. Extender Minerals plans to mine barite veins situated on the shore of Mistinikon Lake, 6 miles southwest of Matachewan. There was no production in 1973.

There are many occurrences of barite across Canada. Of note are occurrences in Newfoundland, at Buchans, where there is an estimated 0.5 million tons of barite in tailings; in Nova Scotia, east of Lake Ainslie on Cape Breton Island, and near Brookfield on the mainland; in northern Ontario, in Yarrow, Penhorwood and Langmuir townships, and on McKellar Island in Lake Superior; and in northern British Columbia, at Mile 397, and north of Mile 548 on the Alaska Highway.

The Lake Ainslie deposit on Cape Breton Island is reported to contain 3 million tons of ore grading 44 per cent barite and 17 per cent fluorspar.

Uses, consumption and trade

The dominant use for barite is as a weighting agent in oil and gas well drilling muds. Principal specifications are usually a minimum specific gravity of 4.25, a particle size of at least 90 per cent minus 325 mesh, and a maximum of 0.1 per cent water-soluble solids.

In 1972, apparent consumption of barite in Canada was estimated to be 78,900 tons, based on an estimated 67,772 tons utilized in the well drilling industry.

Barite is used in paint as a special filler or "extender pigment". This is a vital constituent that

Table 1. Canada barite production, trade and consumption, 1972-73

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Production (mine shipments)	77,261	804,096	98,000	1,020,000
Imports				
United States	21,748	827,000	31,505	1,192,000
People's Republic of China	55	1,000	75	4,000
Total	21,803	828,000	31,580	1,196,000
Exports				
United States	20,188	231,000	50,012	577,000
Total	20,188	231,000	50,012	577,000

	1971	1972
Consumption (available data)[1]		
Well drilling	49,690^e	67,772^e
Paints and varnish	2,397	2,633
Glass and glass products[2]	5,121	7,176
Rubber goods	249	222
Other[3]	743	1,097
Total	58,200	78,900

Source: Statistics Canada.
[1]Available data reported by consumers and estimates by Mineral Development Sector.
[2]Includes glass fibre and glass wool.
[3]Includes miscellaneous chemicals, cleansers, detergents and miscellaneous products.
^{p}Preliminary; – Nil; ^{e}Estimated.

provides bulk, improves consistency of texture, surface characteristics and application properties, and controls prime pigment settling and viscosity of paints. Specifications for barite in the paint industry are about 95 per cent $BaSO_4$, particle size at least minus 200 mesh, and a high degree of whiteness or light reflectance.

The glass industry uses barite to increase the workability, act as a flux, assist decolouration and increase the brilliance or lustre of glass. Specifications call for a minimum of 98 per cent $BaSO_4$, not more than 0.15 per cent Fe_2O_3, and a particle size range of 40 to 140 mesh. Consumption of barite in the glass industry, including glass fibre and glass wool, amounts to the largest percentage of total consumption, next to well drilling uses.

Where used as a filler in rubber goods the specifications for natural barite vary, but the main factors are whiteness and particle size range. Some requirements, perhaps where weight is most desired, may allow for the use of off-white material.

The balance of Canada's barite consumption went for such diverse uses as the manufacture of ceramic products, soaps and detergents.

Table 2. Canada, barite production, trade and consumption, 1964-73

	Production[1]	Imports	Exports	Consumption[2]
	(short tons)			
1964	169,149	3,206	156,527	15,800
1965	203,025	3,686	185,032	21,700
1966	221,376	4,165	199,054	26,500
1967	172,270	5,924	146,103	32,000
1968	138,059	7,901	116,491	29,500
1969	143,230	6,243	108,610	41,000
1970	147,251	7,526	99,544	55,200
1971	120,765	11,332	73,879	58,200
1972	77,261	21,803	20,188	78,900
1973^p	98,000	31,580	50,012	..

Source: Statistics Canada.
[1]Mine shipments.
[2]Includes estimates by the Mineral Development Sector.
^{p}Preliminary; .. Not available.

There is as yet no barium chemicals industry in Canada. Barium chemicals include: barium carbonate, which is the most important; chemical or precipitated barium sulphate, referred to in the trade as *blanc fixe*; and lithopone, a chemically precipitated mixture of 70 per cent barium sulphate and 30 per cent zinc sulphide. Lithopone is a white pigment that has been largely replaced by titanium dioxide pigments. Specifications of barite for the barium chemicals industry are about 95 per cent $BaSO_4$, and not more than 1 to 2 per cent Fe_2O_3.

World review

There is worldwide production and considerable international trade in barite even though transportation costs in some cases may be nearly as great as the cost of the lump material. World production of barite in 1973 was estimated at 4.37 million tons of which about three quarters was consumed in oil well drilling. Dependence on this industry as a principal market means that demand is subject to considerable fluctuation as the tempo of oil and gas exploration varies in time and in geographic location. Conversely, oil and gas exploration takes place throughout the world resulting in consistent world demand that is most economically served by production from many countries. The viability of any deposit is dominantly influenced by transportation costs to markets.

In the United States, production of an estimated 963,000 tons annually is derived mostly from Missouri, Arkansas and Nevada, with smaller amounts from nine other states. This country generally imports from 500,000 to 700,000 tons of crude barite annually. The pattern of consumption of ground barite (excluding the barium chemicals industry) in the United States is similar to that in Canada.

In Ireland, Milchem (U.K.) Ltd., planned to commence barite production with an initial annual capacity of 60,000 tons a year. This quantity, with planned additional output by Magcobar (Ireland) Ltd., and Horace Taylor Minerals Ltd., is expected to increase total capacity in the U.K. and Ireland by 125,000 tons a year.

Thailand has significantly increased production in recent years and production capacity is limited primarily by the inaccessibility of many of the known deposits to establish transportation routes, particularly in the northern regions.

In China, estimated annual production is over 170,000 tons of barite, however, quantities available for export are expected to decrease in view of increasing domestic drilling usage.

There is a possibility that offshore drilling will take place on the Indo-Pakistan shelf which could result in larger markets for Indian and Pakistani deposits.

The great deal of drilling activity in Indonesia and the Philippines continues to offer encouragement to increased barite production in Australia and the Far East.

Table 3. World production of barite, 1972-73

	1972	1973^e
	(short tons)	
United States	906,000	963,000
West Germany	406,000	410,000
Mexico	288,000	290,000
Peru	260,000	250,000
Ireland	220,000	240,000
Italy	200,000	210,000
France	121,000	125,000
Morocco	103,000	110,000
Greece	94,000	110,000
Canada	77,000	98,000
Yugoslavia	66,000	70,000
Other countries	1,523,000	1,520,000
Total	4,264,000	4,396,000

Source: U.S. Bureau of Mines Commodity Data Summaries, January 1974. Canada totals from Statistics Canada.
^{e}Estimated.

Outlook

Barite production over the longer-term is as secure as the overall demand for energy, barring substitution for either barite or petroleum products. Demand over the shorter-term is largely defined by the progress of petroleum exploration. (*Text continued on page 4*)

Prices

United States prices of barite according to Engineering and Mining Journal of December, 1973.

	($ per short ton)
Chemical and glass grade	
Hand picked, 95% $BaSO_4$ not over 1% Fe	22.50 - 24.50
Magnetic or flotation, 96% $BaSO_4$ not over 0.5% Fe	29.50 - 34.45
Imported drilling mud grade, specific gravity 4.20-4.30 cif	
Gulf ports	14 - 18
Canada	15
Ground	
Water, 99½% $BaSO_4$ 325 mesh, 50-lb bags	55 - 78
Dry ground drilling mud grade, 83-93% $BaSO_4$ 3-12% Fe, specific gravity 4.20-4.30	37 - 44
Imported	
4.20-4.30 specific gravity	31

A possible barite substitute, Fer-O-Bar, developed by a subsidiary of Metallgesellschaft, is scheduled to be manufactured on a full-production scale by 1975. The process is unique and there is skepticism regarding cost competitiveness, abrasive qualities, chemical reaction characteristics, and viscosity suspension qualities under all possible conditions that may be encountered.

Exploration for new deposits in Canada and feasibility studies presently underway could bring about changes in the production pattern and the quantity of output in the near future. Continued oil and gas well drilling activity in the Mackenzie Delta, Arctic regions, and off the east coast of Canada suggests a growing market for barite in these areas.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
49205-1	Drilling mud and additives	free	free	free
68300-1	Barites			
	On and after Jan. 1, 1971	free	12	25
	On and after Jan. 1, 1972	free	10	25
92842-1	Barium carbonate	10	15	25
92818-1	Barium oxide, hydroxide peroxide	10	15	25
93207-5	Lithopone	free	12½	25

United States

Item No.			On and After January 1, 1972
472.02	Barium carbonate, natural, crude	free	
472.04	Barium carbonate, natural, ground		6%
			($ per lt)
472.10	Barium sulphate, natural		1.27
472.12	Barium sulphate, natural, ground		3.25
			(¢ per lb)
472.14	Barium sulphate, precipitated (*blanc fixe*)		0.3
473.72	Lithopone, containing under 30% zinc sulphide		0.43
473.74	Lithopone, containing 30% or more zinc sulphide		0.43 + 3.5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Tariff Schedules of the United States, Annotated (1972) TC Publication 452.

CELESTITE

Celestite ($SrSO_4$), the main source of strontium, is used to produce commercial strontium compounds, principally strontium carbonate and strontium nitrate. Strontium carbonate is used in glass faceplates in colour television sets, where it improves the absorption of X-rays emitted by picture tubes operated at high voltages. An increasing use for this compound is in the manufacture of ferrites, a material required in the production of ceramic permanent magnets, which are being used in larger quantities in small motors.

Kaiser Celestite Mining Limited, a subsidiary of Kaiser Aluminum & Chemical Canada Limited, and Canada's only producer of celestite, mined celestite ore from an open pit near Loch Lomond, Cape Breton Island, N.S. Concentrate was produced from a flotation mill at the mine site. The concentrate was shipped to the Point Edward, Nova Scotia plant of Kaiser Strontium Products Limited, for treatment with imported natural sodium carbonate to produce technical and chemical-grade strontium carbonate, commercial-grade strontium nitrate and sodium sulphate. Capacities of the plants are: 225 tons of $SrSO_4$ concentrate a day from the mill, 90 tons a day of $SrCO_3$, and up to 100 tons a day of sodium sulphate. There is capacity at the Point Edward plant to produce small quantities of strontium nitrate, used in pyrotechnics and tracer ammunition. Operating problems and cost overruns were associated with the new plant and newly developed process, however, technological difficulties have been largely resolved. Research into new and expanded uses of strontium carbonate continues and a slow but steady growth in consumption is anticipated.

Current producers of strontium carbonate in the United States obtain their celestite from Mexico.

Prices

United States prices according to Chemical Marketing Reporter, December 1973.

Strontium carbonate	($ per pound)
technical grade, bags	
carlot, truckload, works	.13–.21
Strontium nitrate	($ per 100 pounds)
bags, carlot, works	15.00

Tariffs

Canada

Item No.	British Preferential	Most Favoured Nation	General
92839-5 Strontium nitrate effective July 1, 1974 to June 30, 1984	free	free	free

United States

Item No.	On and After January 1		
	1971	1972	1973
Strontium Metal			
632.46 Unwrought, waste and scrap	6%	5%	5%
632.68 Alloys of strontium	9%	7.5%	7.5%
473.19 Strontium chromate pigments	6%	5%	5%
Strontium Compounds			
421.70 Carbonate	free	free	free
421.72 Carbonate (precipitated)	7%	6%	6%
421.74 Nitrate	7%	6%	6%
421.76 Oxide	7%	6%	6%
421.82 (mineral celestite)	free	free	free
421.84 Sulphate	6%	5%	5%
421.86 Other	6%	5%	5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Tariff Schedules of the United States, Annotated (1972) TC Publication 452.

Bentonite

G. O. VAGT

Bentonite is a clay composed mainly of the mineral montmorillonite, a hydrated aluminum silicate with weakly attached cations of sodium and calcium. Bentonite has different properties depending on the predominance of sodium or calcium. The sodium bentonites have a great physical avidity for water which provides bentonite with unique swelling properties forming gels from 15 to 20 times the original dry volume. On agitation these gels may become fluid in character and then revert to a stable gel state when quiescent. Sodium bentonite also possesses a high dry-bonding strength, especially at elevated temperatures, and this ceramic feature is important in some uses.

Montmorillonite clays have high ion-exchange properties and by adsorption, absorption and chemical activity, bentonite can collect many types of inorganic and organic compounds, sometimes selectively. In general, the nonswelling or calcium bentonites exhibit the more pronounced adsorptive characteristics. While naturally-occurring clays may exhibit adsorptive or bleaching properties, their efficiencies are commonly improved by acid leaching or, as the process is generally termed, activation.

Another clay, "fuller's earth," is also largely a montmorillonite clay and is very similar to nonswelling bentonite. These clays have natural bleaching and absorbent properties and were originally used by fullers to remove dirt and oil from wood. The terminology is confusing and bentonite and fuller's earth may or may not be separated in world trade and production figures by country.

Bentonite is generally accepted as originating from deposits of volcanic ash that have been altered by induration and weathering. The deposits occur in relatively flat-lying beds of various chemical compositions and impurities, the latter consisting of quartz, chlorite, biotite, feldspar and jarosite. Natural clay may be creamy white, grey, blue, green or brown; and in places, beds of distinctly different colour are adjacent. Fresh moist surfaces are waxy in appearance; on drying, the colour lightens and the clay has a distinctive cracked or crumbly texture.

Production and occurrences in Canada

Canadian bentonite occurrences are confined to Cretaceous and Tertiary rocks at many localities in Manitoba, Saskatchewan, Alberta and British Columbia. Although clay beds occur in rocks older than Cretaceous, none in Canada has been identified as bentonite. In the Truax area of Saskatchewan, south of Avonlea, Indusmin Limited discontinued an evaluation program on its bentonite prospect where previous diamond drilling indicated 4,000,000 tons of material. Preliminary tests indicate that the bentonite would be suitable for use in the pelletizing of iron ore and in iron foundries.

Three companies mine and process bentonite in Canada; statistics on total production are not available for publication.

In Alberta, Dresser Minerals Division of Dresser Industries, Inc. recovers swelling bentonite from the Edmonton Formation, of Upper Cretaceous age. The deposits are in the Battle River Valley, 9 miles south of Rosalind, the site of the company's processing plant. Baroid of Canada, Ltd. mines a similar bentonite from the same formation, about 14 miles northwest of the company's processing plant and rail siding at Onoway.

Bentonite is mined selectively from relatively shallow paddocks or pits in the dry summer months. Some natural drying may be done by spreading and harrowing material before trucking it to plants for further processing. Both companies dry, pulverize and bag the bentonite. Swelling bentonite from Alberta is used mainly as a foundry clay. Other uses are as a drilling mud additive, as feed pelletizing material, as a fire-retardant additive to water and as a sealer for farm reservoirs.

In Manitoba, Pembina Mountain Clays Ltd. mines nonswelling bentonite from the Upper Cretaceous Vermilion River Formation, 19 miles northwest of Morden, which is in turn 80 miles southwest of Winnipeg. Some bentonite is dried and pulverized in a plant at Morden but the bulk of production is railed from Morden to the activation plant at Winnipeg, where it is leached, washed, filtered, dried, pulverized and bagged. The main use is for decolourizing and purifying mineral and vegetable oils, animal fats and tallows.

Uses, consumption and trade

Bentonite has many uses, but generally constitutes only a small part of the final product.

Select swelling bentonite has found widespread and rapidly growing uses as a binder in the pelletizing of iron mineral concentrates. About 18 pounds is used in every long ton of concentrate to provide the pellet

Table 1. Canada, bentonite imports and consumption, 1972-73

	1972		1973^p	
	(Short tons)	($)	(Short tons)	($)
Imports				
Bentonite				
United States	237,157	2,660,000	204,891	3,084,000
Greece	69,070	686,000	21,280	234,000
Total	306,227	3,346,000	226,171	3,318,000
Activated clays and earths				
United States	22,979	2,068,000	24,040	2,385,000
Greece	13,400	230,000	152,908	1,492,000
France	238	80,000	2,122	815,000
Other countries	15	3,000	10	4,000
Total	36,632	2,381,000	179,080	4,696,000
Fuller's earth				
United States	7,024	185,000	13,569	201,000
Total	7,024	185,000	13,569	201,000

	1970	1971	1972
	st	st	st
Consumption[1] (available data)			
Pelletizing iron ore	243,744	223,787	209,274
Well drilling	24,833	17,624	11,022
Foundries	34,363	40,492	42,234
Chemicals	2,038	520	18
Fertilizer stock and poultry feed	69	95	182
Paint and varnish	219	368	286
Pulp and paper	191	194	179
Other products[2]	1,764	8,163	8,952
Total	307,221	291,243	272,147

Source: Statistics Canada.
[1]Includes fuller's earth. Breakdown by Mineral Development Sector; [2]Explosives, frits and enamels, refractory brick and cements, ceramic products, gypsum and concrete products, petroleum refining and refining vegetable oils and other miscellaneous minor uses.
^{p}Preliminary.

with sufficient "green" strength to withstand handling during the drying and firing stages. The amount of bentonite required varies with the mineralogy and particle size of the concentrate.

Special muds used in oil and gas well drilling contain about 10 per cent swelling bentonite, which is used principally to prevent the loss of drilling fluid into permeable zones by coating the wall of the drill-hole with a gel. It also serves as a lubricant and helps to keep the drill cuttings in suspension.

Swelling bentonite serves as a binder in moulding sands used by iron and steel foundries. Nonswelling bentonite is also used as a binder in some low-temperature foundries.

Swelling bentonite is used as a binder in the pelletizing of base-metal concentrates and stock feeds. It is used in small quantities as a plasticizer in abrasive and ceramic mixes; as a filler in paints, paper, rubber, pesticides, cosmetics, medicinal products, and cleaning and polishing compounds; in the grouting of sub-surface water-bearing zones; and in the sealing of dams and reservoirs. Bentonite slurry is effective in fighting forest fires and in retaining the walls of excavations prior to the placement of concrete or other structural materials.

Some nonswelling bentonite is used in pelletizing stock feed, as a carrier for pesticides, and as a cleaning powder for animals.

Activated bentonite is used in decolouring mineral and vegetable oils, animal fats, waxes, beverages and syrups. It is also used as a catalyst in the refining of fluid hydrocarbons.

Consumption of bentonite in Canada has increased greatly in the last decade (see Table 2), largely because of increased consumption as a binder in iron concentrate pelletizing as more of these plants have been constructed. Consumption of bentonite in well drilling in the oil and gas industry is subject to considerable fluctuation. Iron and steel foundries require bentonite as a binder for moulding sands; approximately 40,000 tons are used annually in Canada. Relatively minor quantities of activated clays and fuller's earth are imported mainly from the United States, and some activated bentonite from Manitoba is exported to the United States.

Bentonite production in the United States is centred on extensive deposits in Wyoming where the name was derived from the Cretaceous Fort Benton Formation. These Cretaceous deposits are the world's outstanding swelling bentonite occurrences and the specifications and standards for bentonite used in industry are based on these high-quality clays. Although there are numerous occurrences of bentonite in many countries it is mined in only a few. Because of the high standards of Wyoming bentonite this material is transported over such distances that transportation costs commonly exceed the value of the product at the mine, in some cases by several times. Canada is the main importer from the United States, but some bentonite is shipped to Australia and western Europe. Nonswelling bentonite, fuller's earth, and bleaching clays are produced in numerous states, the major ones being Florida, Georgia, Mississippi and Texas.

Table 2. Canada, bentonite imports and consumption, 1964-73

	Imports[1]		Consumption[2]
	st	$	st
1964	123,533	1,659,076	161,695
1965	192,170	2,310,566	176,536
1966	204,038	2,606,000	201,022
1967	235,451	3,346,000	215,928
1968	323,093	4,041,000	231,349
1969	311,327	4,638,000	278,460
1970	386,984	5,590,000	307,221
1971	370,146	5,357,000	291,243
1972	349,883	5,912,000	272,147
1973[p]	418,820	8,215,000	..

Source: Statistics Canada.
[1] Includes fuller's earth and activated clays and earths.
[2] Includes fuller's earth.
[p] Preliminary; .. Not available.

Outlook

The bulk of Canada's bentonite consumption is used in pelletizing iron ore concentrates. At present, the most suitable material for this purpose is imported from the United States. Based on presently known occurrences the development of a Canadian source of suitable material for pelletizing will largely depend upon future progress in developing Saskatchewan bentonite and whether mining costs and freight rates are competitive. The slowdown in import growth since 1970 is attributed to more stabilized consumption patterns resulting from the completion of new pellet plants. A new 6-million-ton-a-year iron ore pellet plant that came into production in 1973 at Sept-Îles, Quebec, will, when operative at full capacity, result in increased imports. No other pellet plant construction is foreseen in the near- or medium-term. No major changes in production and consumption in industries other than in ore pelletizing are foreseen.

Prices

United States bentonite prices quoted in Chemical Marketing Reporter, December 31, 1973.

	($)
Bentonite, domestic, 200 mesh, bags, car lots, fob mines, per ton	15.50–16.00
Bentonite, imported Italian white, high gel, bags, 5-ton lot ex-warehouse, per lb	.1688

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
29500–1	Clays, not further manufactured than ground	free	free	free
93803–2	Activated clay	10%	15%	25%
20600–1	Fuller's earth, in bulk	free	free	free

United States

Item No.		On and After Jan. 1, 1972
		(¢ per long ton)
521.61	Bentonite	40
521.51	Fuller's earth not beneficiated	25
521.54	Wholly or partly beneficiated	50
		(¢ per lb)
521.87	Clays, artificially activated with acid or other material	0.05 +6% ad val

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), T.C. Publication 452.

Bismuth

M. GAUVIN

Bismuth is obtained in Canada as a byproduct in the processing of certain lead-zinc, lead-zinc-copper and copper ores. The more important sources during 1973 were lead-zinc-copper ores mined in northeastern New Brunswick, lead-zinc ores produced in southeastern British Columbia and silver-cobalt ores produced in northern Ontario. The molybdenite mines of northwestern Quebec, which produced bismuth as a byproduct until 1972, were Canada's largest producers of bismuth. Due to economic conditions, the last operating molybdenite mine in Quebec closed late in 1972. Minor amounts are recovered from the flue dusts of Gaspe Copper Mines, Limited and from lead-zinc-copper ores mined in Quebec.

The preliminary estimate of bismuth production in Canada, based on bismuth recovered from domestic ores and concentrates plus the bismuth content of bullion and concentrates exported totalled 90,000 pounds valued at $444,000, compared with 275,029 pounds valued at $849,675 in 1972. The drop in production is accounted mainly for by the closure of the molybdenite mines in northwestern Quebec. Revised and corrected statistics now show a much lower production rate in British Columbia.

In 1973, world production of bismuth, excluding United States production, as estimated by the United States Bureau of Mines, was some 9.0 million pounds; an increase of 3.7 per cent from the 8.7 million pounds produced in 1972. Japan was the leading producer with an output of 1.9 million pounds followed by Mexico, Peru and Bolivia. The United States, which is a substantial producer from its own and imported ores, does not publish its production statistics.

World demand for bismuth, in line with general economic activity, rose significantly in 1973. United States consumption continued rising and was the highest since 1966. The strong demand was reflected in the gradual increase of bismuth prices during the year.

Bolivia, traditionally a major supplier of bismuth, constructed its first bismuth smelter at Telmayu which started production in 1972. The plant, owned by Corporacion Minera de Bolivia (Comibol), produces crude bismuth metal which is sent to Europe for refining. Comibol is presently planning to build a refinery to raise the bismuth content of its product from 90 per cent bismuth to 99.9 per cent bismuth. The refinery is expected to become operational in 1975. The country's major bismuth deposits are located at the Tasna mines, Baracoles in the North Group, and Esmoraca.

Peko-Wallsend Ltd. of Australia will soon become the world's largest producer of bismuth when its new copper smelting and bismuth recovery plant near Tennant Creek, Northern Territory is completed. Originally scheduled for completion in 1973, the bismuth section is now expected to start operating late in 1974. Eventually, the company intends to produce bismuth bullion; meanwhile bismuth-gold concentrate and bismuth dust will be sold. When completed, the complex plant is expected to recover some 1,300 tons of bismuth annually as crude bullion.

An important development on the international scene was the incorporation during 1973 at La Paz, Bolivia, of the Bismuth Institute.* The six charter members of the Institute are the world's major producers and its prime objective is to stimulate consumption of bismuth metal in all forms. The Institute will also keep statistics on consumption and production of the metal, but such data will be available only to members.

No sales of bismuth were reported from the United States government stockpile during the year. At the end of 1972 the stockpile had been reduced to its objective of 2,100,000 pounds. During 1973 a bill was approved by Congress which reduced the objectives of materials contained in governmental stockpiles. The stockpile objective for bismuth was reduced to 95,900 pounds. At the end of the year, Congressional approval had not been given to sell any of the 2,004,100 pounds which had been declared excess to stockpile requirements.

Outlook

World demand for bismuth will continue to follow the general trend of economic activity of the world's industrialized nations. Bismuth is derived mainly as a byproduct in the processing of lead and copper ores.

* Sponsored by: Centromin-Peru, Corporacion Minera de Bolivia, Mining & Chemical Products Ltd., Peko-Wallsend Ltd., Salsigne S.A., Sidech S.A.

Table 1. Canada, bismuth production and consumption, 1972-73

	1972		1973^p	
	(pounds)	($)	(pounds)	($)
Production, all forms[1]				
New Brunswick	38,592	50,056	57,000	283,000
British Columbia	93,820	336,814	18,000	88,000
Ontario	22,304	80,071	13,000	61,000
Quebec	120,313	382,734	2,000	12,000
Total	275,029	849,675	90,000	444,000
Consumption refined metal (available data)				
Fusible alloys and solders	7,584^r		4,821	
Other uses[2]	30,308^r		52,031	
Total	37,892^r		56,852	

Source: Statistics Canada.
[1] Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported. [2] Includes bismuth metal used in manufacture of pharmaceuticals and fine chemicals, other alloys and malleable iron.
^{p}Preliminary; ^{r}Revised.

With the expansion in world production of these ores, and with the new smelter operating in Bolivia and the Australian smelter scheduled to go on stream in 1974, world supply of bismuth should be able to meet any increase in demand.

Domestic sources

New Brunswick. The Smelting Division of Brunswick Mining and Smelting Corporation Limited produced bismuth metal at its plant at Belledune, about 25 miles northwest of Bathurst, New Brunswick. In 1973, production amounted to 30,620 pounds of refined bismuth grading 99.9 per cent or better, compared with production of 33,870 pounds in 1972. The Kroll-Betterton process is used to treat the desilverized lead bullion and produce a bismuth-lead-calcium-magnesium dross. The dross is then pyrometallurgically refined with chlorine to produce bismuth metal.

Nigadoo River Mines Limited reopened its lead-zinc-copper-silver mine near Bathurst, with production to start in January 1974. In previous operations, substantial amounts of bismuth contained in the lead concentrate produced were recovered by the custom smelter to whom the mine sold the concentrates.

British Columbia. Cominco Ltd. remained the only producer of bismuth metal in British Columbia, deriving most of its output from lead concentrates produced at its Sullivan lead-zinc mine at Kimberley. Other sources included lead concentrates from other company mines and custom shippers. Lead bullion produced from the smelting of these concentrates contains about 0.05 per cent bismuth. Bismuth is recovered as 99.99+ per cent metal from the treatment of residues resulting from the electrolytic refining of the lead bullion. For use in research and in the electronics industry bismuth is further processed at the company's near-by high-purity plant to give it a purity of up to 99.9999 per cent.

Uses

A major use of bismuth is in pharmaceuticals, cosmetics and industrial and laboratory chemicals including catalytic compounds. Various bismuth compounds, salts and mixtures are used in pharmaceuticals for indigestion remedies, antacids, burn and wound dressings. Insoluble salts of bismuth are given to patients before X-ray examination of the digestive tract. Cosmetics containing bismuth oxychloride which imparts a 'pearlescent' glow to eye shadow, lipstick, nail polish and powders comprise one of the larger end-use markets of bismuth, but consumption in this market depends on changing fashion trends and is declining.

Another important outlet for the metal is fusible or low-melting-point alloys for fire-protection devices, electrical fuses, fusible plugs and solders. Many of these alloys contain 50 per cent or more bismuth with the chief additive metals being cadmium, lead and tin. In safety applications, the dependability of the melting

Table 2. Canada, bismuth production, exports and consumption, 1964-73

	Production, (all forms[1])	Exports[2]	Consumption[3]
		(pounds)	
1964	399,958	300,073	53,700
1965	428,759	..	48,300
1966	525,659	..	56,400
1967	668,476	..	47,900
1968	648,232	..	59,300
1969	579,059	..	33,800
1970	590,340	..	24,548
1971	271,196	..	35,876
1972	275,029	..	37,892[r]
1973[p]	90,000	..	56,852

Source: Statistics Canada.
[1] Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported.
[2] Refined and semirefined bismuth metal.
[3] Refined bismuth metal reported by consumers.
[p] Preliminary; .. Not available; [r] Revised.

temperatures of the various bismuth alloy compositions is of utmost importance. Pure bismuth metal expands 3.3 per cent on changing from a molten to a solid state. Nonshrinking low-melting-point bismuth alloys are used in the holding of jet engine airfoil blades during the machining of the root sections. Type metal contains bismuth because of the expanding property of bismuth alloys. Bismuth-tin alloys are sprayed on patterns to make moulds in the plastic industry.

The metal is also used as an important additive to improve the machinability of aluminum alloys, malleable irons and steel alloys and, with indium, forms a low-melting alloy used for holding lenses in the ophthalmic industry. Until 1969, bismuth-molybdate catalysts were used in the production of acrylic plastics when other catalysts displaced them. The United States Atomic Energy Commission uses bismuth in many nuclear research applications because of the metal's low thermal neutron absorption rate.

Prices

The Canadian price for bismuth, as quoted by Cominco Ltd., for bars 99.99 per cent pure, in lots of 1 ton or more was $4.00 a pound from January 1 to February 22. From February 23 to February 28 the price was $4.40 a pound and from March 1 to June 13 the price was $4.50 a pound. Successive price rises of 50 cents a pound occurred on June 14 and September 18. On November 8 the price was raised to $6.50 a pound which was maintained for the balance of the year. The United States price, in ton-lots, as published by Metals Week, was U.S. $4.00 a pound from January 1 to March 2 and U.S. $4.50 a pound from March 3 to June 3. A dual-pricing situation prevailed from June until December when price controls were removed by the Cost of Living Council. During this period, foreign producers were selling bismuth at a higher price than domestic producers. The domestic producers' price

Table 3. Estimated world production of bismuth, 1971-73

	1971	1972	1973[e]
		(pounds)	
Japan (metal)	1,790,000	1,974,000	1,900,000
Peru	1,591,000	1,609,000	1,500,000
Bolivia	1,470,000	1,058,000	1,200,000
Mexico	1,257,000	1,387,000	1,600,000
People's Republic of China (in ore)	550,000[e]	550,000	..
Canada	271,000	275,000	90,000
Australia (in concentrates)	537,000	830,000	..
South Korea	214,000	210,000	300,000
Yugoslavia (metal)	202,000	196,000	200,000
Romania (in ore)	180,000	180,000	..
Other countries	384,000	398,000	2,200,000
Total[1]	8,446,000	8,667,000	8,990,000

Source: Statistics Canada for Canada; for remaining countries, U.S. Bureau of Mines, *Minerals Yearbook* Preprint 1972 and U.S. Commodity Data Summaries, January 1974.
[1] Total for listed figures only; it excludes United States production, which is not available for publication, as well as that of some other smaller producing countries.
[e] Estimated; .. Not available.

was raised to $4.75 a pound on June 4. On July 16 it was raised to $5.00 a pound the ceiling under United States price controls. On December 6 a uniform price of $6.50 a pound was established with the lifting of price controls where it remained for the balance of the year.

Table 4. United States consumption of bismuth by principal uses, 1972-73

	1972	1973
	(pounds)	
Fusible alloys	754,432	932,630
Other alloys	18,004	15,602
Pharmaceuticals[1]	983,877	1,117,644
Experimental uses	1,105	21
Metallurgical additives	549,973	830,928
Other uses	8,143	9,790
Total	2,315,534	2,906,219

Source: Mineral Industry Surveys, United States Department of the Interior, Bureau of Mines, Bismuth in the First Quarter 1974.
[1] Includes industrial and laboratory chemicals.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
33100-1	Bismuth ores and concentrates	free	free	free
35106-1	Bismuth metal, not including alloys, in lumps, powders, ingots or blocks	free	free	25%

United States

Item No.		
601.66	Bismuth ores and concentrates	free
632.10	Bismuth metal, unwrought; waste and scrap bismuth alloys	free
632.64	Containing by weight not less than 30% lead	free

		On and After January 1		
		1970	1971	1972
			(% ad val.)	
632.66	Other	12.5	10.5	9
633.00	Bismuth metal, wrought			

Sources: The custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1972) TC Publication 452.

Cadmium

G.S. BARRY

Cadmium occurs in nature predominantly as a sulphide, greenockite, associated with zinc sulphide ores, especially sphalerite, the common zinc ore mineral. This association with zinc minerals continues during processing and cadmium is recovered as a byproduct of zinc refining. Canadian zinc ores contain up to 0.07 per cent cadmium and zinc concentrates contain up to 0.7 per cent cadmium. Most of the world's cadmium production is from zinc concentrates that grade 0.1 to 0.3 per cent cadmium.

Canadian mine production in 1973, as reported by Statistics Canada, was 4,196,594 pounds, a small decrease from 1972. This amount represents the metallic cadmium recovered at domestic smelters from Canadian ores, plus the recoverable cadmium content of ores and concentrates exported.

Cadmium is recovered at electrolytic zinc plants as a precipitate or oxide sponge produced during the purification of the zinc electrolyte. In Canadian plants, the metal is then produced either by the electrolytic process, where cadmium is redissolved in sulphuric acid and plated out in electrolytic cells, or by a purification process in which residues are releached and reprecipitated and the resulting sponge is briquetted, melted in an electric furnace, dezinced and cast. At zinc primary distillation plants, cadmium is reduced and vapourized with zinc in a retort or furnace. The vapour is condensed and cadmium (B.P. 776°C) is separated from zinc (B.P. 905°C) by fractional redistillation.

Metallic cadmium is recovered as a byproduct at the electrolytic zinc plants of Cominco Ltd. at Trail, British Columbia; Hudson Bay Mining and Smelting Co., Limited at Flin Flon, Manitoba; Canadian Electrolytic Zinc Limited at Valleyfield, Quebec; and at Ecstall Mining Limited's new plant near Timmins. In 1973, metallic cadmium produced in Canada totalled 3,085,219 pounds compared with 2,251,094 pounds in 1972.

For the first time in history Japan became the world's largest producer of metal with a smelter output in 1973 of 3,350 tons from primary and secondary sources. The former leader, the United States, recorded a production of 3,245 tons. The U.S.S.R. and .Canada are the next largest world cadmium metal producers.

Canadian exports of refined cadmium totalled 3,261,521 pounds in 1973 compared with 2,261,621 pounds in 1972. The United States, Britain and the Netherlands remained Canada's largest customers importing over 99 per cent of Canada's exports.

The available data indicates that Canadian consumption continues to decline moderately. It is estimated to have been 120,958 pounds in 1973, down from 123,395 pounds in 1972. Apparent consumption in the United States was 12.5 million pounds, 1 per cent less than consumption in 1972. Cadmium consumption can only be estimated roughly, since there is no way to check consumers' inventory changes, and these are known to fluctuate widely. Producers' stocks of metal declined from 2.3 million pounds at the end of 1972 to 1.6 million pounds at the end of 1973.

World demand improved substantially during 1973 and was reflected in a large drop in producer stocks and a rise in Canadian and United States producer prices during the year. The producers' price, which was strong in 1972 and was \$3.00 a pound at the end of the year, rose from \$3.25 to \$3.75 a pound before the end of the first quarter of 1973. In early April, the producers' price was raised to \$3.75 a pound. The price remained unchanged to the end of the year. The United States sales from the noncommercial stockpile were 771,239 pounds during the year. At the end of 1973, the U.S. government had a total inventory of 8,442,119 pounds of which 3,995,619 pounds were classed as "uncommitted excess"; 2,442,119 pounds of this excess were authorized for release.

The strong demand that existed in 1973 carried through into 1974 and is expected to continue for at least most of 1974.

Canadian production

Table 4 lists data on cadmium production as reported by individual mines. Additional information is given in the following review by provinces:

Newfoundland. The Buchans Unit of American Smelting and Refining Company remains the only producer in Newfoundland. Production was only slightly more than one third of the normal annual output due to a 25-week strike.

New Brunswick. Brunswick Mining and Smelting Corporation Limited, which operates two mines near Bathurst, no longer produces cadmium at its smelter at

Table 1. Cadmium production, exports and consumption, 1972-73

	1972		1973P	
	(pounds)	($)	(pounds)	($)
Production				
All forms[1]				
Ontario	2,575,274	6,515,443	2,764,697	10,063,497
British Columbia	695,650	1,759,995	810,779	2,951,236
Quebec	334,343	845,888	270,518	984,686
Manitoba	277,181	701,268	205,204	746,943
Saskatchewan	81,338	205,785	63,538	231,278
Newfoundland	158,800	401,764	52,498	191,093
Northwest Territories	81,200	205,436	16,800	61,152
Yukon	32,711	82,759	12,560	45,718
New Brunswick	31,490	79,670	–	–
Total	4,267,987	10,798,008	4,196,594	15,275,603
Refined[2]	2,251,094		3,085,219	
Exports				
Cadmium metal				
United States	1,290,117	2,831,000	2,004,985	6,491,000
Britain	615,959	1,313,000	1,222,900	3,481,000
Netherlands	253,992	466,000	30,865	101,000
Republic of South Africa	–	–	2,224	7,000
Venezuela	300	1,000	440	2,000
Singapore	–	–	100	1,000
Japan	16	1,000	4	...
France	8	...	3	...
India	55,152	98,000	–	–
Belgium and Luxembourg	22,046	27,000	–	–
Brazil	11,013	26,000	–	–
West Germany	11,027	8,000	–	–
Malaysia	1,984	3,000	–	–
Australia	7	...	–	–
Total	2,261,621	4,774,000	3,261,521	10,020,000
Consumption (cadmium metal)[3]				
Plating	78,913		87,651	
Solders	5,705		8,258	
Other products[4]	38,759		25,049	
Total	123,395		120,958	

Source: Statistics Canada.
[1]Production of refined cadmium from domestic ores, plus recoverable cadmium content of ores and concentrates exported. [2]Refined metal from all sources and cadmium sponge. [3]Available data reported by consumers. [4]Mainly chemicals, pigments and alloys, other than solder.
PPreliminary; – Nil; . . .Less than one thousand dollars.

Belledune. All its zinc concentrates are now exported for treatment at foreign smelters. Cadmium is recovered, but amounts were not reported in the 1973 statistics.

Quebec. Canadian Electrolytic Zinc Limited (CEZ) at Valleyfield recovers refined cadmium from zinc concentrates from the Mattagami and Orchan mines of northwestern Quebec and from the Geco mine, in Ontario. The zinc concentrates of northwestern Quebec are low in cadmium, containing from 0.11 to 0.16 per cent. Production at the CEZ plant in 1973 was 598,000 pounds, compared with 854,000 pounds in 1972.

Table 2. Canada, cadmium production, exports and consumption, 1964-73

	Production		Exports	
	All Forms[1]	Refined[2]	Cadmium Metal	Consumption[3]
	(pounds)			
1964	2,772,984	2,501,921	1,623,679	178,000
1965	1,755,925	1,790,488	1,364,645	172,000
1966	3,236,862	2,217,322	2,012,323	171,000
1967	4,836,317	2,002,892	1,676,676	155,000
1968	5,014,965	2,113,949	1,802,780	125,000
1969	5,213,054	2,123,955	1,686,573	132,136
1970	4,307,953	1,844,706	1,549,035	124,959
1971	4,063,805	1,568,787	1,438,789	117,395
1972	4,267,987	2,251,094	2,261,621	123,395
1973[p]	4,196,594	3,085,219	3,261,521	120,958

Source: Statistics Canada.
[1]Production of refined cadmium from domestic ores plus cadmium content of ores and concentrates exported. [2]Refined cadmium from all sources, including that obtained from imported lead and zinc concentrates; includes cadmium in sponge. [3]As reported by consumers.
[p]Preliminary.

Table 3. World smelter production of cadmium

	1972[r]	1973[e]
	(short tons)	
United States	4,145	3,245
Japan	3,339	3,350
U.S.S.R.	2,646	2,646
Canada	1,125	1,542
Belgium	1,268	1,250
Federal Republic of Germany	1,006	1,200
France	631	700
Australia	793	750
Poland	386	388
Italy	459	460
Other countries	2,415	3,111
Total	18,213	18,642

Sources: World Bureau of Metal Statistics; for Canada, Statistics Canada.
Note: Data are for production of cadmium as unwrought metal from domestic and imported materials. Secondary metal is included where known, but the total in aggregate is less than one per cent of the world total. 1973 figures from United States Bureau of Mines, Commodity Data Summaries, January 1974.
[r]Revised; [e]Estimated.

Ontario. Ecstall Mining Limited at Timmins, the largest producer of cadmium in Canada produced 2,960,000 pounds in zinc concentrates of which 1,133,300 pounds was recovered as cadmium metal at its zinc plant. The cadmium section of the plant did not operate before the fall of 1972, and production for that year was only 173,000 pounds. Other zinc-copper mines in Ontario produce zinc concentrates carrying low to moderate cadmium values. Noranda Mines Limited's Geco mine at Manitouwadge is the second largest producer. Its concentrates, grading approximately 0.38 per cent cadmium, are treated by Canadian Eletrolytic Zinc Limited.

Manitoba and Saskatchewan. The electrolytic zinc plant of Hudson Bay Mining and Smelting Co., Limited at Flin Flon treats zinc concentrates produced in these two provinces. Production at this plant was 306,570 pounds of cadmium in 1973.

British Columbia. Metallic cadmium amounting to 1,153,000 pounds was recovered at the metallurgical works of Cominco Ltd. at Trail. Cominco treats ores and concentrates from its own mines in British Columbia, from its subsidiary Pine Point Mines Limited, N.W.T. and, on a custom basis, from various mining operations in British Columbia and other provinces. A number of smaller producers in British Columbia ship their zinc concentrates abroad, mainly to Japan, where cadmium is recovered.

Yukon Territory. United Keno Hill Mines Limited mines silver-lead-zinc ore high in cadmium, recovering 17,944 pounds in 1973. Anvil Mining Corporation Limited is a large producer and exporter of zinc concentrates, however, they are low in cadmium.

Northwest Territories. Pine Point Mines Limited continued to be the only supplier of cadmium in the Northwest Territories, shipping zinc concentrates which are smelted mainly at Trail. The Pine Point ores have a low cadmium content.

Uses

Cadmium is a soft, ductile, silvery-white electropositive metal with a valence of two. It is used mainly for electroplating other metals or alloys, principally iron and, to a lesser extent, copper, to protect them against oxidation. A cadmium coating, like a zinc coating, protects those metals lower in the electromotive series by physical enclosure and by sacrificial corrosion. Cadmium is usually preferred to zinc as a coating because it is more ductile, is slightly more resistant to common atmospheric corrosion, can be applied more uniformly in recesses of intricately shaped parts, and can be electrodeposited with less electric current per unit of area covered. It is also preferred for its more

(text continued on page 71)

Table 4. Companies reporting cadmium production, 1973 (and 1972)

Company and Location	Mill Capacity	Grade of Zinc Concentrates: Cadmium	Zinc	Lead	Copper	Silver	Zinc Concentrate Produced	Cadmium Contained in Zinc Concentrates	Remarks
	tons ore day	%	%	%	%	oz/ton	tons	pounds	
Newfoundland									
American Smelting and Refining Company (Buchans Unit), Buchans	1,250 (1,250)	0.21 (0.22)	55.81 (56.66)	3.97 (3.83)	0.79 (0.73)	4.91 (4.39)	20,561 (52,990)	87,000 (231,000)	Prolonged strike during 1973. Company reports six years ore reserves remaining.
New Brunswick									
Brunswick Mining and Smelting Corporation Limited, Bathurst, No. 6 mine and No. 12	9,850 (9,850)	0.11 (0.10)	53.28 (53.97)	2.16 (1.71)	0.27 (0.28)	2.69 (2.53)	330,811 (189,710)	. . (. .)	Concentrates sent mainly to Europe where some cadmium is recovered.
Heath Steele Mines Limited, Newcastle	3,100 (3,100)	. . (. .)	48.99 (48.71)	1.49 (1.70)	0.39 (0.88)	2.42 (3.05)	78,094 (48,174)	. . (. .)	Concentrates sent mainly to Europe where some cadmium is recovered.
Quebec									
Joutel Copper Mines Limited, Joutel	700 (700)	0.13 (0.14)	52.74 (52.12)	. . (0.40)	. . (0.36)	. . (1.58)	25,030 (12,974)	70,083 (36,326)	
Manitou-Barvue Mines Limited, Val d'Or	1,500 (1,600)	0.18 (0.18)	57.96 (54.0)	. . (. .)	. . (. .)	. . (. .)	5,982 (920)	21,960 (3,312)	Mine reactivated in July 1972.
Mattagami Lake Mines Limited, Matagami	3,850 (3,850)	0.13 (0.14)	52.2 (52.2)	– (–)	0.35 (0.47)	1.21 (1.29)	178,104 (172,134)	. . (. .)	Two thirds of production processed at CEZ where cadmium is recoverd; rest exported.
Orchan Mines Limited, Matagami, Orchan and Garon mines	2,000 (1,900)	0.11 (0.11)	53.38 (53.8)	0.41 (. .)	. . (. .)	. . (. .)	40,936 (67,250)	. . (147,950)	Garon Lake mine started production during the year.

Table 4. (cont'd)

Sullivan Mining Group Ltd., Stratford Centre Cupra, D'Estrie and Weedon mines	1,500 (1,500)	0.28 (0.30)	56.56 (56.08)	0.49 (0.43)	1.02 (1.22)	1.19 (1.24)	12,232 (13,362)	71,333 (80,000)	The Cupra Division operates a concentrator for all three mines. The Weedon mine closed during 1973.
Ontario									
Ecstall Mining Limited, Timmins	10,000 (10,000)	0.25 (0.24)	52.69 (52.15)	. . (. .)	0.42 (0.38)	4.70 (5.46)	589,894 (622,365)	2,960,475 (3,034,000)	Average of "a" and "c" types of zinc concentrates.
Mattabi Mines Limited, Sturgeon Lake	3,000 (3,000)	0.13 (. .)	55.38 (55.14)	. . (. .)	. . (. .)	. . (. .)	202,513 (80,378)	. . (. .)	Mine commenced production in 1972. About half of the production is processed at CEZ where cadmium is recovered.
Noranda Mines Limited, Geco Division, Manitouwadge	5,000 (5,000)	0.38 (0.38)	53.89 (52.95)	– (–)	0.68 (0.76)	1.67 (1.64)	100,890 (115,626)	. . (868,066)	Concentrates are mainly shipped to CEZ where cadmium is recovered.
Selco Mining Corporation Limited, South Bay Division, Uchi Lake	500 (500)	0.25 (0.25)	52.0 (52.0)	. . (. .)	. . (. .)	. . (. .)	41,878 (42,100)	199,000 (210,500)	Reserves significantly increased.
Willroy Mines Limited, Manitouwadge Division, Manitouwadge	1,700 (1,700)	0.18 (0.18)	52.45 (53.08)	. . (. .)	. . (0.50)	. . (. .)	17,295 (20,878)	61,457 (77,466)	
Manitoba and Saskatchewan									
Hudson Bay Mining and Smelting Co., Limited Flin Flon (Flin Flon, Schist Lake, Chisel L., Stall Lake, Osborne Lake, Anderson Lake, Dickstone, White Lake, Ghost Lake mines)	8,500 (8,500)	. . (. .)	48.84 (48.06)	0.58 (. .)	0.62 (0.82)	1.39 (1.04)	90,796 (85,416)	270,901 (193,912)	

Table 4 (concl'd)

Company and Location	Mill Capacity	Grade of Zinc Concentrates: Cadmium	Zinc	Lead	Copper	Silver	Zinc Concentrate Produced	Cadmium Contained in Zinc Concentrates	Remarks
	tons ore day	%	%	%	%	oz/ton	tons	pounds	
British Columbia									
Bradina Joint Venture, Owen Lake	500 (500)	0.28 (0.28)	48.18 (46.96)	7.48 (6.13)	1.01 (1.18)	20.34 (23.56)	8,277 (8,365)	48,282 (46,847)	
Cominco Ltd., Sullivan mine, Kimberley	10,000 (10,000)	. . (. .)	48.30 (48.60)	6.30 (4.50)	– (–)	2.58 (2.55)	198,454 (195,379)	. . (. .)	Cominco's output of metal cadmium from all sources was 576.5 tons.
Kam-Kotia-Burkam Joint Venture, Silmonac Mine, Sandon	150 (150)	0.43 (0.45)	51.97 (54.67)	1.05 (. .)	– (–)	59.86 (67.37)	1,133 (2,708)	9,744 (24,259)	
Reeves MacDonald Mines Limited, Remac Annex mine	1,000 (1,000)	0.57 (0.62)	52.01 (51.93)	2.69 (1.12)	– (–)	5.18 (6.15)	14,129 (22,498)	172,514 (278,527)	Developing new ore zone.
Teck Corporation Limited, Beaverdell mine, Beaverdell	110 (110)	0.30 (0.49)	47.54 (47.60)	2.30 (2.13)	– (–)	65.61 (65.28)	318 (380)	1,910 (3,713)	
Western Mines Limited, Lynx and Myra Falls, Buttle Lake, V.I.	1,000 (1,000)	0.23 (. .)	53.34 (53.14)	0.98 (1.02)	1.11 (1.09)	6.00 (4.08)	44,736 (33,630)	211,262 (168,662)	Milled higher grade ore from Myra Falls and lower grade ore from Lynx mine.
Yukon Territory									
United Keno Hill Mines Limited, Elsa, Husky, No Cash mines, Elsa	550 (550)	0.74 (0.78)	55.70 (59.60)	1.14 (. .)	– (–)	32.65 (19.10)	1,404 (2,916)	17,944 (46,731)	Mill now operating at rate of 330 tpd.

pleasing aesthetic appearance. Because it is more costly and much less plentiful than zinc, it is not as widely used. Improvement in zinc electroplating techniques in recent years have tended to reduce the consumption of cadmium in plating.

Cadmium-plated articles are used in the manufacture of automobiles, household appliances, aircraft, radios, television sets and electrical equipment. Plating accounts for about half the total consumption of cadmium.

The second largest use is in the manufacture of pigments. Cadmium sulphides give yellow to orange colours and cadmium sulphoselenides give pink to red and maroon. Cadmium stearates act as stabilizers in the production of polyvinyl chloride plastics, and cadmium phosphors are used in both black-and-white and colour television tubes. The use of cadmium compounds in recent years has expanded at a rate of 5 to 10 per cent annually and is now the largest potential growth area. Expansion in this use, which now accounts for about 35 per cent of cadmium consumption, has more than made up for reduced consumption in plating.

Cadmium is a valuable alloying metal and has applications in cadmium-silver solders and in cadmium-tin-lead-bismuth fusible or low-melting-point alloys for automatic sprinkler systems, fire-detection apparatus, and valve seats for high-pressure gas containers. Low-cadmium copper (about 1 per cent cadmium) is used in the manufacture of trolley and telephone wires because of the improved tensile strength imparted by cadmium. Low-cadmium copper is also now employed in automobile radiator finstock, replacing the low-silver copper formerly used. Another growing application is in the production of nickle-cadmium storage batteries. These batteries are considerably more expensive than the standard lead-acid battery, but have a longer life and higher peak power output, are smaller, and are superior in low-temperature operation. They are especially suitable for use in airplanes, satellites, missiles and ground equipment for polar regions, as well as in portable items such as battery-operated shavers, toothbrushes, drills and hand saws. Uses of cadmium in alloys account for about 15 per cent of cadmium consumption.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
32900-1	Cadmium in ores and concentrates	free	free	free
35102-1	Cadmium metal, not including alloys in lumps, powders, ingots or blocks	free	free	25%

United States

Item No.				
601.66	Cadmium in ores and concentrates	free		
		On and After Jan. 1, 1970	On and After Jan. 1, 1971	On and After Jan. 1, 1972
632.14	Cadmium metal, unwrought waste and scrap (duty on waste and scrap suspended on or before June 30, 1973)	1¢ per lb	free	free
633.00	Cadmium metal, wrought	12.5%	10.5%	9%
632.84	Cadmium alloys, unwrought			

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972) TC Publication 452.

Prices

Most electrolytic zinc plants recover between 45 and 75 per cent of the cadmium in zinc concentrates. Usually settlement to the mine is based on a standard deduction of approximately 3 pounds of cadmium per ton of concentrate (i.e., 0.15%) and payment for 60% of the remaining assayed content.

Canadian producers' cadmium prices throughout 1973, as quoted in The Northern Miner, for sticks, bars, balls, etc. 99.8% pure.

Effective Date	Lots of 2,000 lb and over	Lots under 2,000 lb
	($ per lb)	($ per lb)
January 1	3.00	3.20
January 25	3.25	3.45
March 1	3.75	3.95

United States producers' prices throughout 1973, as quoted by the Engineering Mining Journal.

Effective Date	($ per lb)
January 1	3.00
January 25	3.25
March 1	3.75

Outlook

Cadmium is a byproduct of zinc mining and refining, and the ups-and-downs of cadmium supply, demand and prices are closely related to general economic activity and zinc production. The cadmium market is a relatively minor market and small changes can make a big difference in prices. In line with the expectation that the economic boom of 1972 and 1973 will continue for at least most of 1974, cadmium demand and prices are expected to remain firm. Sales from the United States' stockpile are expected to account for a larger proportion of U.S. consumption in 1974 than in 1973. Such sales have a stabilizing effect on price fluctuations and moderated the price increases in 1973.

According to the U.S. Bureau of Mines, the increased development of nickel-cadmium batteries will eventually produce a larger circulating load of secondary cadmium, but only a small percentage of total demand can come from this source. The toxic effects of cadmium in air, acid solutions, and water-borne silt may restrict its use in plating establishments or as compounds in pigments or stabilizers if stricter anti-pollution standards are put into effect. Scavenging systems for industrial waste waters are available but small consumers may find the increased cost unacceptable. In industralized nations, smelters producing cadmium byproducts will be enjoined to recover as high a percentage of cadmium input as is economically feasible in order to prevent its dispersal into the environment.

Calcium

J.G. GEORGE

Calcium, a member of the alkaline earth family, is silvery white in colour, extremely soft and ductile and has a low tensile strength. The metal tarnishes rapidly under atmospheric conditions and is a powerful reducing agent. It is the fifth most abundant element in the earth's crust, but does not occur naturally in its elemental form. Although calcium occurs chiefly in limestone and dolomite, high-calcium limestone deposits are the principal sources of calcium metal.

Metallic calcium may be recovered by thermal and electrolytic methods. There are only three producers of metallic calcium in the noncommunist world: Chromasco Corporation Limited in Canada; Charles Pfizer and Co. Inc. in the United States; and Planet-Wattohm S.A., a subsidiary of Compagnie de Mokta, in France. All three use a thermal reduction method. Canada continued to be a leading international producer and supplier of calcium metal. Statistics on world production and consumption of calcium are not available.

Canadian industry

Chromasco Corporation Limited produces calcium metal at its metallurgical plant at Haley, near Renfrew, Ontario. It utilizes the same vacuum retort method, known as the "Pidgeon process," used to produce its principal product, magnesium. Other products from the Haley operation, in addition to magnesium and calcium metals, include magnesium and calcium alloys and barium, strontium and thorium metals. To make calcium, high-purity quicklime (CaO) and commercially pure aluminum are briquetted and then charged into horizontal electric retorts made of chrome-nickel steel. Under vacuum and at a temperature of about 1170°C, the aluminum reduces the quicklime to form a calcium vapour. This calcium vapour crystallizes at about 680°–740°C in the water-cooled condenser section of the retort, which projects outside the furnace wall. The initial product, known as "crowns," grades about 98 per cent calcium. Higher purities are obtained by subsequent refining operations.

Chromasco makes three main grades of calcium: Grade 1 – chemical standard, 99.9 per cent calcium with minor amounts of other elements; Grade 2 – nuclear quality, 99.9 per cent calcium, including a magnesium content up to a maximum of 0.5 per cent; Grade 4 – commercial grade (crowns), 98 per cent calcium, 0.5 to 1.5 per cent magnesium, 1 per cent nitrogen maximum, 0.35 per cent aluminum maximum.

Canadian production of calcium metal in 1973 was 617,000 pounds, about 31 per cent more than the 469,378 pounds produced in the previous year, although significantly below the 942,682 pounds produced in 1969. Much of Canadian output is exported; 365,100 pounds being sold in foreign markets in 1973 compared with 253,100 pounds in 1972.

Table 1. Canada, calcium production and exports, 1972-73

	1972		1973p	
	(pounds)	($)	(pounds)	($)
Production (metal)[1]	469,378	337,609	617,000	446,000
Exports (metal)				
United States	58,300	10,000	131,200	91,000
Mexico	–	–	117,700	81,000
West Germany	125,600	90,000	95,600	70,000
India	–	–	13,200	20,000
Britain	9,400	18,000	4,000	8,000
Belgium and Luxembourg	44,000	26,000	–	–
Japan	11,600	9,000	–	–
Other countries	4,200	2,000	3,400	2,000
Total	253,100	155,000	365,100	272,000

Source: Statistics Canada.
[1] Shipments of calcium metal, and calcium metal used in production of calcium alloys.
p Preliminary; – Nil.

Table 2. Canada, calcium production and exports, 1964-73

	Production[1]	Exports
	(pounds)	
1964	138,357	130,800
1965	159,434	148,300
1966	249,179	242,800
1967	543,692	513,000
1968	468,511	353,700
1969	942,682	724,600
1970	443,557	174,100
1971	355,247	152,900
1972	469,378	253,100
1973^p	617,000	365,100

Source: Statistics Canada.
[1] Producers' shipments of calcium metal and calcium metal used in production of calcium alloys.
^{p} Preliminary.

Uses

Metallic calcium is a powerful reducing agent. Accordingly, one of its major applications is in metallurgical processes for removing oxygen and halogens from various metals which resist reduction by normal reductants such as carbon, hydrogen and natural gas. Among such metals are columbium, tantalum, titanium, thorium, uranium, vanadium and zirconium. As a purifier, calcium removes residual sulphur, phosphorus and oxygen from steel and removes bismuth, antimony and arsenic from lead. Metallic calcium is also used in producing organocalcium compounds for special lubricants, corrosion inhibitors and detergents. In certain types of storage batteries, a lead alloy containing only 0.1 per cent calcium exhibits properties superior to an alloy containing 3 per cent antimony generally used. Substitution in this field could be an important factor in any future growth in consumption of calcium. Alloys of calcium and silicon, and of calcium, silicon and magnesium are widely used in the steel industry to control grain size, inhibit carbide formation, improve ductility and reduce internal flaws.

Outlook

As limestone and other calcium minerals are readily available and inexpensive, a shortage of raw materials is almost impossible to perceive. Consumption of calcium metal is limited and, unless its use is greatly accelerated, existing producers will be able to supply the market adequately in the foreseeable future. The longer-term outlook for the metal could improve somewhat if the growth rate for one of the metal's major uses; i.e., in hydraulic cements, should increase. The growth rate might also rise if the so-called "maintenance-free" automotive batteries prove to be successful, on a large-scale basis, from a commercial viewpoint. These permanently (hermetically) sealed batteries use calcium-lead alloy instead of antimonial-lead alloy in the battery grids. It has been reported that some of these new-type batteries do not require any addition of water or electrolyte for a running of 45,000 to 60,000 miles, or virtually no maintenance during the normal battery life. Little change in prices is anticipated in the near-term, although if the rate of inflation continues to rise there could be some upward movement in calcium prices.

Prices

With the exception of the price of calcium-silicon, United States calcium prices, as quoted in *Metals Week*, remained unchanged in 1973 for the most-used products. According to *Metals Week* issue of December 31, 1973 the United States prices were:

	(¢ per lb)
Calcium metal crowns	95
Calcium alloys:	
Calcium-manganese-silicon	38.50
Calcium-silicon	22.75[1]

[1] From the beginning of January 1973 up until the *Metals Week* issue of December 24, 1973, this price had been continually quoted at 24.75¢ per lb.

Tariffs

Canada

Item No.		Most Favoured Nation
		(% ad val.)
92805-1	Calcium metal	15

United States

Item No.		On and after January 1 1971	1972
		(% ad val.)	
632.16	Calcium metal, unwrought	9	7.5
633.00	Calcium metal, wrought	10.5	9

Sources: Canada – The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. United States – Tariff Schedules of the United States (Annotated) 1972, T.C. Publication 452.

Cement

D. H. STONEHOUSE

Portland cement is produced by burning, usually in a rotary kiln, an accurately proportioned, finely ground mixture of limestone, silica, alumina and iron oxide. Kiln discharge, in the shape of rough spheres, is a fused, chemically complex mixture of calcium silicates and aluminates termed clinker, which is mixed with gypsum 4 to 5 per cent by weight, and ground to a fine powder to form portland cement. By close control of the raw mix, of the burning conditions and of the use of additives in the clinker grinding procedure, finished cements displaying various desirable properties can be produced.

There are three basic types of portland cement used in Canada – Norman Portland, High Early Strength Portland and Sulphate-Resisting Portland – all of which are covered in specifications under CSA Standard A5 – 1971 (Canadian Standards Association). Moderate portland cement and low heat of hydration portland cement, designed for mass concrete use such as in dam construction, are manufactured by several companies in Canada and are also covered in CSA Standard A5-1971. Masonry cements produced in Canada should conform to the requirements of CSA Standard A8-1970. Masonry cement (generic name) includes such proprietary names as Mortar Cement, Mortar Mix (unsanded), Mason's Cement, Brick Cement and Masonry Cement. The latter, produced by portland cement manufacturers, is a mixture of portland cement, finely ground high-calcium limestone (35 to 65% by weight) and a plasticizer. The other products do not necessarily consist of portland cement and limestone, and may include a mixture of portland cement and hydrated lime and/or other plasticizers.

The types of cement manufactured in Canada and not covered by CSA standards generally meet the appropriate specifications of the American Society for Testing and Materials (ASTM).

Cement has little use alone but, when combined with water, sand, gravel, crushed stone or other aggregates in proper proportions, acts as a binder cementing the materials together as concrete. Concrete has become a widely used and readily adaptable building material which can be poured on site in large engineering construction projects such as dams or can be used in the form of delicate precast panels or heavy prestressed columns and beams in building construction.

Summary, 1973

Cement is one of a number of industrial mineral commodities produced in Canada in direct support of the construction industry. Others are clays, lime, sand and gravel, stone, asbestos and gypsum. The construction industry is the largest single employer in Canada and is one that is immediately affected by changes in the country's economic climate. In a supply role to a volatile industry the cement industry, in turn, must be capable of adjusting and remaining competitive. A growing export market for cement in northeastern United States, assisted by the diversion of United States cement to the south and southeast where construction activity has rapidly expanded, has resulted in the Canadian cement industry being influenced, at least regionally, by construction activity and intentions in that country. The current lack of capacity in northeastern and midwestern United States was brought on by plant closures, forced by the application of environmental legislation, and by the lack of the appeal the industry has had to attract capital investment for the erection of new plants. These market areas will be available to Canadian producers until the American cement industry recovers. A step in this direction was taken early in December, 1973 when the United States Cost of Living Council lifted wage and price controls in the cement industry.

In Canada, construction is categorized broadly as building construction and engineering construction, and the values of each type give some basis for comparison. Historically, building construction has represented about 60 per cent of the total value of construction and one element within this general category–residential construction–has normally accounted for 30 per cent of total value or one-half of the value of building construction. In terms of current dollars, construction has been credited with an average of 17 per cent of our gross national expenditure over the past 10 years. Construction value has increased by as much as 15 per cent in one year (1971 over 1970). An increase of 9.3 per cent is presently projected for 1973 when the total value is expected to reach $18.6 billion, up from $16.3 billion in 1972. Housing starts during 1973 reached a record – 268,529 compared with 249,914 in 1972. During 1973, the selling price index for cement increased only 1 per cent while that for concrete products rose 6.6 per cent. Cement manufacturing costs are likely to increase during 1974 mainly because of more costly fuel.

Forecasts for construction in 1974 include a growth of about 20 per cent to $22 billion which has been interpreted to indicate a 12 per cent increase in real growth. The outlook for engineering or heavy construction is good, with many major projects under way. Building construction is expected to increase greatly in value as the demand for housing is maintained and as capital spending by the non-residential sector is increased. There is a growing

Table 1. Canada, cement production and trade, 1972-73

	1972		1973p	
	(short tons)	($)	(short tons)	($)
Production[1]				
By province				
Ontario	3,761,195	76,213,423	4,111,000	82,216,000
Quebec	3,180,238	58,545,655	3,449,000	63,798,000
Alberta	902,500	22,605,772	1,006,000	25,161,000
British Columbia	919,189	20,994,112	947,000	21,793,000
Manitoba	566,019	14,750,762	594,000	15,438,000
Saskatchewan	137,016	4,253,478	205,000	6,353,000
Nova Scotia	..	4,825,000	..	5,290,000
New Brunswick	..	4,324,467	..	4,878,000
Newfoundland	..	2,708,668	..	3,167,000
Total	9,975,762	209,221,337	10,884,000	228,094,000
By type				
Portland	9,636,586	..	10,448,640	..
Masonry[2]	339,176	..	435,360	..
Total	9,975,762	209,221,337	10,884,000	228,094,000
Exports				
Portland cement				
United States	1,252,817	22,470,000	1,408,385	24,396,000
Other countries	1,122	38,000	1,203	42,000
Total	1,253,939	22,508,000	1,409,588	24,438,000
Cement and concrete basic products				
United States	..	16,214,000	..	20,867,000
Other countries	..	154,000	..	212,000
Total	..	16,368,000	..	21,079,000
Imports				
Portland cement, white				
United States	14,837	665,000	22,897	1,049,000
Belgium-Luxembourg	5,959	190,000	3,685	126,000
Japan	3,681	100,000	2,557	89,000
West Germany	–	–	35	2,000
Denmark	55	2,000	–	–
Total	24,532	957,000	29,174	1,266,000
Cement, nes[3]				
United States	8,059	677,000	95,153	2,574,000
Britain	9,101	421,000	3,216	176,000
Denmark	927	40,000	778	55,000
West Germany	221	20,000	335	31,000
France	393	13,000	–	–
Total	18,701	1,171,000	99,482	2,836,000
Total cement imports	43,233	2,128,000	128,656	4,102,000

	1972		1973p	
	(short tons)	($)	(short tons)	($)
Refractory cement and mortars				
United States	. .	2,170,000	. .	2,918,000
Ireland	. .	319,000	. .	850,000
Britain	. .	30,000	. .	32,000
Denmark	. .	24,000	. .	20,000
Netherlands	. .	3,000	. .	10,000
Other countries	. .	15,000	. .	12,000
Total	. .	2,561,000	. .	3,842,000
Cement and concrete basic products, nes				
United States	. .	349,000	. .	569,000
France	. .	–	. .	34,000
Mexico	. .	–	. .	32,000
West Germany	. .	51,000	. .	19,000
Britain	. .	151,000	. .	4,000
Total	. .	551,000	. .	658,000
Cement Clinker				
United States	17,316	413,000	5,043	125,000

Source: Statistics Canada.
[1] Producers' shipments, plus quantities used by producers. [2] Includes small amounts of other cements. [3] Includes grey portland, masonry, acid proof, aluminous and other specialty types of cement.
p Preliminary; nes Not elsewhere specified; . . Not available; – Nil.

concern that both labour and materials could be in short supply for the construction industry in 1974. Labour costs have increased by 9.7 per cent over last year and are expected to go up another 10 per cent in the residential building sector where material costs have risen 11 per cent. Non-residential building costs are up over 8 per cent including 11 per cent for material and 7 per cent for labour.

A typical feature of cement manufacturers is their diversification and vertical integration into related construction materials industries. Many cement companies also supply ready-mix concrete; stone aggregates; and preformed concrete products such as slabs, bricks and prestressed concrete units.

Markets for cement tend to be regional because transportation costs represent much of the laid-down price to the consumer and only rarely, as in the case of special cements, are shipments made beyond normal distribution boundaries. Production, therefore, is determined by the regional construction activity and by interpretation of construction intentions. In 1973, cement production in each of the provinces was greater than the 1972 production. This reflected the requirements of greater construction activity.

Cement production capacity at the end of 1973 was about 15.7 million tons a year, excluding the capacity of three plants which only grind clinker and including some listed capacity which could be reactivated or maintained only at considerable expense. Because most changes in capacity were not completed until near the end of the year, capacity utilization, at about 75 per cent, is based on capacity at the end of 1972.

Canada Cement Lafarge Ltd. brought its new 1.1 million-tons-a-year plant at Bath, Ontario into production towards the end of 1973 and phased out its Belleville, Ontario plant. Increases in grinding and storage capacity at the company's Havelock, N.B. operation will give that plant additional output potential. St. Marys Cement Limited completed the installation of a second kiln at its Bowmanville, Ontario plant during 1973. Lake Ontario Cement Limited increased the cement grinding capability of its Picton, Ontario plant with the installation of two roller mills late in 1973.

Capacity increases currently under construction include a 500,000-tons-a-year kiln at Canada Cement Lafarge's plant at St. Constant, Quebec, scheduled for completion in 1974, at a cost of $25 million; a new kiln, plant modernization and quarry development at the company's Exshaw, Alberta site, scheduled for completion in 1974, at a cost of $30 million; a new

Table 2. Canada, cement production, trade and consumption, 1964-73ᵖ

	Production[1]	Exports[2]	Imports[2]	Apparent Consumption[3]
	(short tons)			
1963	7,013,662	272,803	31,579	6,772,438
1964	7,847,384	297,669	32,680	7,582,395
1965	8,427,702	334,887	37,619	8,130,434
1966	8,930,552	407,395	50,615	8,573,772
1967	7,994,954	328,018	44,118	7,711,054
1968	8,165,805	366,506	51,500	7,850,799
1969	8,250,032	634,208	53,396	7,669,220
1970	7,945,915	566,521	97,191	7,476,585
1971	9,075,915	887,846	55,874	8,243,943
1972	9,975,762	1,253,939	42,233	8,765,056
1973ᵖ	10,884,000	1,409,588	128,656	9,603,068

Source: Statistics Canada.
[1] Producers' shipments plus quantities used by producers. [2] Does not include cement clinker. [3] Production plus imports less exports. ᵖPreliminary.

kiln at Lake Ontario's Picton plant, scheduled for completion in 1975, to add 850,000-tons-a-year capacity at a cost of $15 million; a new kiln and new mill installation at St. Marys Cement Limited's operation at St. Marys, Ontario, scheduled for completion in 1976, at an estimated cost of $30 million, to provide an additional 700,000-tons-a-year capacity; the establishment of a new plant at New Westminster, British Columbia, by Haida Cement Company Limited at an estimated cost of $25 million and a capacity of 330,000 tons a year; and a small-capacity plant at Clyde, 40 miles northwest of Edmonton, Alberta which is scheduled to use marl as a raw material. The latter is not included in Table 5 because complete details at time of writing are not available.

Canadian industry and developments

Atlantic region. There are three cement manufacturing plants in the Atlantic provinces serving the markets in the immediate area by road, rail and water transportation routes. The plants represent 5.6 per cent of Canadian cement production capacity in a region having 9.6 per cent of the total population of Canada.

A plant located at Corner Brook, Newfoundland, established in 1951, is operated by North Star Cement Limited. Limestone and shale, raw materials for the dry process being used, are quarried in the immediate area, and gypsum is purchased from The Flintkote Company of Canada Limited, which quarries gypsum at Flat Bay, about 60 miles south of Corner Brook. Shipments of portland cement are made by rail and by sea, mostly to provincial markets. Production depends directly on construction activity. The values of building permits issued, and of heavy construction awards were greater in Newfoundland during 1973. This was reflected in increased cement consumption. Lehigh Portland Cement Co., Allentown, Pennsylvania entered a joint agreement with British Newfoundland Exploration Limited (Brinex) to assess the raw materials available to support a cement manufacturing establishment in the Port au Port region of Newfoundland. The project could lead to a 1-million-tons-a-year plant aimed at export markets.

Nova Scotia's only cement manufacturing facility, a single-kiln, dry process plant incorporating the most modern analytical and control devices, was established in 1965 by Canada Cement Company, Limited (now Canada Cement Lafarge Ltd.) at Brookfield. Limestone at the plant site is chemically very close to a natural cement rock; but variations in lime, alumina and iron content necessitate the addition of iron oxide, coal ash and high-calcium limestone, all of which are available nearby. Gypsum is purchased from the Milford quarry of National Gypsum (Canada) Ltd., about 25 miles south of Brookfield. Portland cement is marketed in bulk or packaged under the brand name "Maritime" cement. During 1973, Nova Scotia cement production showed an increase over 1972, while the number of housing starts and the value of building permits issued increased substantially over the previous year. Heavy construction awards were increased in value over the same period.

Canada Cement Lafarge Ltd. also operates a cement-manufacturing plant at Havelock, New Brunswick. This plant, built in 1951 and expanded in 1966 by the addition of a second kiln, now has a capacity of 450,000 tons a year. The company increased plant capacity with the addition of heavier grinding equipment and with the addition of larger storage facilities. Shipments in 1973 were up about 12 per cent over 1972. Housing starts and the value of building permits issued in 1973 in New Brunswick were greater than in 1972, as was the value of heavy construction awards.

Quebec. In the Province of Quebec, five companies operate a total of seven cement manufacturing plants. Regionally, the companies producing cement in Quebec compete for the construction markets in the Montreal and Quebec City areas as well as for markets in more remote regions where major heavy construction projects are under way—the James Bay project, the Manicouagan project, and the iron ore development north of Port-Cartier. Preparations for the 1976 Olympics will add to construction activity in Montreal, and construction of the Ste-Scholastique airport project continues. In addition, major export markets have been developed in the United States over the past few years for both cement and cement clinker. Cement production in Quebec increased by about 10 per cent over the previous year.

The Montreal East plant of Canada Cement Lafarge Ltd. at Pointe-aux-Trembles has been operated as part of the Canada Cement complex since it was acquired in 1909. Material from the adjacent quarry approximates a natural raw mix which requires only minor amounts of sand, iron oxide and high-calcium limestone for corrective purposes. Situated a mile from docking facilities on the St. Lawrence River, the plant has access to water transportation, and ships to distribution warehouses in the Atlantic provinces and in areas bordering the Great Lakes as well as to local consumers. The plant capacity, 1.4 million tons a year, is second only to that of St. Lawrence Cement Company's Clarkson, Ontario plant, which has a capacity of 1.75 million tons a year. The Montreal plant is scheduled to be phased out some time after the company's new plant at Bath, Ontario comes on stream. Canada Cement Lafarge's plant at St-Constant, south of Montreal, has a capacity of 525,000 tons a year with current plans to add a new kiln of 500,000-tons-a-year capacity by 1974. The plant is modern, technically efficient and could conceivably replace some of the capacity of Canada Cement Lafarge's older Montreal East plant. The company's Hull operation is on the site where cement was first produced in Canada. From this location, areas of the Ottawa Valley are served. The Quebec government has indicated it will expropriate part of this property by mid-1974 and the entire property over the following 10 years.

Miron Company Ltd., with the second largest cement-producing capacity in the Montreal area, operates a dry process plant at St-Michel. The company also supplies concrete and other building materials to the construction industry and maintains a contracting division. During 1973 Genstar Limited of Montreal negotiated to acquire the majority of Miron shares. Genstar through its cement division, operates Inland Cement Industries Limited in Winnipeg, Regina and Edmonton, and Ocean Cement Limited in Bamberton, B.C.

St. Lawrence Cement Company has a plant at Villeneuve, near Quebec City, capable of manufacturing about 790,000 tons of cement a year. Limestone and shale are available at the site, iron oxide and gypsum are brought in by truck and rail. Finished products include normal portland cement, medium heat of hydration cement, high early strength cement, low heat of hydration cement and masonry cement. Shipments are made in bulk or in bags by truck and by rail.

Independent Cement Inc. began construction of its cement-manufacturing plant at Joliette, Quebec in 1965, and it went on stream in the fall of 1966 with a two-kiln operation capable of producing about 435,000 tons a year. A third kiln, adding about 220,000 tons a year to plant capacity, started up in 1970. In 1972, a fourth kiln of similar design was installed. This company has pursued an aggressive sales campaign and has captured a major share of the Montreal area markets.

Ciment Quebec Inc. was established in 1952 at St-Basile, 40 miles west of Quebec City, as a single-kiln operation. Two additional kilns were installed to boost production capacity to about 380,000 tons a year.

Ontario. Four companies operate a total of six cement-manufacturing plants in the Ontario region, serving industrial and urban growth areas in southern Ontario, and shipping to points in Quebec and northern Ontario as well as exporting to the United States. One other company operates a clinker grinding plant.

The industrialized and population-intense region surrounding Lake Ontario and Lake Erie continues to grow and, in so doing, provides markets for cement in many engineering, commercial, industrial and residential building projects, all of which were greater in 1973 than in the previous year. The Ontario cement producers represent 36.7 per cent of total-production capacity in a region occupied by about 36 per cent of the total Canadian population. The industry operated at about 83 per cent of capacity in 1973. Steady growth is indicated by heavy investment in additional capacity during 1973 as well as by announced intentions by producers to increase their capacities during the next few years.

Lake Ontario Cement Limited is one of Canada's largest cement exporters. The plant is located at Picton where favourable raw materials are situated adjacent to deep water, permitting comparatively inexpensive bulk shipments to be made to Great Lakes and St. Lawrence Seaway ports. Shipments, also made by truck and by rail to domestic markets, were at an all-time high in 1973. The company is planning a plant expansion to meet the expected growth in demand for cement and concrete products.

The Belleville plant of Canada Cement Lafarge Ltd., one of the original operations grouped to form the Canada Cement Company in 1909, was phased out of operation at the end of October, 1973, subsequent to the company's new 1.1-million-tons-a-year plant at Bath commencing start-up procedures in mid-September.

Canada Cement Lafarge operates a plant at Woodstock, Ontario capable of producing about 600,000 tons a year from a two-kiln, wet process. The plant was constructed in 1956 to serve the developing area of southwestern Ontario. Clay overburden from the limestone quarry is of a quality that can be utilized in manufacturing masonry cement, high early strength cement and normal portland cement.

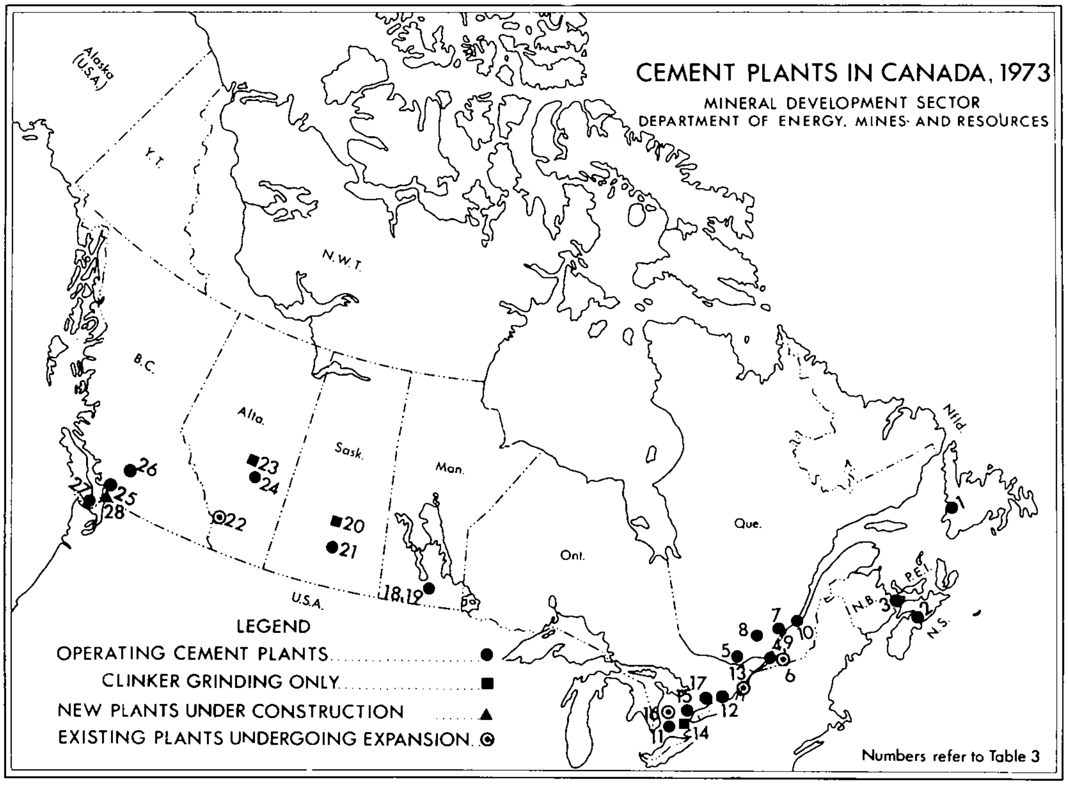
St. Lawrence Cement Company constructed its Clarkson, Ontario plant in 1957 and with the expansion to 1.75 million tons a year in 1968 it became Canada's largest producing plant. The plant now combines a wet and dry process.

Limestone for the plant is brought in by boat from Ogden Point, 100 miles east of Toronto on the north shore of Lake Ontario. A mile-long, overhead, covered

Table 3. Cement plants – approximate annual capacities, end of 1973

Company	Plant Location	Process	Capacity
			(short tons)
Atlantic region			
1. North Star Cement Limited	Corner Brook, Newfoundland	dry	175,000
2. Canada Cement Lafarge Ltd.	Brookfield, N.S.	dry	262,000
3. Canada Cement Lafarge Ltd.	Havelock, N.B.	dry	450,000
Total Atlantic region			887,000
Quebec			
4. Canada Cement Lafarge Ltd.	Montreal	wet	1,400,000[1]
5. Canada Cement Lafarge Ltd.	Hull	wet	210,000
6. Canada Cement Lafarge Ltd.	St-Constant	dry	525,000[2]
7. Ciment Quebec Inc.	St-Basile	wet	380,000
8. Independent Cement Inc.	Joliette	dry	875,000
9. Miron Company Ltd.	St-Michel	dry	1,050,000
10. St. Lawrence Cement Company	Villeneuve	wet	787,500
Total Quebec region			5,227,500
Ontario			
11. Canada Cement Lafarge Ltd.	Woodstock	wet	595,000
12. Canada Cement Lafarge Ltd.	Bath	dry	1,100,000
13. Lake Ontario Cement Limited	Picton	dry	875,000[2,3]
14. Medusa Products Company Canada, Limited	Paris	grinding only	
15. St. Lawrence Cement Company	Clarkson	wet/dry	1,750,000
16. St. Marys Cement Limited	St. Marys	wet	743,000[4]
17. St. Marys Cement Limited	Bowmanville	wet	700,000
Total Ontario region			5,763,000
Manitoba			
18. Canada Cement Lafarge Ltd.	Fort Whyte	wet	630,000
19. Inland Cement Industries Limited	Winnipeg	wet	350,000
Saskatchewan			
20. Canada Cement Lafarge Ltd.	Floral	grinding only	
21. Inland Cement Industries Limited	Regina	dry	227,500
Alberta			
22. Canada Cement Lafarge Ltd.	Exshaw	wet	543,000[3]
23. Canada Cement Lafarge Ltd.	Edmonton	grinding only	
24. Inland Cement Industries Limited	Edmonton	wet	577,500
Total Prairie region			2,328,000
British Columbia			
25. Canada Cement Lafarge Ltd.	Lulu Island	wet	612,500
26. Canada Cement Lafarge Ltd.	Kamloops	dry	210,000
27. Ocean Construction Supplies Limited	Bamberton	wet	700,000
28. Haida Cement Company Limited	New Westminster	dry	330,000[5]
Total British Columbia region			1,522,500
Total capacity (58 kilns)			15,728,000

Source: Published data and company communication.
[1]Likely to be phased out. [2]Capacity to be increased 1974. [3]Capacity to be increased 1975. [4]Capacity to be increased 1976. [5]Not included in totals. Under construction.



conveyor is used to transport stone from the lake carriers to the plant. Gypsum is trucked from producers in southwestern Ontario. The market area for finished cement product is mainly the Toronto-Hamilton strip and southern Ontario served by rail and truck deliveries. Large quantities of clinker are exported to United States points.

Table 4. Canada, cement plants, kilns, production and capacity, 1969-73

	Plants	Kilns	Approximate Annual Capacity	Production	Capacity Utilization
			(tons)	(short tons)	(%)
			(end of year)		
1973	24	58	15,728,000	10,884,000	69
1972	24	59	14,948,000	9,962,455	67
1971	24	58	14,729,000	9,326,312	63
1970	24	58	14,729,000	7,945,915	54
1969	23	56	14,301,000	8,250,032	58

Source: Data supplied by companies to Mineral Development Sector.

St. Marys Cement Limited operates two plants in Ontario. The original plant at St. Marys was constructed in 1912 to serve the Toronto area. It has been expanded and modernized over the years and remains a major producer capable of turning out about 750,000 tons a year. A new and highly automated plant, built at Bowmanville during 1967 and 1968, was expanded during 1973 with the addition of a second kiln to increase capacity to 700,000 tons a year. The plant is favourably situated to ship product via truck and rail to the major marketing area of metropolitan Toronto.

Medusa Products Company of Canada, Limited, of Paris, Ontario grinds a white clinker imported from the Medusa plant at York, Pennsylvania. The white cement is sold mainly in Ontario.

Prairie region. Two companies, Canada Cement Lafarge Ltd. and Inland Cement Industries Limited, operate a total of five clinker-producing plants in the Prairie region along with two clinker-grinding plants. The region accounts for 14.8 per cent of Canadian cement-producing capacity exclusive of the grinding plants and during 1973 produced at approximately 80 per cent of that capacity.

Table 5. Canada destination of domestic cement shipments,[1] 1973

	(short tons)
Ontario	3,978,842
Quebec	2,606,916
Rest of Canada	3,200,187
Canada total	9,785,945
Exports	1,257,594
Total shipments	11,043,539

Source: Statistics Canada.
[1]Special compilation. Direct sales from producing plants.

Canada Cement Lafarge Ltd. operates a plant at Fort Whyte, near Winnipeg, Manitoba. The original facility has been enlarged and rebuilt several times and is today a highly efficient plant capable of producing 630,000 tons of cement a year. High-calcium limestone is obtained from the company's quarry at Steep Rock on the shore of Lake Manitoba, gypsum from Silver Plains, silica from Beausejour and clay from Fort Whyte. Products include portland cement, sulphate-resisting cement, oil well cement and masonry cement for a market area extending from the United States border to the most northerly populated areas and eastward halfway across northern Ontario.

At Exshaw, Alberta, a cement plant has been operated by the Canada Cement group since 1910. Major improvements under way and planned for the Exshaw plant will result in a net increase in production capacity of about 40 per cent to 700,000 tons a year. A new quarry site will be developed and will require the relocation of several roads and structures in Exshaw. Finished cement is shipped by rail and truck to consumers in eastern British Columbia, Alberta and western Saskatchewan. Large quantities of clinker are shipped to the company's grinding, storage and distributing plant at Edmonton, Alberta. A facility at Floral, near Saskatoon, Saskatchewan was built in 1964 as a distribution terminal and in 1966 was expanded to include clinker-grinding equipment. When the demand for cement warrants, the Floral establishment can be expanded further to become a fully integrated cement manufacturing and distributing plant. Clinker for the Floral plant currently is obtained from Fort Whyte.

Inland Cement Industries Limited, a Genstar Limited subsidiary, operates three cement-manufacturing plants–one in Winnipeg, Manitoba, one in Regina, Saskatchewan and one in Edmonton, Alberta. The Winnipeg plant came on stream in 1965 to increase the company's total production capacity to over 1 million tons a year. A limestone quarry at Mafeking, Manitoba, near the Manitoba–Saskatchewan border, supplies limestone to the Regina plant while the Winnipeg plant is supplied from Steep Rock. The Edmonton plant is supplied from Cadomin, Alberta, by a 5,000-ton-unit train which is part of a total, automated, materials-handling system. Other raw materials are obtained close to the plant sites. A market area stretching east to the Lakehead and west to central British Columbia is served by Inland's facilities.

Houg Cement, Limited, Edmonton was scheduled to produce cement from marl early in 1974 near Clyde some 40 miles northeast of Edmonton. Details are limited, but a $5 million expenditure for a 60,000-tons-a-year plant has been reported. Local markets would consist principally of ready-mix operations.

Pacific region. Increased construction activity in the British Columbia region is reflected in greater cement consumption during 1973 and in the fact that a new cement-producing operation is being planned. Haida Cement has scheduled a new plant of 330,000-tons-a-year capacity to be built at New Westminster by 1976 at a cost of $25 million.

Early in 1973, eight companies operating in the cement-concrete industry in British Columbia were charged in provincial court under the Combines Investigation Act for illegally lessening and preventing competition in the supply and sale of cement and ready-mix concrete. The case continued into 1974.

Canada Cement Lafarge Ltd. produces cement at Richmond on Lulu Island near Vancouver, British Columbia using limestone barged down the Strait of Georgia from a quarry at Vananda on Texada Island. The plant was built in 1958 and later the capacity was doubled to the present 612,000 tons a year. A new plant with a capacity of over 210,000 tons a year began production in 1970 at Kamloops, British Columbia.

Ocean Cement & Supplies Ltd. quarried limestone at Bamberton on Vancouver Island for cement manufacture and for use as an aggregate. The cement plant has a capacity of about 700,000 tons a year. Inland Cement Industries Limited and Ocean Cement & Supplies Ltd. are now operated as a cement division of Genstar.

Markets and trade

Cement markets are regional in scope and are centred in developing or growing urban areas where construction activity is concentrated, or in areas where mining or heavy engineering construction projects are being performed. The market area influenced by a given cement-producing plant is dependent on the amount of transportation cost that the selling price can absorb. A potential large volume of sales could warrant a secondary distribution terminal; water transportation to a distribution system could extend a plant's market area even farther. Because raw materials for cement manufacture are available in nearly all areas, most countries can supply their own cement requirements if the market volume warrants a plant. Few countries

Table 6. Canada, mineral raw materials[1] used by the cement industry

Commodity	1971	1972^p
	(short tons)	
Shale	945,224	671,491
Limestone	13,422,375	13,978,794
Gypsum	399,915	494,476
Sand	161,767	246,370
Clay	1,173,700	1,032,047
Iron oxide	81,503	91,410

Source: Statistics Canada.
[1]Includes purchased materials and materials produced from own operations.
^{p}Provisional.

rely entirely on imports for their cement needs. However, some countries rely heavily on export markets for their cement production in order to operate facilities economically.

Specialty cements, such as white cement, are transported greater distances than ordinary grey portland cement, when the transportation costs do not represent as high a proportion of the landed price and when quantities are generally much smaller than for portland cement.

Cement from plants in the United States and Canada is traded between the two countries where competition and tariffs permit. The current situation in which record amounts of both cement and clinker are being exported to the United States market is an anomaly created by the combined effects of a cement shortage in parts of the United States and an extremely buoyant construction industry, particularly in the south and southeast. Canadian market areas are reflected in the distribution of shipments from Canadian producers, shown in Table 5.

Although cement is used mainly in the construction industry, significant amounts are used in the mining industry to consolidate backfill, where mining methods dictate. Amounts so used grew from about 5,000 tons in 1960 to a reported 231,000 tons in 1970, the increase being related to the mechanization of backfilling techniques and to research conducted with support from National Research Council's Industrial Research Assistance Program. In 1972, the amount so used was recorded as 202,397 tons in 15 operations.

The use of a gypsum-free portland cement in a new patented process for the production of cold-bonded iron ore pellets offers an interesting market possibility.

Outlook

Construction in Canada will continue to show an annual increase in value, and cement producers will have to compete with all other building materials to obtain a share of the construction dollar. Not only is practical research in the use of cement-concrete needed, but effective advertising and public relations must be used to encourage acceptance of modular construction at a time when reasonably priced, attractive and convenient housing units are in short supply. In general, modest gains are expected in the near term with activity across the country expected to range from promising to cautious. The availability of other construction materials will play a major role in determining the amount of cement required for construction. Projects have been delayed because of shortages of steel, rebar, gypsum products, etc. Work stoppages in the transportation industry seriously

Table 7. Capacity changes during 1973, cement plants

Company	Plant Location	Net Increase (decrease)	Approximate Cost	Remarks
		(tons/year)	($ million)	
New Brunswick				
Canada Cement Lafarge Ltd.	Havelock	100,000	5	Additional grinding and storage capacity
Ontario				
Canada Cement Lafarge Ltd.	Bath	1,100,000	55	New plant. Heat on September
Canada Cement Lafarge Ltd.	Belleville	(770,000)		Phased out October 31
St. Marys Cement Limited	Bowmanville	350,000	15	New Kiln. Heat on November
	Total	780,000	75	

Source: Mineral Development Sector.

Table 8. Planned capacity increases, cement plants

Company	Plant Location	Net Increase	Expected Date of Completion	Approximate Cost	Remarks
		(tons/year)		($ million)	
Quebec					
Canada Cement Lafarge Ltd.	St. Constant	500,000	1974	25	New kiln (second)
Ontario					
Lake Ontario Cement Limited	Picton	150,000	1974	6	New cement grinding capability (2 roller mills)
		850,000	1975	15	New kiln (fourth)
St. Marys Cement Limited	St. Marys	700,000	1976	30	New kiln (sixth) and new mill
Alberta					
Canada Cement Lafarge Ltd.	Exshaw	200,000	1975	30	New kiln (sixth) plant modernization and new quarry development
British Columbia					
Haida Cement Company Limited	New Westminster	330,000	1975	25	New plant
	Total	2,730,000		131	

Source: Mineral Development Sector.

delayed construction. The shortage of skilled labour could reach problem proportions for the construction industry, if not generally, certainly in some regions as more and larger projects are undertaken. In general, labour relations in the construction industry have shown improvement with a mature and national approach to labour-management problems which, hopefully, will continue and thereby do much to reduce the cyclical aspects of the industry.

The cement industry in Canada is capable of meeting the immediate demands on it and is in a position to expand in anticipation of even greater demand.

New plants are being built and existing ones are being expanded utilizing modern equipment and techniques of manufacture. New plant locations are suitably situated with respect to both resource material and markets. The expense of adapting older facilities to meet newly imposed environmental control regulations can contribute to a decision in favour of a new plant, and has, in the United States, forced a number of plant closures. Continued diversification and vertical integration by cement producers will eventually result in the write-off of some comparatively inefficient production capacity as the emphasis on a cement-concrete industry increases. Although individual companies continue to conduct research relative to cement production, much experimentation concerning the use of cement and concrete is done through the Portland Cement Association (PCA), an industry-supported, nonprofit organization whose purpose is to improve and extend the uses of cement and concrete through scientific research and engineering fieldwork. The Association is active in all parts of Canada, and can offer detailed information on concrete use, design and construction from its regional offices.

Specifications

Portland cement used in Canada should conform to the specifications of CSA Standard A5-1971 published by the Canadian Standards Association. This standard covers the five main types of portland cement as follows: Normal, Moderate, High Early Strength, Low Heat of Hydration, and Sulphate-

Table 9. Cement, world production and capacity

Country	Annual Capacity[e] 1973	1972	1973[e]
	(thousand short tons)		
United States (incl. Puerto Rico)	87,600	83,697	87,400
Canada (shipments)	10,884	9,976	11,000
Other North America (except Cuba)	17,000	13,668	14,600
Total North America	115,484	107,341	113,000
South America	35,000	29,506	30,600
Europe (free)	247,000	215,110	230,600
Asia (free)	165,400	133,042	145,000
Africa	28,000	22,180	24,000
Oceania	8,000	6,531	6,800
Communist Countries (except Yugoslavia)	235,000	188,922	205,000
World Total	833,884	702,632	755,000

Data source: U.S. Bureau of Mines, Commodity Data Summaries, January 1974.
[e]Estimate.

Resisting Portland cements. Masonry cement produced in Canada should conform to the CSA Standard A8 – 1970.

The cement types manufactured in Canada and not covered by the CSA standards generally meet the appropriate specifications of the American Society for Testing and Materials (ASTM).

Cembureau, The European Cement Association, has published *Cement Standards of the World – Portland Cement and its Derivatives,* in which standards are compared. Cembureau's *World Cement Directory* lists production capacities by company and by country.

Table 10. World production of cement, 1962 to 1972

	1962	1972	Increase %
	(thousand short tons)		
U.S.S.R.	62,634	114,684	83
United States	66,163	83,697	27
Japan	31,732	66,841	111
West Germany	31,518	47,559	51
Italy	22,236	36,879	66
France	18,609	33,387	79
Spain	8,041	21,429	167
Britain	15,714	19,894	27
India	9,466	17,306	83
Poland	8,316	15,417	85
China	8,818	15,400	75
Canada	6,878	9,976	45
Czechoslovakia	6,294	8,863	41
Other countries	97,940	211,300	116
Total	394,359	702,632	

Source: Statistics Canada; U.S. Bureau of Mines *Minerals Yearbook,* 1964 for 1962. United Nations Monthly Bulletin of Statistics, February 1974.

World review

Because of the direct relationship of cement-concrete construction, the production and, more particularly, the consumption of cement can be monitored as an indication of a country's rate of development.

World production was close to 700,500,000 tons, up between 7 and 8 per cent from 1972. Even greater additions to production capacities than those witnessed during the past few years will be needed to meet demand in many developing countries. The

Table 11. World cement production, per capita, 1962 and 1972

	1962 (pounds)	1972 (pounds)	Increase %
Belgium	1,145	1,611	41
West Germany	1,151	1,542	34
Italy	885	1,357	53
France	792	1,291	63
Japan	669	1,250	87
Spain	522	1,243	138
Czechoslovakia	908	1,224	35
U.S.S.R.	566	927	64
Canada	740	913	23
United States	709	802	13

Table 12. Canada, production of concrete products

	1972	1973^p
Concrete bricks (number)	$125,691,505^r$	176,206,297
Concrete blocks (except chimney blocks)		
Gravel (number)	$180,960,733^r$	214,326,843
Other (number)	41,316,111	42,502,255
Concrete drain pipe, sewer pipe, water pipe and culvert tile (short tons)	1,510,442	1,555,674
Concrete ready mix (cubic yards)	15,520,378	17,351,556

Source: Statistics Canada.
^{r}Revised; ^{p}Preliminary.

following items are indicative of trends in the regions noted, but in no way represent a total coverage.

Asia. In Japan, Mitsubishi Cement, Hokoku Cement and Mitsubishi Mining Companies merged to form Mitsubishi Mining and Cement Co. Ltd. In a continuation of the trend to larger kilns, Chichibu Cement plans to add a 2.2-million-tons-a-year wet-process unit at its Kumagaya plant, while a 2.5-million-tons-a-year suspension preheater kiln is to be added to the Isa plant of Ube Industries.

In Taiwan, Cheng Tai Cement Corp. plans a 500,000-metric-tons-a-year dry-process plant at Tsying.

Cement Corp. of India announced plans to invest \$69 million in three 400,000-tons-a-year plants. Pakistani companies will install a total of 2.5 million tons a year of new cement-producing capacity by 1976.

Cibinong Cement Co. plans a \$14.5 million, 500,000 metric ton cement plant in West Java, Indonesia. The firm is 51 per cent owned by a subsidiary of Kaiser Cement & Gypsum Co. Twenty-five per cent is owned by the largest Indonesian producer, P. T. Semen Gresik. Mitsubishi Corp. of Japan will supply the equipment to double capacity before 1976 if demand in the West Java and Jakarta areas increases as anticipated. The plant is scheduled to go on stream in late 1974. Cement Industries of Malaysia Sdn. Bhd. will construct a \$38 million quarry and cement plant at Perlis. German, French and U.S. interests also are involved.

A 500,000-tons-a-year plant in Central Java will be built by Indonesian holding company P. T. Gunnung Ngadeg Djaja in cooperation with two Japanese firms – Mitsui & Co. Ltd. and Onoda Cement Co. at a cost of \$56 million.

A new Indonesian cement plant, with production capacity of 500,000 tons a year, will be built by Morrison-Knudsen's international subsidiary. The contract totals \$6.3 million.

The Siam Cement Co. is to enlarge its plant at Kaeng Khoi, Thailand with the addition of a second production unit, giving the company a total capacity of 3.4 million tons a year from three locations.

Europe. The Italian cement industry which was reported in apparent crisis during 1971 and 1972 recovered nicely to record increased production mainly because of expanded export trade. Production capacity is currently about 45 million tons a year from 116 plants, with forecasts of reaching 47.7 million tons a year by 1976.

In France, the cement industry has grown to rank sixth in the world. In the process the number of current firms has dropped from 37 to 18 during 10 years with the trend to larger plants and to a more concentrated production effort.

Israel, faced with the need to import about 1 million tons of cement a year will bring on a new 400,000-tons-a-year plant at Mitzpe Ramon, Negev.

The Halkis Cement Co. S.A. of Athens will expand its Halkis plant by 1 million tons a year, for a total of 2.6 million tons a year. Cost of the project will be more than \$20 million. A long-term agreement has been signed by Atlantic Cement Company (Newmont Mining Corporation) and Cia Valencia de Cementos Portland of Spain for the acquisition by Atlantic of at least \$120 million worth of cement over the next decade. The material will be shipped from the port of Valencia in Norwegian 22,000 ton self-unloading vessels, arriving at Atlantic terminals in Boston; Bayonne, N.J.; Norfolk; Baltimore; Savannah; and Jacksonville.

In general, the European cement-producing industry is continuing to grow dramatically in anticipation of greater demands on it in the near future. Important producers in the communist bloc are Russia with over 100-million-tons-a-year capacity, Poland with six new plants planned and over 14-million-tons-a-year capacity, Romania and Czechoslovakia.

Africa. In South Africa, increasing domestic and export markets for cement together with an increase in price have prompted an interest in new plant installation.

Oceania. Three cement producers were recently registered in the Philippines. Marinduque Mining and Industrial Corporation will export clinker and cement to Vietnam, Borneo, Hong Kong, Singapore and Japan. Baenotan Consolidated Industries Inc., the leading exporter of cement and clinker, have contracted with Asia Cement (Malaysia) PTE Ltd. of Singapore to supply clinker on a five-year contract. The third company, Hi Cement Corporation is also a major exporter.

South America. Fabrica National de Cementos of

Ocumare, Venezuela will expand its plant with the addition of 1,750-tons-a-day capacity. Equipment will include a 240 foot kiln, a four stage cyclone preheater and an electrostatic precipitator.

North America. To meet the projected demands of industrial expansion, in the late 1950's many cement companies added to their production capacities with the result that the North American industry developed a total capacity in excess of that required to meet the demand. The cement industry had then to 'sell' its product by providing services and technical assistance to consumers and by researching new and competitive construction uses for concrete. Vertical integration, diversification and mergers, although always a part of the cement industry, have become more common on the North American scene.

About 16 per cent of world cement production comes from North America, with the United States contributing nearly 80 per cent of the total, and Canada and Mexico following in that order. Numerous plant changes and additions have been announced throughout the industry in North America. Virtually all plants are undergoing some modernization and improvement of dust-collecting facilities because of new or anticipated pollution control standards and a few plants in the United States have cited this as a reason for closure. Canada's cement capacity, together with that planned to come on stream during the next two years, permits export of clinker and cement without harm to domestic markets. A realistic, practical, production capacity, as opposed to a listed capacity, would probably indicate surprisingly little excess production capability in Canada's cement industry. This would be especially obvious in certain regions of the country, and at the height of activity during a construction year.

In the United States, low prices, high costs, low profit margins and under capacity are of major concern to the cement industry. The energy situation will undoubtedly have an influence on these items either directly or indirectly, as will environment regulations. No new plants were opened in 1973 in the United States. There were eight major expansions in which a total of seven new kilns and 17 new grinding mills were added. The eight major improvement and expansion programs involving new kilns, kilns and mills, etc., were those of the Ash Grove Cement Co., Louisville, Nebr.; The Flintkote Company, Glens Falls Portland Cement Div., Glens Falls, N.Y.; the Ideal Cement Company, (Division of Ideal Basic Industries, Inc.) Trident, Mont.; the Louisville Cement Co., Speed, Ind.; the Marquette Cement Co., Oglesby, Ill.; the Monarch Cement Co., Humboldt, Kans.; the Louisiana Cement Co., New Orleans, La. and the Santee Portland Cement Co., Holly Hill, S.C. The Ash Grove installation is actually the first phase of a three-stage program to replace an old plant, and the Marquette, Glens Falls and Ideal installations are essentially new plants alongside old ones. The only plant known to have been shut down permanently in 1973 was that of Ideal Basic Industries, Inc. at San Juan Bautista, Calif.

By the end of 1973, the United States cement industry had a capacity of 94 million tons a year. Eleven expansions, plus two new plants scheduled for 1974 will add about 4.7 million tons a year to that capacity.

Table 13. Canada, value of construction 1972-73

	1972			1973[1]		
	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total
			(thousands of dollars)			
Newfoundland	199,980	280,404	480,384	173,987	240,960	414,947
Nova Scotia	234,748	226,397	461,145	272,397	271,395	543,792
New Brunswick	215,005	159,740	374,745	237,627	179,528	417,155
Prince Edward Island	45,324	18,360	63,684	54,789	18,441	73,230
Quebec	2,255,142	1,377,384	3,632,526	2,412,724	1,492,843	3,905,567
Ontario	4,206,634	2,025,906	6,232,540	4,230,006	2,228,943	6,458,949
Manitoba	402,912	342,034	744,946	443,828	395,762	839,590
Saskatchewan	257,446	320,022	577,468	287,671	332,118	619,789
Alberta	918,999	1,047,101	1,966,100	907,050	1,265,628	2,172,678
British Columbia, Yukon, Northwest Territories	1,369,795	1,124,206	2,494,001	1,377,749	1,234,428	2,612,177
Canada	10,105,985	6,921,554	17,027,539	10,397,828	7,660,046	18,057,874

Source: Statistics Canada.
[1] Intentions.

In a move which illustrates the position of cement producers in Canada, Europe and the United States, Lone Star Industries Inc., and Canada Cement Lafarge, Ltd. signed an agreement to form Citadel Cement Corporation, Atlanta, Georgia. Each will own 50 per cent of the new company with Lone Star providing two plants – at Roanoke, Virginia and at Birmingham, Alabama – and Canada Cement Lafarge supplying $30 million capital. Capacity of the Roanoke plant is to be doubled by 1975 and a new 750,000-tons-a-year plant is planned for Demopolis, Alabama.

Mexico. General Portland, Inc. contracted with Cementos Anahuac del Golfo SA. for shipment of 750,000 tons a year during 1976-1979. Earlier negotiations to acquire equity in the Mexican firm's Tamuin plant have ceased. A $23.9 million expansion project is planned for the Orizaba, Mexico plant of Cementos Veracruz SA. Production capacity will be increased from 250,000 to 600,000 metric tons a year. Twenty per cent of Cementos Veracruz is owned by Holderbank of Switzerland, which supplies it with technical and managerial assistance under a long-term contract; five per cent belongs to Cementos Apasco and the rest to other Mexican investors; $10.5 million is being invested by International Finance Corporation, Washington, D.C.

Tariffs

Canada Item No.		British Preferential (¢)	Most Favoured Nation (¢)	General (¢)
29000-1	Portland and other hydraulic cement, nop; cement clinker per 100 lb	free	free	6
29005-1	White, nonstaining portland cement, per 100 lb	4	4	8

United States Item No.		On and After Jan. 1, 1972 (¢ per 100 lb incl. weight of container)
511.11	White nonstaining portland cement	1
511.14	Other cement and cement clinker	free
		(%)
511.21	Hydraulic cement concrete	free
511.25	Other concrete mixed	7.5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States (Annotated), 1972, TC Publication 452.

Chromium

M.A. BOUCHER

Canada does not have mineable grade chromium deposits and, therefore, relies on imports. In 1973, Canadian imports of chromium in ores and concentrates amounted to 27,597 short tons valued at $2.1 million compared with 24,728 tons valued at $1.7 million in 1972. Table 1 shows that the United States is one of Canada's major suppliers of chromite; however, it is all re-exported material, originating mainly from South Africa and U.S.S.R. Imports of ferrochromium were 38,280 tons valued at $9.2 million in 1973 compared with 15,204 tons valued at $4.4 million in 1972. Most of our ferrochromium comes from South Africa.

Increased imports of ferrochromium were also reported by other major steel producing countries because, in 1973 more ore was converted to ferrochromium by two important ore producers; i.e., Rhodesia and the Republic of South Africa.

Canadian production and consumption of ferrochromium

Chromite deposits in Canada are of low tonnage and of low Cr:Fe ratio so they cannot be mined economically. Ferrochromium (charge chrome) is produced in Canada by Union Carbide Canada Limited at Welland, Ontario. However, the plant is expected to close late in 1974 because of the high cost of eliminating pollution from its old furnaces. At the time of closure, the company will have accumulated enough material to cover its sales for the year 1975.

Consumption of chromium in the form of ore and ferrochromium has been about 40,000 short tons a year over the past five years. Based on Canadian crude steel production forecasts, it is predicted that by 1980, Canadian ferrochromium consumption will be about 36,000 short tons (gross weight).

Important consumers of chromium include Atlas Steels Division of Rio Algom Mines Limited; The Steel Company of Canada, Limited; Colt Industries (Canada) Ltd.; Quebec Iron Foundries Ltd.; and Fahralloy Canada Limited. Among the manufacturers of chromite-bearing firebrick cement and mortars are: Dresser Industries Canada, Ltd.; Kaiser Refractories Company, Division of Kaiser Aluminum & Chemical Canada Limited; and Quigley Company of Canada Limited.

World production and trade

Estimated world mine production of chromite was 6.90 million tons in 1973 compared with 6.84 million tons in 1972 and 6.91 million tons in 1971. The U.S.S.R. and the Republic of South Africa are the two most important producers, followed by Turkey, Albania, Rhodesia and the Philippines.

The United States does not produce any chromite and, in 1973, imports of chrome ore totalled 931,000 tons, down 12 per cent from 1972. During the period from 1969 to 1972, the major suppliers of chromite to the United States were: U.S.S.R., 32 per cent; Republic of South Africa, 30 per cent; Turkey, 18 per cent; the Philippines, 14 per cent; and others, 6 per cent. Total U.S. imports of ferrochromium alloys rose sharply from 141,000 tons in 1972 to a record 155,000 tons in 1973. Low-carbon ferrochromium accounted for 43,000 tons, and high-carbon ferrochromium accounted for 112,000 tons. Low-carbon ferrochromium came mainly from South Africa, Japan, Sweden and Rhodesia, while high-carbon ferrochromium came mainly from Rhodesia and South Africa.

Increased pollution control costs combined with domestic price restrictions, energy problems and increased competition from Rhodesia and South Africa forced Foote Mineral Company and Ohio Ferro-Alloys to close their plants at the end of 1973 leaving Airco Alloys, Union Carbide Corporation and Chromium Mining & Smelting Corporation, Limited as the only United States chrome alloy producers. The future of ferrochromium production in the United States is uncertain. It will depend upon the Environmental Protection Agency's final decision on its proposed standards for ferroalloy plants as well as the availability of ore and the ability to compete with low-cost South African and Rhodesian material.

Japan, another important consumer of chromium, relies almost entirely on imports. During 1973, Japanese ferrochromium producers succeeded in gaining firm commitments from Turkey for a total of 2.6 million tons of chromite over the next 10 years. Also, basic agreements have been reached between Japanese companies and Brazil to establish a joint venture for ferrochromium production in Brazil. The plant will have a capacity of 35,000 tons a year, with production slated to start in 1976. The Japanese interests are expected to hold 49 per cent of the venture and most of the output is expected to go to Japan. Plans include doubling the capacity if demand requires. Production of ferrochromium increased considerably during 1973-74, compared with 1972-73. Latest figures show a production of 508,830 metric tons for 1973-74 and 333,053 metric tons for 1972-73. Over 75 per cent of the total consists of high- and medium-carbon ferrochromium.

Table 1. Canada, chromium trade and consumption, 1972-73

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Imports				
Chromium in ores and concentrates				
United States	12,731	1,005,000	9,476	845,000
Philippines	3,407	254,000	11,778	816,000
Cyprus	2,778	265,000	3,763	352,000
South Africa	2,209	108,000	2,580	80,000
Mozambique	3,383	80,000	–	–
Ireland	220	30,000	–	–
Total	24,728	1,742,000	27,597	2,093,000
Ferrochromium				
South Africa	11,413	3,110,000	25,142	5,451,000
United States	3,148	1,113,000	7,406	2,325,000
Yugoslavia	–	–	2,204	702,000
Brazil	–	–	2,862	499,000
Norway	195	50,000	386	110,000
Sweden	190	55,000	273	95,000
West Germany	38	22,000	7	4,000
Japan	220	85,000	–	–
Total	15,204	4,435,000	38,280	9,186,000
Chromium sulphates basic for tanning				
United States	1,609	263,000	837	228,000
Britain	120	26,000	225	47,000
Japan	310	59,000	111	24,000
Total	1,499	348,000	1,173	299,000
Chromium oxides and hydroxides				
United States	485	325,000	622	457,000
France	–	–	636	415,000
Britain	478	333,000	207	149,000
Netherlands	–	–	62	41,000
Belgium and Luxembourg	19	10,000	55	40,000
West Germany	16	14,000	27	30,000
Japan	5	2,000	10	5,000
U.S.S.R.	132	65,000	–	–
Italy	39	21,000	–	–
Total	1,174	770,000	1,619	1,137,000

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Chrome dyestuffs				
West Germany	22	91,000	14	69,000
United States	28	50,000	22	65,000
Switzerland	31	51,000	28	44,000
Netherlands	3	7,000	4	16,000
Japan	6	11,000	6	12,000
Britain	7	15,000	2	9,000
Poland	–	–	1	2,000
France	–	–	1	3,000
Italy	1	3,000	–	–
Total	98	228,000	78	220,000
Consumption (chromite)	62,712	. .	38,030	. .

Source: Statistics Canada.
^{p}Preliminary; – Nil; . . Not available.

In line with the recovery of world steel production, the South African chromite and ferrochromium industries are improving. The principal producer is Transvaal Consolidated Land and Exploration Co. Ltd. followed by Union Corporation Limited and Union Carbide Corporation. The principal producer of ferrochromium is African Metals Corporation, a state-owned company with captive mines. Exports of ferrochromium have improved because of the closing of plants in different parts of the world and the switching of production overseas for environmental reasons.

The chrome industry is expanding in Rhodesia. Rhodesian chrome continues to be in demand as a result of its high quality. Metallurgical grade ore has a chrome to iron ratio of between 2:1 and 3:1 compared with South Africa's general ratio of about 1:5. In spite of sanctions, Union Carbide Corporation has expanded its operation at its Que Que smelters. Union Carbide Corporation operates two mines and a smelter, it is reported to be Rhodesia's main producer of chrome ore. By mid-1975 or early in 1976 Rhodesian ferrochromium production capacity is expected to triple to 400,000 tons a year. According to the U.S. Bureau of Mines, 67 per cent of the metallurgical chrome reserves of the world are in Rhodesia.

Uses

Most chromite consumed by the metallurgical industry is converted to ferrochromium and then consumed in the manufacture of stainless, high-speed and other alloy steels. About 90 per cent goes into various grades of stainless steel where it is an essential component. In stainless steel about 250 to 400 pounds of chromium are used in each ton of steel produced in order to promote hardenability, increase resistance to abrasion and wear and retard corrosion. The cost of chromium represents about 6 per cent of the selling price of most stainless steels. Much smaller amounts are used in many of the lower alloy and carbon steels.

Table 3. World production of chromium ore, 1971-73

	1971	1972	1973^e
		'000 st	
U.S.S.R.	1,980	2,040	2,000
Republic of South Africa	1,812	1,635	1,700
Albania	589	671	720
Turkey	665	710	700
Rhodesia	400	400	400
Philippines	476	388	400
India	288	310	
Iran	194	198	
Malagasy Republic	154	154^e	
Finland	123	123^e	
Pakistan	27	36	
Cyprus	45	33	980
Brazil	31	33	
Yugoslavia	38	31	
Japan	35	27	
Greece	27	26^e	
Sudan	23	25	
Colombia	1	1	
Total	6,908	6,841	6,900

Source: U.S. Bureau of Mines Preprint for 1972; Commodity Data Summary. January 1974 for 1973.
^{e}Estimated.

Table 2. Canada, chromium trade and consumption, 1964-73

	Imports		Exports	Consumption^2	
	Chromite^1	Ferro-chromium^2	Ferro-chromium^2	Chromite	Ferro-chromium
	(short tons)		(short tons)	(short tons)	
1964	20,794	10,482	172	57,734	11,212
1965	35,408	15,336	205	69,105	12,903
1966	20,880	12,536	35	64,550	17,200
1967	34,485	21,740	–	70,549	19,557
1968	22,401	15,045	1	77,075	45,696
1969	41,924	25,123	..	68,484	25,035
1970	30,445	22,943	..	61,963	31,257
1971	32,716	39,906	..	61,313	22,861
1972	24,728	15,204	..	62,712	24,975
1973^p	27,597	38,280	..	38,030	..

Source: Statistics Canada.
^{1}Chromium content. ^{2}Gross weight.
^{p}Preliminary; – Nil; .. Not available.

Chromite is used as a refractory because of its high melting point, neutral chemical character and its moderate thermal expansion. Chromium chemical products are used in the manufacture of pigments, leather tanning, electroplating, fungicides and in a wide variety of chemical processes as catalysts, oxidants, etc.

Outlook

Production of ferrochromium in Canada may be curtailed in view of the competition from the major ore producing countries that are tending to export their chromium at a higher stage of processing. As a result, Canada's chromite ore imports have declined since 1969 and ferrochromium imports have increased.

Technological developments

The argon-oxygen decarburization (AOD) process developed by Union Carbide Corporation in the late sixties is now being used in several parts of the world. Prior to its development, low-carbon ferrochromium was the alloy of choice in the production of stainless steel. With the AOD process, inexpensive high-carbon ferrochromium can be used in the charge without sacrificing product quality. The AOD steel refining process is a duplexing operation. First, scrap and alloying metals are melted in an electric arc furnace. Then the molten metal is transferred to another vessel while a mixture of argon and oxygen gases are bubbled up through it. This processing reduces the carbon content to almost any desired level with little or no loss of chromium into the slag by oxidation. The process is also fast and offers good control over the final product (through the use of the inert argon). Some variations of the process (VOD and Witten) helped enlarge its popularity, and its use spread to Europe and Japan. The trend in 1950 and in 1972 was:

	Per cent chromium added per ton of stainless steel	
	1950	1972
Charge chrome	8	48
Ferrochromium-silicon	10	12
Low-carbon ferrochromium	82	40

Increased chrome usage is likely to result from the production of stainless steel containers required to house emission control devices to be installed in U.S. built automobiles starting July 1, 1974. From 20 to 30 pounds of stainless sheet containing approximately 12 per cent chromium will be required for the average automobile. The emission control device mixes hot gases from the engine with air in a stainless steel catalytic converter thereby converting poisonous carbon monoxide into carbon dioxide.

M & T Chemicals Inc., has developed a commercial process for single layer microcracked chromium plating. The microcracks (3,000 cracks a linear inch) serve as corrosion-resistant barriers for the base metal by widely dispersing any corrosion from moisture, salt and other atmospheric conditions. The new coating is eye appealing and should be accepted by major automotive makers.

Prices

Canadian prices for chrome ore follow the American price because most of our imports come from the United States as re-exported material. In 1973, prices of lower-grade South African Transvaal chrome ore were boosted in the U.S. by improved chemical markets, continued increase usage in producing ferrochromium by two important chromite ore producers (which leaves less ore available for export), the

Table 4. Consumption of chromite and tenor of ore used by primary consumer groups in the United States, 1965-72

	Metallurgical Industry		Refractory Industry		Chemical Industry		Total	
	Gross Weight	Average Cr_2O_3	Gross Weight	Average Cr_2O_3	Gross Weight	Average Cr_2O_3	Gross Weight	Average Cr_2O_3
	(thousand short tons)	(%)	(thousand short tons)	(%)	(thousand short tons)	(%)	(thousand short tons)	(%)
1965	907	49.8	460	34.7	217	45.0	1,584	44.8
1966	828	49.6	439	34.6	194	44.9	1,461	44.5
1967	866	49.7	310	34.0	179	45.2	1,355	45.5
1968	804	49.7	311	34.1	202	45.1	1,316	45.4
1969	898	49.1	302	35.0	211	45.1	1,411	45.5
1970	912	48.0	278	35.9	213	45.3	1,403	45.2
1971	720	47.8	193	36.3	180	45.6	1,093	45.4
1972	727	47.9	224	35.9	189	45.7	1,140	45.2

Source: U.S. Bureau of Mines *Minerals Yearbook* Preprint, 1972.

Republic of South Africa and Rhodesia and soaring freight costs; prices moved from $24-27 a long ton to $33-34. Renewed Rhodesian shipments to the U.S. in 1972 and 1973 was probably the major factor that pushed down the price of both Russian and Turkish ore.

In Canada, the price of ferrochromium moved up only slightly in 1973.

Prices

Chrome prices published by Metals Week

	December 22 1972		December 28 1973	
	(U.S. $)			
Chrome ore per long ton, dry basis, subject to penalties if guarantees not met, fob cars Atlantic ports				
Transvaal 44% Cr_2O_3, no ratio	24-27		33-34	
Turkish 48% Cr_2O_3, 3:1 ratio	55-56		37	
Russian 54-56% Cr_2O_3, 4:1 ratio, per metric ton in 1971	45.00-46.50		37-39	
Chromium metal				
Electrolytic, 99.8% fob shipping point, per lb	1.30		1.53	
Vacuum melting (pellet) per lb	1.37		1.60	
9 per cent C, per lb	1.56		1.50	
Aluminothermic, delivered per lb, 99.25%	1.30		1.38	
	(U.S. ¢)			
Ferrochrome per lb Cr content, fob shipping point				
High carbon 67-70% Cr, 5-6% C	23.7		23.7	
Charge chrome, 63-71% Cr, 3% Si max, 0.04% S, 4.5-6% C	–		–	
Imported charge chrome	19.0-19.5		21.0-22.5	
Blocking chrome				
10-14% Si	27.6		27.6	
14-17% Si	28.6		28.6	
Chromsol, 57-62% Cr, 4-6% Mn, 1.5% Si, 6.5% C, per lb, alloy, fob shipping point	14.65		15.75	
HS chrome – 66	42.5		42.5	
Low carbon				
67-73% Cr, 0.025% C	–		36.5	
67-71% Cr, 0.05% C	–		35.0	
Simplex, 0.01% max C	–		–	
Simplex, 0.020% max C	–		–	
Imported low carbon				
delivered 0.05% C	35-36		34.0	
0.025% C	37-37.5		35.5	
	Cr (¢)	Si (¢)	Cr (¢)	Si (¢)
Ferrochrome silicon, per lb Cr plus lb Si				
36/40, 0.05% C	–	–	–	–
40/43, 0.05% C	–	–	–	–
"L", 0.02% C	–	–	–	–

– No quote.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
32900-1	Chrome ore	free	free	free
34700-1	Chromium metal, in lumps, powder, ingots, blocks or bars and scrap alloy metal containing chromium for use in alloying purposes	free	free	free
37506-1	Ferrochrome	free	5	5
92821-1	Chromium oxides and hydroxides From July 15, 1971 to Feb. 28, 1976 with the exception of the following:	free		
	Chromic oxides	10	15	25
	Chromium trioxide	10	15	25
92838-8	Chromium potassium sulphate	free	free	10
92828-9	Chromium sulphate, basic	free	free	10

United States

Item No.		On and After Jan. 1, 1971	On and After Jan. 1, 1972
601.15	Chrome ore	free	
		(%)	(%)
632.18	Chromium metals, unwrought (duty on waste and scrap suspended)	6	5
633.00	Chromium metal, wrought	10.5	9
632.84	Chromium alloys, unwrought Ferrochromium	10.5	9
607.30	Not containing over 3% by weight of carbon	5	4
607.31	Containing over 3% by weight of carbon	0.625¢ per lb on chromium content	
416.45	Chromic acid	7	6
422.92	Chromium carbide	7	6
531.21	Chrome brick	15	12.5
473.10	Chrome colours	6	5
420.98	Chromate and dichromate	1.05¢ per lb	0.87¢ per lb

Sources: For Canada, the Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States Annotated, TC Publication 452.

December 1974

Clays and Clay Products

G.O. VAGT

Clays are secondary minerals, hydrous aluminum silicates, formed by the chemical weathering or alteration of aluminous minerals such as feldspar and mica. They are classified into three major groups based on detailed chemistry and structure: the kaolinite group, the montmorillonite group and the illite groups. Clay deposits suitable for the manufacture of ceramic products may include nonclay minerals such as quartz, calcite, dolomite, feldspar, gypsum, mica, iron-bearing minerals and organic matter. The nonclay minerals may, or may not be deleterious, depending upon individual amounts present.

The commercial value of clays and shales that are similar in composition to clays, depends mainly on their physical properties and location. Properties of prime importance are: plasticity, strength, shrinkage, vitrification range and refractoriness, fired colour, porosity and absorption.

Canadian industry and developments

In 1973 the value of products manufactured from Canadian clays was $58.0 million, compared with $52.4 million in 1972. The increase was largely a result of expansion in the residential construction industry, which reached a record level in 1973*. One hundred and sixty-nine active companies operated 194 plants classified within the ceramics industry, based on data compiled in Operators List 6 (1972), *Ceramic Plants in Canada*, published by the Mineral Development Sector.

The Atlantic Provinces. Four brick and tile manufacturing plants were operated in the Atlantic provinces. The L.E. Shaw, Limited plant at Lantz, Nova Scotia will undergo alterations of three round kilns and one tunnel kiln, in addition to improving the material preparation process. The modernization will effect a 15-20 per cent increase in production capacity. Local raw materials include shale, stoneware clays, red clay and fire clay.

A plant operated by E. and A. Lorenzen at Lantz, Nova Scotia produced art pottery and stoneware utilizing local sources of red and buff clay. Ahlstrom Canada Limited of Moncton, New Brunswick manufactured glass containers from imported silica sand and domestic nepheline syenite. Two porcelain enamel plants in New Brunswick, each with a total capacity of over one hundred thousand square feet a month, utilized local sources of commercial frit in the spray and dip process on cast iron and sheet steel.

Quebec. Eight major brick and tile plants operated in Quebec producing products from local shale and clay. No production of sewer pipe was reported. Thirteen plants classified as porcelain and pottery plants, including five which manufactured art pottery, were operated. Chinaware, electrical porcelain, wall and floor tiles, vitreous sanitaryware and ferrite products were also produced. The principal consumers of ceramic-grade china clay and ball clays imported their entire requirements from the United States or England. Refractory products were produced by five plants which manufactured products such as bricks, mortars or ramming mixes. Most raw materials, including ball clay, fire clay and flint clay, were imported. Two abrasive plants manufactured resin bond sanding disks. Domestic raw materials included silica sand, fused alumina and resins. Petroleum coke was imported. Four glass plants were operated using mainly domestic raw materials. Five porcelain enamel plants situated in Montreal used domestic commercial frit primarily in the spray and dip process on cast iron and sheet steel.

Ontario. Thirty-nine major brick and tile plants operated in Ontario. Most of these are situated in the Toronto-Hamilton area and in the extreme southwestern part of the province. Local resources of common clay or shale were utilized, primarily in the stiff-mud process, for the manufacture of brick and tile products. Two companies manufactured sewer pipe and flue lining by the stiff-mud process from imported fire clay and local raw materials. Products classified as porcelain and pottery were manufactured by twenty-nine plants, nine of which make art pottery. The remainder mainly produced sanitaryware products, electrical porcelain, wall and floor tile, dinnerware products and ferrites. Nepheline syenite, common clay and feldspar were acquired locally. Ball clay, china clay, talc and flint were imported. Thirteen plants manufactured refractory products from imported ball clay, fire clay, refractory grogs and flint clays. Bonded abrasives were manufactured at six plants using about 50 per cent domestic raw materials.

*See Table 10 of the Stone section of the *Canadian Minerals Yearbook 1973* (preprint No. 46).

All silicon carbide utilized was obtained in Canada. The principal product of the seven glass plants operating in Ontario was glass containers. One plant produced glass fibre insulating products from imported silica sand and domestic nepheline syenite, limestone, soda ash and dolomite. Eighteen porcelain enamel plants were operated.

The Prairie Provinces. In Manitoba, local stoneware clay was used to manufacture face brick by the stiff-mud and dry-press processes. In Saskatchewan, brick and sewer pipe were manufactured at one plant and common and face brick at another. The former plant, in Regina, and the latter, in Estevan, have reported capacities of 1,500 tons a month and 1.5 million bricks a month. In Alberta, plants in Edmonton, Medicine Hat and Redcliff manufactured brick and tile. In southern Alberta, six porcelain and pottery plants manufactured products including stoneware, sanitaryware, electrical porcelain and dinnerware. Local common clay and fire clay, and imported ball clay and china clay were used. Only one refractory plant operated in the region in 1973, producing fire clay refractories, special shapes and face brick from local and imported sources of fire clay. Four glass plants, all in Alberta, produced various products, including containers, glass wool, glass fibre mats, pipe covering and plastic pipe, primarily from domestic raw materials.

British Columbia. Brick or tile products were manufactured at three plants and sewer pipe at one plant in

Table 1. Canada, production of clays and clay products from domestic sources, 1971-73

	1971[r]	1972[r]	1973[p]
	($000)	($000)	($000)
Production[1] from domestic sources,			
by provinces			
Newfoundland	80	257	210
Nova Scotia	1,845	1,684	1,991
New Brunswick	627	668	774
Quebec	6,565	8,100	9,133
Ontario	30,538	30,484	33,624
Manitoba	469	667	973
Saskatchewan	1,140	1,758	1,901
Alberta	4,031	4,438	4,572
British Columbia	4,900	4,301	4,817
Total, Canada	50,195	52,357	57,995
Production[1] from domestic sources,			
by products			
Clay–fire clay			
other clay	563	637	716
Firebricks and fire clay blocks and shapes	1,655	1,219	1,371
Brick-soft mud process	1,849	2,190	1,933
stiff mud process	25,122	27,624	31,060
dry press	6,411	7,131	8,018
fancy and ornamental	651	753	847
sewer brick and paving brick	72		
Structural hollow blocks	839	237	266
Drain tile	5,224	4,114	4,626
Sewer pipe	4,306	4,028	4,529
Flue linings	1,207	1,579	1,775
Pottery (glazed and unglazed including earthenware sanitaryware, stoneware, flower pots, etc.	2,296	2,845	2,854
Total	50,195	52,357	57,995

Source: Statistics Canada.
[1] Producers' shipments. Distribution for 1973 estimated by Statistics Section, Mineral Development Sector.
[p] Preliminary; [r] Revised.

B.C. These are situated in Vancouver, Haney and Kilgard. One plant, in Coquitlam, manufactured vitreous sanitaryware and three plants, in Haney, Sardis and Saanichton, manufactured pottery. Refractories were produced at three plants that are situated in Abbotsford, Surrey and Vancouver. Glass containers were manufactured by one company in Burnaby and one in Lavington.

Summary. The brick and tile manufacturing industry accounts for approximately one third of the ceramic plants in Canada. These plants manufacture clay products which include common brick, facing brick, structural tile, quarry tile and drain tile, primarily from local common clays and shales. In recent years, requirements for brick as a structural material in low- to medium-rise buildings have been emphasized. The

Table 2. Canada, imports and exports of clays, clay products and refractories

	1972		1973p	
	(short tons)	($000)	(short tons)	($000)
Imports				
Clays				
Bentonite	306,227	3,346	226,671	3,318
Drilling mud	14,098	2,671	13,777	3,309
China clay, ground or unground	232,036	6,324	204,429	6,417
Fire clay, ground or unground	49,348	901	35,128	1,005
Clays, ground or unground	76,184	939	94,424	1,407
Clays and earth, activated	36,632	2,381	179,080	4,696
Subtotal, clays	714,525	16,562	753,509	20,152
	(M)		(M)	
Clay products				
Brick-building glazed	2,153	186	2,664	221
nes	22,639	1,605	24,130	1,882
Building blocks	..	197	..	242
Clay bricks, blocks and tile nes	..	285	..	508
Earthenware tile	(ft^2)		(ft^2)	
under 2½" x 2½"	19,681,017	4,678	15,557,393	4,850
over 2½" x 2½"	31,323,111	6,700	34,989,628	8,254
Subtotal, brick blocks, tile	..	13,651	..	15,957
Tableware ceramic	..	33,231	..	37,114
Porcelain insulating fitting	..	5,760	..	5,458
Pottery settings and firing supplies	..	248	..	344
Subtotal, porcelain pottery	..	39,239	..	42,916
	(short tons)	($000)	(short tons)	($000)
Refractories				
Firebrick				
Alumina	27,160	5,464	37,587	6,750
Chrome	2,841	437	3,491	629
Magnesite	11,506	3,103	17,503	4,943
Silica	5,638	1,203	3,638	770
nes	180,407	13,334	180,937	15,244
Refractory cements and mortars	..	2,561	..	3,842
Acid-proof brick	..	202	..	254
Crude refractory material	7,464	608	8,735	740
Grog (refractory scrap)	15,795	616	12,104	577
Refractories, nes	..	1,472	..	2,717
Subtotal, refractories	..	29,000	..	36,466
Total clays, clay products and refractories	..	98,452	..	115,491

Table 2 (concl'd)

	1972		1973^p	
Imports (concl'd)	(short tons)	($ 000)	(short tons)	($ 000)
By main countries				
United States	. .	47,702	. .	58,006
Britain	. .	25,051	. .	27,834
Japan	. .	14,668	. .	13,614
Italy	. .	2,403	. .	3,365
West Germany	. .	2,862	. .	3,292
Greece	. .	242	. .	1,726
France	. .	695	. .	1,686
Ireland	. .	480	. .	1,030
Austria	. .	579	. .	634
Denmark	. .	–	. .	469
Others	. .	3,770	. .	3,835
Total	. .	98,452	. .	115,491
Exports				
Clays, ground and unground	4,685	227	5,629	327
	(M)		(M)	
Clay products				
Building brick clay	17,098	1,392	14,670	1,492
Clay bricks, blocks, tiles nes	. .	628	. .	852
Subtotal, bricks, blocks, tiles	. .	2,020	. .	2,344
High-tension insulators and fittings	. .	971	. .	1,486
Tableware	. .	3,179	. .	4,189
Subtotal, porcelain tableware	. .	4,150	. .	5,675
Refractories				
Firebrick and similar shapes	46,721	7,144	68,036	10,942
Crude refractory materials	973,113	861	1,162,896	1,476
Refractory nes	. .	1,547	. .	1,643
Subtotal, refractories	. .	9,552	. .	14,061
Total clays, clay products and refractories	. .	15,949	. .	22,407
By main countries				
United States	. .	11,487	. .	16,708
Chile	. .	1	. .	772
Dominican Republic	. .	435	. .	628
South Africa	. .	584	. .	351
Britain	. .	457	. .	351
Mexico	. .	81	. .	235
France	. .	173	. .	200
Australia	. .	181	. .	191
Belgium and Luxembourg	. .	–	. .	130
Pakistan	. .	23	. .	117
Jamaica	. .	223	. .	81
Guyana	. .	3	. .	77
Others	. .	2,301	. .	2,566
Total	. .	15,949	. .	22,407

Source: Statistics Canada.
^p Preliminary; . . Not available; nes Not elsewhere specified; M = 1,000; – Nil.

use of an oversize "through the wall" (TTW) brick, which provides wall thickness, now provides a significant market for brick manufacturers.

Seven plants manufacture sewer pipe from domestic common clay, shale or stoneware clay along with some imported shale and fire clay. Of the porcelain and pottery producers, seven sanitaryware plants, eight electrical porcelain plants, five wall tile plants (including two that also make floor tile), four dinnerware plants and the art potteries are the principal consumers of ceramic-grade china clay and ball clays. These raw materials are imported mainly from the United States and Britain. Some of the art potteries and one of the dinnerware plants imported unfinished ware and completed the manufacturing process by glazing or decorating.

Most of the 22 plants that manufacture refractories utilized imported clay including ball clay, fire clay and kaolin, as the principal ingredients in many of their products. Only the British Columbia producers of refractories were able to operate with domestic raw materials by making use of the clay at Sumas Mountain. The nine abrasives plants utilized both domestic and imported raw materials. The distribution was approximately half and half, except for silicon carbide, which was supplied entirely from domestic sources, and petroleum coke, which was imported. The 18 glass plants mainly utilized domestic sources of raw materials, except those in Quebec and Ontario, which accounted for most of the imported silica sand used. Porcelain enamel was produced and utilized at 25 plants.

Uses, nature and location of deposits

Common clays and shale. Common clays and shales are the principal raw materials available from Canadian deposits for the manufacture of clay products. These materials are usually higher in alkalis, alkaline materials and iron-bearing minerals and much lower in alumina than the high-quality kaolins, fire clays, ball clays and stoneware clays. Common clays and shales are found in all parts of Canada, but deposits having excellent drying and firing properties are generally scarce and new deposits are continually being sought.

The clay minerals in common clays and shales are chiefly illitic or chloritic. The presence of iron usually results in a salmon or red fired colour. Their fusion points are low, usually well below pyrometric cone equivalent number 15 (PCE 15–the pyrometric cones are a convenient method of relating temperature and time by a single value), which is defined by a temperature of approximately 1,430°C and is considered to be the lower limit of the softening point for fire clays.

Suitable common clays and shales are utilized in the manufacture of heavy clay products such as common brick, facing brick, structural tile, partition tile, conduit tile, quarry tile and drain tile. Some Canadian common clays are mixed with stoneware clay for the manufacture of facing brick, sewer pipe, flue lining and related products. The raw materials utilized in the heavy clay industry usually contain up to 35 per cent quartz. If the quartz, together with other nonplastic materials, exceeds this percentage, the plasticity of the clay is reduced and the quality of the ware is lowered. If calcite or dolomite is present in sufficient quantities the clay will fire buff and the fired strength and density will be adversely affected.

Most of the common surface clays are the result of severe glaciation. Such Pleistocene deposits are of interest to the ceramic industry and include stoneless marine and nonmarine sediments, reworked glacial till, interglacial clays and floodplain clays. These deposits are characterized by low melting temperatures. Some Tertiary and Cretaceous deposits that occur near the surface are of interest. An important characteristic of these older deposits is the wide range of refractoriness, or fusibility, depending on the locality and the nature of the formation.

The common shales have been found to provide the best source of raw material for making brick. The principal shales useful to the ceramic industry are found in Cambrian, Ordovician and Carboniferous rocks in eastern Canada, and Jurassic, Cretaceous and Tertiary rocks in western Canada. In many instances these shales are more refractory than the Pleistocene clays; in some areas, particularly in western Canada, they are very refractory.

China clay (kaolin). China clay is a high-quality white, or nearly white, clay formed from the decomposition of the mineral feldspar, a major constituent of granite. The natural decompositional process, known as kaolinization, results in a hydrated aluminum silicate ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$) with the approximate percentage composition as follows: 40% Al_2O_3, 46% SiO_2 and 14% H_2O.

None of the crude kaolins known to exist in Canada have been developed, primarily because of beneficiation problems and the small size of some deposits. Most occurrences contain a high proportion of quartz with particles that vary from coarse to very fine. High proportions of substances such as mica, feldspar, magnetite, pyrite and colloidal iron have been observed. In the crude material the percentage of kaolinite frequently is small, making removal of impurities from Canadian kaolins difficult.

China clay is used primarily as a filler and coater in the paper industry, a raw material in ceramic products and a filler in rubber and other products. The following properties are required in clays used by the paper industry: low-viscosity characteristics when in clay-water systems, intense whiteness, high coating retention and freedom from abrasive grit. In the ceramic industry china clay is used as a refractory raw

Table 3. Canada, shipments of clay products produced from imported clay[1] 1970-72

	1970		1971		1972	
	('000 ft^2)	($000)	('000 ft^2)	($000)	('000 ft^2)	($000)
Glazed floor and wall tile	13,228	5,622	15,023	5,820	17,641	6,958
Electrical porcelains	. .	15,837	. .	18,592	. .	17,273
Pottery, art and decorative ware	. .	1,643	. .	1,576	. .	644
Pottery, other	. .	1,725	. .	. .	. .	2,753

Source: Statistics Canada.
[1] Does not include refractories.
. . Not available.

Table 4. Canada, shipments of refractories, 1970-72

	1970		1971		1972^p	
	('000 ft^2)	($000)	('000 ft^2)	($000)	('000 ft^2)	($000)
Firebrick and similar shapes[1]	139,384	22,236	145,504	21,875	135,796	21,833
Cement, mortars, castables	96,754	13,778	95,196	13,909	88,031	13,435

Source: Statistics Canada.
[1] Includes fire clay blocks and shapes, firebrick, etc., made from domestic clays, and rigid firebrick, stove linings and other shapes made from imported clays, chrome ore, magnesite, etc. Silica brick not included.
^{p}Preliminary.

Table 5. Canada, clays and clay products production and trade, 1964-73

	Production					
	Domestic Clays[1]	Imported Clays[2]	Total	Refractory Shipments[3]	Imports[4]	Exports[4]
			(millions of dollars)			
1964	40.8	30.2	71.0	25.3	54.7	8.9
1965	42.8	31.4	74.2	27.4	59.4	10.3
1966	43.0	35.9	78.9	28.6	71.7	12.6
1967	44.3	35.5	79.8	30.7	70.7	13.7
1968	48.7	39.6	88.3	33.2	65.4	11.8
1969	49.5	34.5	84.0	35.5	76.3	14.0
1970	51.8	33.6	85.4	42.3	81.2	15.6
1971	50.2^r	35.1	85.3^r	39.8	84.5	15.5
1972	52.3	39.4	91.7	39.7	98.5	15.9
1973^p	58.0	. .	. .	. .	115.5	22.4

Source: Statistics Canada.
[1] Production (shipments) of clays and clay products from domestic material. [2] Production (shipments) of clay products from imported clays. [3] Includes firebrick and similar shapes, all types, refractory cements, mortars, castables, plastics, etc., plus all other products shipped. [4] Includes refractories.
^{p}Preliminary; . . Not available; ^{r}Revised.

material. In prepared whiteware bodies such as wall tile, floor tile, sanitaryware, dinnerware, pottery and electrical porcelain, quantities of nepheline syenite, silica, feldspar and talc are used as well.

Lower-quality kaolins in North America may be mined and more expensive processing may be justified as higher-quality kaolins become depleted. If this situation arises, the development of a few Canadian deposits may become more attractive, particularly if new processing techniques and equipment become available.

In southern Saskatchewan, deposits of sandy kaolin occur near Wood Mountain, Fir Mountain, Knollys, Flintoft and other localities. Despite considerable work, no satisfactory method of producing a good commercial kaolin from these deposits has been developed.

A deposit of refractory clay which is very plastic to very sandy, and is similar to a secondary china clay, occurs along the Fraser River near Prince George, British Columbia. This material has been investigated as a source of kaolin, as a fire clay and as a raw material for facing brick.

Various kaolinitic-rock deposits have been investigated in Manitoba. The reported deposits are principally in the northwest at Cross Lake and Pine River, on Deer Island (Punk Island) and Black Island in Lake Winnipeg, and at Arborg. Kaolinitic clays occur near Kergwenan and are being used for the manufacture of brick and tile.

Various companies have shown considerable interest in Quebec's kaolin-bearing deposits although the deposits, in general, contain an excessive amount of quartz and iron minerals. Kaolin-bearing rock occurs at St-Rémi-d'Amherst, Papineau County; Brebeuf, Terrebonne County; Point Comfort, on Thirty-one Mile Lake, Gatineau County; and Château-Richer, Montmorency County.

Extensive deposits of kaolin-sand mixtures occur in northern Ontario along the Missinaibi and Mattagami rivers. Algocen Mines Limited has found substantial quantities of kaolin-silica mixtures along the Missinaibi River north of Hearst. Results to date indicate that the kaolin has good refractory characteristics and meets specifications for filler-grade material. Potential uses for the silica, which comprises 80 per cent of the deposit, include glass manufacture, abrasive flour and ceramic applications. Distance from markets and the difficult terrain and climate of the area have hindered development.

Ball clay. Ball clays are a very fine grained, sedimentary kaolinitic type of clay with unfired colours ranging from white or various shades of grey depending on the amount of carbonaceous material present.

Ball clays obtained in Canada are mineralogically similar to high-grade, plastic fire clay. They are composed principally of fine-particle kaolinite and quartz, with less alumina and more silica than kaolins. Ball clays are extremely refractory products. In whitewares they impart a high green strength as well as plasticity to the bodies. Although white firing clays are most suitable, fired products which are cream coloured do not interfere with the quality of the whiteware products.

Ball clays are known to occur in the Whitemud Formation of southern Saskatchewan. Good-quality deposits are present at Willows, Readlyn, Big Muddy Valley, Blue Hills, Willow Bunch, Flintoft and in other areas. Clay from the Willows area has been used for many years in the potteries at Medicine Hat and Vancouver; however, the lack of proper quality control, the distance from large markets and lack of reserves have been the principal disadvantages affecting the widespread use of this material. Some ball clays from the Flintoft area are used for white-to-buff facing brick and for household pottery and crocks.

Fire clay. Fire clays contain high percentages of alumina or silica. They may be sedimentary or residual in origin, plastic or nonplastic and are composed mainly of kaolinite. The classification of fire clays may be related to the composition, physical characteristics, refractoriness, use, or association with other minerals. Descriptive terminology includes plastic fire clay, nonplastic fire clay, high-alumina fire clay, siliceous fire clay, flint clay, coal measure fire clay, or high-heat duty fire clay. Fire clays are plastic when pulverized and wetted, rigid when subsequently dried and of sufficient purity and refractoriness for use in commercial refractory products.

Canadian fire clays are used principally for the manufacture of medium- and high-duty firebrick and refractory specialties. High-duty refractories require raw materials having a PCE of about 31.5 to 32.5 (approximately 1,699° to 1,724°C). Intermediate-duty refractories require raw materials having a PCE of about 29 (approximately 1,659°C) or higher. Clays having a PCE of less than 29 but greater than 15 (approximately 1,430°C) may be suitable for low-duty refractories or ladle brick as well as for other clay products. No known Canadian fire clays are sufficiently refractory for the manufacture of super-duty refractories without the addition of some very refractory material such as alumina. However, in 1967, a sample from northern Ontario having a PCE of 33 was examined at the Mines Branch of the Department of Energy, Mines and Resources, Ottawa.

Various grades of good-quality fire clay occur in the Whitemud Formation in southern Saskatchewan.

Good-quality fire clays occur on Sumas Mountain in British Columbia. Some fire clay from the Sumas deposit is exported to the United States, and a small quantity is used at plants in Vancouver.

Fire clay and kaolin, as previously stated, occur in the James Bay watershed of northern Ontario along the Missinaibi, Abitibi, Moose and Mattagami rivers. Considerable exploration has been carried out in some parts of these areas in recent years.

At Shubenacadie, Nova Scotia, some seams of clay are sufficiently refractory for medium-duty refractories. Research has indicated that these deposits may be suitable for production of ladle brick. Clay from Musquodoboit, Nova Scotia has been used by a few foundries in the Atlantic provinces, and the properties and extent of this clay were investigated by the Nova Scotia Department of Mines.

Ontario and Quebec have no producing domestic sources of clay. These provinces import most of their requirements from the United States.

Stoneware clay. Stoneware clays are similar to low-grade plastic clays and are characterized by good plasticity, a vitrification range between PCE 4 and 10, a long firing range and a fired colour from buff to grey. They range from commercially inferior material through semirefractory to firebrick clays. They should have low fire shrinkage, enough plasticity and toughness for shaping, no lime- or iron-bearing concretions and very little coarse sand.

Stoneware clays are used extensively in the manufacture of sewer pipe, flue liners, facing brick, pottery, stoneware crocks and jugs, and chemical stoneware.

The principal source of stoneware clay in Canada is the Whitemud Formation in southern Saskatchewan and southeastern Alberta. The Eastend area in Saskatchewan was formerly the source of much of the clay used at Medicine Hat. Stoneware clay pits are presently located in the Alberta Cypress Hills, southeast of Medicine Hat, and at Avonlea, Saskatchewan. Stoneware clays occur on Sumas Mountain, near Abbotsford, British Columbia. These clays are used in the manufacture of sewer pipe, flue lining, facing brick and tile.

In Nova Scotia, stoneware clays occur at Shubenacadie and Musquodoboit. The Shubenacadie clays are used principally for the manufacture of buff facing brick. Other similar deposits occur at Swan River, Manitoba, where some buff brick has been manufactured, Kergwenan, Manitoba and in British Columbia at Chimney Creek Bridge, Williams Lake, Quesnel and near the Alaska Highway at Coal River.

Quebec and Ontario import stoneware clay from the United States for manufacture of facing brick and sewer pipe.

Table 6. Canada, consumption (available data) of china clay, by industries, 1971-72

	1971	1972
	(short tons)	
Ceramic products	13,020	12,819
Paint and varnish	4,208	3,385
Paper and paper products[1]	124,720	128,513
Rubber and linoleum	10,048	8,413
Other products[2]	18,663	23,716
Total	170,659	176,846

Source: Statistics Canada. Component breakdown by Statistics Section, Mineral Development Sector.
[1]Includes paper and paper products and paper pulp.
[2]Includes miscellaneous chemicals, cleansers, detergents, soaps, medicinals and pharmaceuticals and other miscellaneous products.

Table 7. Ceramic plants in Canada, 1972

Type of Plant	Atlantic	Quebec	Ontario	Prairie Provinces	British Columbia	Total
Brick and tile	4	8	39	6	3	60
Clay sewer pipe	2	–	2	2	1	7
Porcelain and pottery	1	13	29	6	4	53
Refractories	–	5	13	1	3	22
Glass	1	4	7	4	2	18
Abrasives	–	3	6	–	–	9
Porcelain enamel	2	5	18	–	–	25

Note: Some plants produce more than one group of products.
Source: Based on revised data available to National Mineral Inventory, Mineral Development Sector.
– Nil.

Specifications

The following specifications, published by the Canadian Standards Association, are applicable to the specified clay products manufactured in Canada:

A 82.1 – 1965 Burned clay brick
A 82.2 – 1967 Methods of sampling and testing brick
A 82.3 – 1954 Sand-lime building brick
A 60.1 – 1969 Vitrified clay pipe
A 60.2 – 1962 Methods of testing vitrified clay pipe
A 60.3 – 1969 Vitrified clay pipe joints
A 82.5 – 1954 Structural clay non-load-bearing tile (reaffirmed 1967)
A 82.6 – 1954 Standard methods for sampling and testing structural clay-tile (reaffirmed 1954 and 1967)

Expanded common clays and shales are utilized as thermally expanded lightweight aggregates and are reviewed separately in "Lightweight Aggregates."*

World review

United States. Total mine production of clays, including bentonite and fuller's earth, was an estimated 61,520,000 short tons in 1973. This was about 3.5 per cent above the total for 1972.

The major uses for clays, other than those used in the heavy clay products industry, were as follows: refractories, paper manufacture, iron ore pelletizing, absorbent and filtering uses, and pottery and stoneware. Demand for clays is expected to increase at annual rates of between 2 per cent and 5 per cent through 1980, however, the continued growth of the energy intensive clay-based industries would be severely impeded by persistent energy problems.

The United States export market for quality kaolin has generally increased in recent years, primarily from the fast rate of industrial growth in several European countries. Production of kaolin increased over that of 1972 but did not reach the production capacity of the industry. Exports to Europe and Asia remained essentially the same as in 1972.

Britain. Britain is the world's leading producer of kaolin and ball clay for export. Approximately 20 per cent of total clay production is exported, according to sources available to the United States Bureau of Mines (USBM). Major growth areas for British exports have been Europe, the United States and Japan. In western Europe the major users were West Germany, France and the Netherlands, which reflects their high *per capita* rate of paper consumption.

*See the Lightweight Aggregates section of the *Canadian Minerals Yearbook 1973* (preprint No. 1).

Europe and Japan. The kaolin operations in continental Europe and Japan are reported to be mainly small scale, using limited processing equipment and producing products of lower grade because of the lack of high-grade kaolin deposits. The industry in these countries is fragmented except in Bavaria (West Germany), Brittany (France) and Czechoslovakia, where significant advances are being made. Present kaolin consumption in Europe and Japan is largely in paper manufacture; however, local producers have had only limited success in the market because quality is inadequate. West Germany, with a production of nearly 500,000 tons, is the second largest producer of kaolin in Europe. Most of the kaolin is used in the ceramic and other industries to which it is best suited.

Czechoslovakia is the largest producer of kaolin in eastern Europe. Output is reported to be approximately 400,000 tons a year. The high quality of the kaolin is indicated by the fact that about 180,000 tons is consumed in paper manufacture. Czechoslovakia is increasing its share of the European market at the expense of British and United States kaolin. In France many companies produce kaolin, although operations are generally small, fairly widely dispersed and relatively distant from major markets. On the other hand, the industry in Brittany, which accounts for about 80 per cent of France's output, is expected to expand its production substantially through more integrated support by a central body in Paris. Also, a major American producer has acquired an interest in an operation in Brittany which will bring new capital to the region along with additional technical and marketing expertise.

Spain has the fourth largest production of kaolin in western Europe. In 1970 the estimated total was 285,000 tons. Output was reported to have expanded over two and a half times since 1970 and, according to the National Mining Plan, which envisages a complete modernization of many of the operations, output will double again by 1976.

Greece produces approximately 60,000 tons of kaolin annually, almost all for domestic consumption.

Denmark produces between 30,000 and 35,000 tons of kaolin a year. Most of the output is utilized in the manufacture of low-alumina refractories and glazed heavy-clay products. Requirements for paper and other uses are mainly imported from Britain, Czechoslovakia and West Germany.

The Netherlands produces no kaolin, but acts as a very important distribution point for American and British clay entering Europe.

Production of kaolin in Japan is on a very small scale except at the Itaya Mine, Yamagata Prefecture, Honshu Island, which produces about 150,000 tons a year. Total kaolin output is approximately 390,000 tons a year based on USBM statistics. Most of the production goes into the manufacture of refractories, for which it is best suited. The United States is the principal source of imports, supplying about 100,000 long tons annually. Lesser amounts of kaolin are imported from South Korea, Britain and the U.S.S.R.

Outlook

The broad aspects of the clay industry in Canada have not changed appreciably for many years. Continued activity in residential, commercial and industrial building construction indicates that demand for most clay and clay products will remain high in 1974. Average prices for most clay products are expected to rise slowly, reflecting increasing costs associated with land acquisition, land rehabilitation and environmental factors.

The few known deposits of fire clays and ball clays in the developed areas of Canada are being utilized. Much work has been carried out on deposits containing kaolin, but these have not been developed because of small size, high cost of beneficiation, or remoteness from transportation or industry. Ontario and Quebec are particularly deficient in developed deposits of refractory- or kaolin-type clays. Lower-quality deposits in the United States and Britain, the major export countries, will be utilized in the future, probably at increased cost and as a result of the development of improved beneficiation methods.

There has been a great increase in ways that kaolin can be processed, both chemically and mechanically. This trend is continuing as producers endeavour to increase markets and to meet the tighter specifications of industries in which consumers are placing much more emphasis on brightness, colour and viscosity. In the United States continued demand for paper grades, particularly for coating, is assured, barring adequate substitutes. The rubber industry will continue to be a big consumer, but its recent steady intake suggests that it will not expand very rapidly. The ceramics market, in common with the rubber market, is already large and not expanding rapidly. Paint and fibreglass applications are good potential growth areas, if the right grades are developed; newer uses, such as for catalysts in oil-refining, may prove to be growing markets. Canada imported 38 per cent more alumina firebrick and 52 per cent more magnesite firebrick in 1973 than in 1972. Proportionally, there has been a decrease in the use of fire clay brick and an upswing in materials such as high alumina, alumina silicates, basic refractories and monolithics (a family of materials applied by means of casting, ramming, or gunning to form a virtually jointless furnace lining). The major emphasis in the production of refractory products will be to cope with the higher operating temperatures and greater through-puts required in industrial furnaces; the higher-grade, superduty refractories are in heavy demand. Steel processes such as the basic oxygen furnace, pressure pouring and continuous casting, represent relatively new refractory requirements. New products and designs have also been dictated by changes in reducing atmospheres in the chemical and petrochemical industry, by increased demands for high-purity glass and by the need for more economical production of ceramics.

Clay and shale, like other low-cost construction materials, must be produced near the heavily populated areas where the markets are situated. This necessary feature of the industry will continue to produce increasingly complex problems related to rising land costs, land-use conflicts, environmental control requirements, and cost of land rehabilitation. Demands in industry have indicated that some end-use products such as brick and tile find competition from cement, glass, metals and plastic manufacturers. On the other hand, clays, being generally less expensive and very satisfactory for their intended uses, are usually able to hold their own, or to increase at the expense of the alternate materials, for many end-uses.

Bentonite and fuller's earth

Bentonite, a clay which consists primarily of montmorillonite, a hydrous aluminum silicate with weakly attached cations of sodium and calcium, is reviewed separately.*

Fuller's earth is primarily a calcium montmorillonite clay characterized by natural bleaching and absorbent properties; it is similar to nonswelling bentonite. The terminology is confusing and bentonite and fuller's earth may not necessarily be separated in world trade and production statistics by country. Attapulgite, a magnesium-aluminum silicate, is a form of high-quality fuller's earth.

Prices

United States clay prices, according to Chemical Marketing Reporter, December 31, 1973.

	($ per ton)
Ball clay	
Domestic, crushed, moisture-repellent, bulk car lots, fob Tennessee	8 – 11.25
Imported lump, bulk, fob Great Lakes ports	40.50
Imported, airfloated bags, car lots, Atlantic ports	70.00
China clay (kaolin)	
Water washed, fully calcined, bulk car lots, fob Georgia	76.00
Partially calcined, same basis	69.00
Dry-ground, air floated soft, fob Georgia	14.00

*See the Bentonite section of the *Canadian Minerals Yearbook 1973* (preprint No. 6).

Tariffs

Canada

Item No.		British Preferential (%)	Most Favoured Nation (%)	General (%)
29500-1	Clays, including fire clay, and pipe clay not further manufactured than ground	free	free	free
29525-1	China clay	free	free	25
28100-1	Firebrick containing not less than 90 per cent silica; magnesite firebrick or chrome firebrick; other firebrick valued at not less than $100 per 1,000, rectangular shaped, not to exceed 100 x 25 in.^{3} for use in kiln repair or other equipment of a manufacturing establishment	free	free	free
28105-1	Firebrick, nop, of a class or kind not made in Canada, for use in construction or repair of a furnace, kiln, etc.	free	free	15
28110-1	Firebrick, nop	5	10	22½
28200-1	Building brick and paving brick	10	10	22½
28205-1	Manufactures of clay or cement, nop	12½	12½	22½
28210-1	Saggars, hillers, bats and plate setters, when used in the manufacture of ceramic products	free	free	free
28300-1	Drain tiles, not glazed	free	17½	20
28400-1	Drain pipes, sewer pipes and earthenware fillings therefore; chimney linings or vents, chimney tops and inverted blocks, glazed or unglazed, nop	15	20	35
28405-1	Earthenware tiles, for roofing purposes	free	17½	35
28415-1	Earthenware tiles, nop	12½	20	35
28500-1	Tiles or blocks of earthenware or of stone prepared for mosaic flooring	15	20	30
28600-1	Earthenware and stoneware, viz., demijohns, churns and crocks, nop	20	20	35
28700-1	All tableware of china, procelain, semiporcelain or white granite, excluding earthenware articles (Feb. 20/73–Feb. 19/74)	free	15	35
28705-1	Articles of chinaware, for mounting by silverware manufacturers	12½	17½	22½
28710-1	Undecorated tableware of china, procelain, semi-porcelain for use in the manufacture of decorated tableware	free	10	35
28800-1	Stoneware and Rockingham ware and earthenware, nop	17½	20	35
28805-1	Chemical stoneware	free	10	35
28810-1	Hand forms of porcelain for manufacture of rubber gloves	free	free	35
28900-1	Baths, bathtubs, basins, closets, closet seats and covers, closet tanks, lavatories, urinals, sinks and laundry tubs of earthenware, stone, or cement, clay or other material, nop (from Feb. 20/73–Feb. 19/74)	12½	15	35

Tariffs (concl'd)

United States Item No.		On and After January 1 1970	1971	1972
		(¢ per long ton)		
521.51	Fuller's earth, not beneficiated	35	30	25
521.41	China clay or kaolin	46	40	33
521.54	Fuller's earth, wholly or partly beneficiated	70	60	50
521.81	Other clays, not beneficiated	20	10	free
521.84	Other clays, wholly or partly beneficiated	70	60	50
521.61	Bentonite	56	48	40
521.71	Common blue clay and other ball clays not beneficiated	50	46	42
521.74	Common blue clay and other ball clays, wholly or partly beneficiated	99	92	85
521.87	Clays artificially activated with acid or other material	0.07¢lb +8.5%	0.06¢lb +7%	0.05¢lb +6%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa. Tariff Schedules of the United States, Annotated (1972) T.C. Publication, 452.
Note: In addition to the above tariffs various duties are in existence on manufactured clay products, viz., brick pottery, artware, etc.

Coal and Coke

M. K. McMULLEN

In 1973, total coal production increased to 22.6 million tons, an increase of 10.9 per cent over 1972. The value of coal produced rose by nearly 14 per cent to some $171 million. Regionally, coal production increased in British Columbia, Alberta and Saskatchewan and declined in Nova Scotia and New Brunswick. Bituminous coal output rose to 13.6 million tons, an increase of 1 million tons over 1972. Subbituminous coal production was fractionally ahead to 4.9 million tons, and lignite increased by 700,000 tons to 4 million tons in 1973. Exports increased by some 40 per cent to 12 million tons in 1973 and accounted for approximately one half of total production and 88 per cent of total bituminous coal production. Over 11.7 million tons were shipped to Japan. Imports from the United States decreased to 16.5 million tons from 19.3 million tons in 1972. Of the coal consumed in Canada, about 17.2 million tons were used to generate electricity in thermal power stations, and 8.5 million tons were carbonized to make 5.9 million tons of coke. Lesser amounts of coal were consumed by industrial and commercial users throughout Canada.

Outlook

In recent years the growth in Canada's coal industry has been spurred primarily by the coking coal market to Japan and, to a lesser degree, by the increasing use of subbituminous and lignite coal for power generation in the prairie provinces. This expansion will continue but production of coal for domestic thermal generation of electricity will show a faster rate of growth than coking coal exports.

The development of the new coking coal operations in western Canada since 1969 to meet export commitments to Japan has had a number of production problems involving mining and preparation plant operations, as well as a general shortage of skilled workers. In addition, while overcoming these problems, considerable financial burdens have been incurred. In 1973, it was evident that many of the technical difficulties were being overcome and that rising coal prices were noticeably improving the financial affairs of most companies. Shipments to Japan of some 11.7 million tons in 1973 were over 90 per cent of contractual amounts. Indeed only two companies failed to meet or exceed their basic annual contract tonnages. With this performance, a degree of maturity has been achieved and good progress has been made towards profitability for the coking coal industry in western Canada.

Internationally, it was apparent by mid-1973 that the strong demand for steel products throughout the world was continuing and that coking coal supply availability was becoming increasingly tighter. This, combined with the oil crisis of late 1973 and early 1974 and United States price freeze policies, led to demands in excess of existing productive capacity, distortions in established spot marketing patterns and substantially higher prices for both coking and steam coals. These events have been to the benefit of most Canadian coking coal exporters who have been able to renegotiate higher prices with Japanese purchasers in early 1974. Canadian coal consumers also had to pay more for their supplies. In the short-term, the uncertainty regarding energy price levels, the continuing tightness in many markets and the growing tendency to equate fossil fuel prices with international oil price levels will tend to reinforce higher prices for coal.

If present demand pressures are maintained it is unlikely that sufficient additions to world supply capability can be made in the near-term. Rapidly escalating mine development and operating costs, uncertainty regarding the availability of sufficient capital for new projects, shortages of mining equipment and labour, transportation bottlenecks and regulatory lags are problems causing longer and longer lead-times for mine development. It now appears in North America that many new mines now planned will not have a significant impact on supply capability until 1980.

Domestically, much-improved marketing opportunities have opened up in central Canada for western Canada coking and steam coals in part resulting from the possibility that additional volumes of United States coal, sufficient to meet market demand, may not be available in the foreseeable future. In 1974, some 200,000 – 300,000 tons of coking coal from western Canada will be used by steelmakers in Ontario, and up to 500,000 tons of bituminous steam coal will be used by The Hydro-Electric Power Commission of Ontario (Ontario Hydro). This market could grow substantially within the next five years.

In Canada, in the term to 1980, it is likely that more export sales will be made, possibly totalling some 3-6 million tons annually, mainly to Japan for coking coal and that an annual market of 3-6 million tons, mainly high-volatile bituminous steam coal, will be established in central Canada. It is expected that most, if not all, of this supply will come from coal-producing regions in western Canada.

In Canada, the growth potential of coal for power generation is excellent, particularly in Alberta, Saskatchewan and Ontario. In Alberta, indicated requirements for subbituminous coal could reach nearly 14 million tons in 1980. In Saskatchewan, lignite production for power generation could reach 8 million tons by the end of the decade. Ontario Hydro's 1973 consumption of some 7.6 million tons may be at least double that amount by 1980. In the east, Nova Scotia and New Brunswick are looking seriously again at additions of coal-fired capacity to their systems, based on local coal resources. Consequently, consumption of coal for power generation in Canada could grow from approximately 17.2 million tons in 1973 to nearly 40 million tons in 1980.

Table 1. Canada, coal production[1] by types, provinces and territories, 1972-73

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Bituminous				
Nova Scotia	1,425,439	16,116,667	1,158,411	15,545,876
New Brunswick	429,544	3,483,530	394,219	3,618,374
Alberta	4,118,747	41,542,488	4,256,676	46,823,436
British Columbia	6,547,098	72,251,247	7,772,866	85,579,255
Total	12,520,828	133,393,932	13,582,172	151,566,941
Subbituminous				
Alberta	4,905,690	10,654,387	4,939,721	11,114,372
Lignite				
Saskatchewan	3,282,798	6,551,991	4,028,280	8,500,160
All types, Canada total	20,709,316	150,600,310	22,550,173	171,181,473

Source: Statistics Canada.
[1] Raw coal production less non-saleable preparation plant waste.
^{p} Preliminary.

Table 2. Canada, coal production, imports, exports and consumption, 1963-73

	Production	Imports[1]	Exports	Domestic Consumption
	(short tons)			
1963	10,541,623	13,370,406	1,054,367	23,774,032
1964	11,219,311	14,989,114	1,291,664	24,731,197
1965	11,500,069	16,595,393	1,225,994	25,835,511
1966	11,179,873	16,436,755	1,228,820	25,290,069
1967	11,141,334	16,114,190	1,338,353	24,986,330
1968	10,989,007	17,046,745	1,447,012	27,317,782
1969	10,671,879	17,347,404	1,377,872	26,455,330
1970	16,604,164	18,863,779	4,391,572	29,512,533
1971	18,432,199	18,136,181	7,733,775	28,249,835
1972	20,709,316	19,264,890	8,513,403	28,393,096
1973^p	22,550,173	16,475,440	12,023,700	. . .

Source: Statistics Canada.
[1] Imports from United States and United Kingdom – coal for consumption.
^{p} Preliminary; . . . Not available.

For 1974, production of all types of coal in Canada is expected to reach 25 million tons, an increase of about 10 per cent over 1973. It is estimated that about 12.5 million tons will be exported to Japan and about 500,000 tons will be sent as spot shipments to the United States, western Europe and South America. Imports are expected to be marginally lower than levels in 1973.

Production and mine developments

British Columbia. The coal producing region in British 'olumbia is the Crowsnest Pass area of the south-eastern portion of the province. This basin has large resources of low and medium-volatile bituminous coal characterized by thick coal seams which occur within faulted and disturbed lower Cretaceous rocks. Isolated smaller coal basins in other parts of the province contain coal seams ranging in rank from lignite to anthracite.

In 1973, Kaiser Resources Ltd. achieved stability and profitability from its coking coal mine at Sparwood for the first time since the company started production in 1970. Kaiser completed a financial 'ructurin of the company, including Japanese equity and a revised contract with higher prices, and achieved continuing success from its earlier implemented modifications to its mining plan and preparation plant operation. The revised contract became effective on July 1, 1973 and called for basic annual tonnage of 4.5 million long tons at a price of .19.85 per ton fob Roberts Bank. In 1973, even though the railway strike affected shipments and preparation plant operations in the latter half of the year, the mine produced clean coal at a rate in excess of 4,500,000 long tons annually.

Kaiser's subsidiary, Westshore Terminals L. . had difficulty at its Roberts Bank terminal where one of its two stacker-reclaimers used in stockpiling and loading coal was shut down for approximately six months. This mainly affected shipments of Fording Coal Limited.

Fording Coal Limited, a subsidiary of Canadian Pacific Investments Limited, completed its first full year of production in 1973. The mine, located near Elkford, some 35 miles north of Sparwood, experienced some technical problems with its mining and preparation plant operations and was affected by the rail strike. Shipments of coking coal to Japanese customers were less than the contract quantity of 3 million long tons of clean coal annually, which is the design capability of the Fording project. During the year, Fording received two price increases for its coking coal shipped to Japan. The first was an interim increase bringing the price to $17.73 a long ton. In November this price was raised retroactively to April 1, 1973 to $21.55 a long ton fob Roberts Bank.

Exploration picked up in 1973 as it became apparent that coking coal supply capability around the world was becoming tight. In northeastern British Columbia, Coalition Mining Limited (Brascan Resources Limited) continued to test the mining potential of the Sukunka River coking coal property which was optioned from Brameda Resources Limited in 1971. Agreement was reached in 1973 between Brameda and the Government of British Columbia through the British Columbia Railway (BCR), whereby BCR may acquire a 40 per cent interest in the property by June 30, 1975. Nearby in the Quintette area, Denison Mines Limited and its partner Alco Standard Corporation reached agreement with Mitsui Mining Co., Ltd. and Tokyo Boeki Ltd. to carry out exploration and a feasibility study of their Babcock coking coal property. Farther north, in the Pine Pass area, Pine Pass Coal Company Ltd. conducted exploration activities during 1973. In the southeastern portion of the province, Rio Algom Mines Limited was active with exploration and feasibility studies on its Sage Creek coking coal property located just north of the United States border.

In the Crowsnest Pass region the Line Creek property of Crows Nest Industries Limited and the Elk River property of Scurry-Rainbow Oil Limited and its partner Emkay Canada Natural Resources Ltd. were maintained with some development work as these companies investigated marketing opportunities which could lead to bringing their properties into production. In late 1973 it was announced that Byron Creek Collieries Limited would ship 250,000 tons of bituminous steam coal from its Crowsnest Pass property east of Fernie to Ontario Hydro in 1974 for test burning.

Alberta. Most of Alberta's coal resources are bituminous and subbituminous, but coal of all ranks from lignite to anthracite occurs in the province. Bituminous coal, much of which is of good coking ·ality is loca ed in the foothills and mountain belts whereas subbituminous coal is found in the Plains region. Alberta is Canada's leading coal-producing province and has the largest number of coal mines. Many of these mines are small with production less than 25,000 tons a year, however, the trend in recent years has been to larger but fewer mines to meet expanding markets.

During 1973, four mines produced coking coal in Alberta with McIntyre Porcupine Mines Limited being the largest. In early 1973, McIntyre shut down its No. 5 underground mine and consolidated its underground operations at its No. 2 mine. Surface mining continued at its No. 8 mine and development work progressed for a new surface mine near Sheep Creek (No. 9 mine). In April, McIntyre discontinued its long-term contract to supply the Japanese steel industry with 2 million long tons of coal a year for 15 years. In its place, McIntyre signed a two-year agreement with its Japanese customers with the first year calling for a basic volume of 1.25 million long tons annually at a price of $21.95 (U.S.) fob

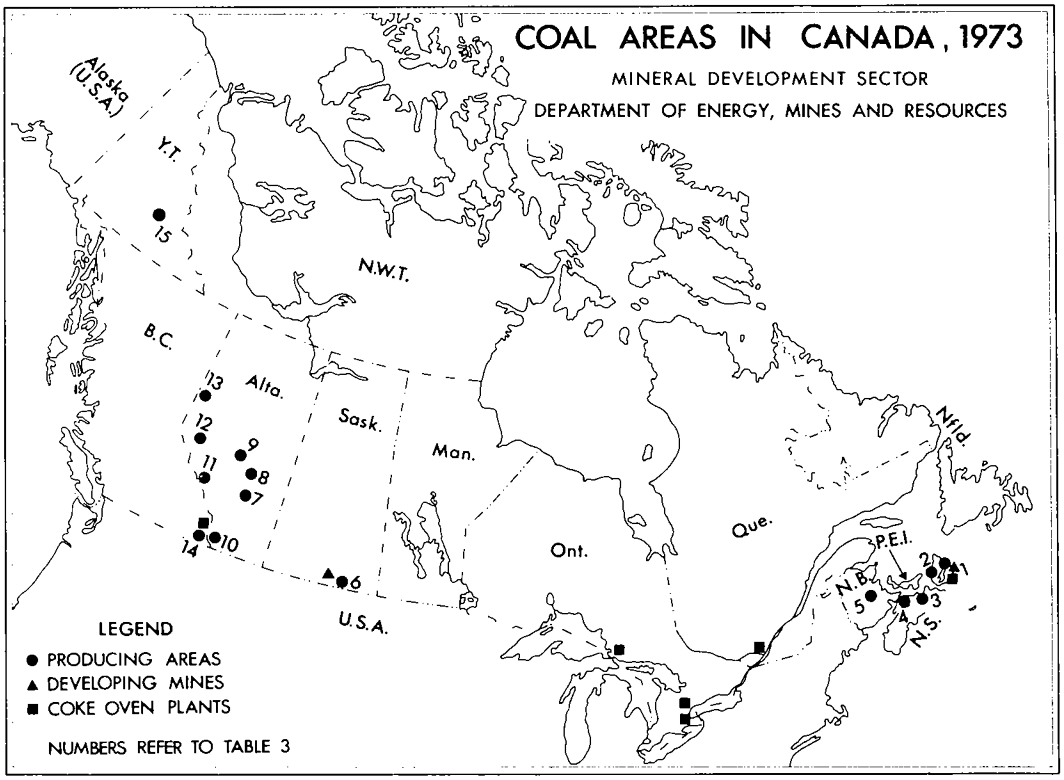


Table 3. Principal coal producers in 1973

Company and Mine Location	Estimated 1973 Production	Coal Rank	Chief Markets	Remarks
Nova Scotia	(short tons) (raw coal)			
1. Cape Breton Development Corporation (DEVCO)				
No. 12, New Waterford	82,000	Hvb A	Power Generation, Industrial, Residential	Underground, mine sealed in 1973 due to fire
Lingan Mine, Lingan	175,000	Hvb A	Power Generation	Underground, two long walls scheduled to start in 1974
No. 26, Glace Bay	632,000	Hvb A	Metallurgical, Industrial, Domestic	Underground
Princess, Sydney Mines	187,000	Hvb A	Power Generation, Industrial, Residential	Underground

Table 3. (cont'd)

Company and Mine Location	Estimated 1973 Production	Coal Rank	Chief Markets	Remarks
Alder Point	2,000	Hvb	Power Generation	Surface, began December 1973
2. Evans Coal Mines Limited St. Rose	25,000	Hvb B	Power Generation, Residential	Underground
3. Drummond Coal Company Limited, Drummond, Westville	20,000	Mvb & Hvb A	Power Generation	Underground
4. River Hebert Coal Company Limited	38,000	Hvb A	Power Generation	Underground
New Brunswick				
5. N.B. Coal Limited Minto, Chipman areas	442,000	Hvb A	Power Generation, Paper Mills	Surface, operates at 6 locations
Saskatchewan				
6. Manitoba and Saskatchewan Coal Company (Limited) M & S Mine, Bienfait	582,000	Lig A	Power Generation, Industrial	Surface
Boundary Dam Mine, Estevan	nil	Lig A	Power Generation	Surface, will begin production in January 1974 at a planned capacity of 1.8 million tpy.
6. Manalta Coal Ltd. Klimax Mine, Estevan	534,000	Lig A	Power Generation, Industrial	Surface
6. Utility Coals Ltd. c/o Manalta Coal Ltd. Utility Mine, Estevan	2,868,000	Lig A	Power Generation	Surface
Alberta				
Subbituminous mines				
7. Century Coals Limited Atlas, East Coulee	38,000	Sub B	Residential, Power Generation	Underground
8. Manalta Coal Ltd. Vesta Mine, Halkirk	465,000	Sub C	Power Generation, Residential	Surface
8. Forestburg Collieries Limited Diplomat Mine, Forestburg	533,000	Sub C	Power Generation, Residential	Surface
9. Manalta Coal Ltd. Whitewood Mine, Wabamun	2,443,000	Sub A & B	Power Generation	Surface
Highvale Mine, Sundance	1,268,000	Sub C	Power Generation	Surface, doubling production in 1974

Table 3. (concl'd)

Company and Mine Location	Estimated 1973 Production	Coal Rank	Chief Markets	Remarks
Bituminous mines				
10. Coleman Collieries Limited Vicary Creek, Coleman	797,000	Mvb	Japan for coke-making	Underground
Tent Mountain, Coleman	257,000	Mvb	Japan for coke-making	Surface
11. The Canmore Mines, Limited Canmore	230,000	An & Lvb	Japan for coke-making	Underground and Surface
12. Cardinal River Coals Ltd. Cardinal River Mine, Luscar	1,900,000	Mvb	Japan for coke-making	Surface
13. McIntyre Porcupine Mines Limited Smoky River Mines, Grande Cache	2,417,000	Lvb	Japan for coke-making	Surface and Underground Plan to open No. 9 Surface mine in 1974
British Columbia				
14. Kaiser Resources Ltd. Michel Colliery, Natal	1,297,000	Lvb	Japan for coke-making	Underground (hydraulic mining, room-and-pillar) and Surface
Balmer Strip, Natal	5,928,000	Lvb	Japan for coke-making	Surface
14. Fording Coal Limited Fording Mine, Fording Valley	3,921,000	Lvb	Japan for coke-making	Surface
Yukon				
15. Anvil Mining Corporation Limited Tantalus Butte Coal Mine, Carmacks	20,000	Hvb B	Anvil lead-zinc mine for heating and concentrate drying	Underground

Source: Data supplied to the Mineral Development Sector by companies.
An – Semi-anthracite; Lvb – Low volatile bituminous; Mvb – Medium volatile bituminous; Sub – Subbituminous; Lig – Lignite; UG – Underground; Hvb – High volatile bituminous.

Vancouver beginning April 1, 1973. The second year of the contract will be negotiated before April 1974. Later in the year, McIntyre made sales of coking coal to two steelmakers in the eastern United States and to The Steel Company of Canada, Limited (Stelco) in Hamilton. McIntyre and the other three coking coal producers in Alberta, like the two producers in British Columbia, were affected in the latter part of 1973 by the railway strike.

In 1973, Cardinal River Coals Ltd. continued to produce coking coal in excess of its full-rated capacity of 1 million long tons annually. In August, Cardinal was successful in revising its export contract with Japan to include an additional 500,000 long tons

Table 4. Canada, coal production by rank, province, type of mining and average output per man-day, 1973^p

	Production[1]		Average output per man-day[2(e)]	
	Underground	Surface	Underground	Surface
	(short tons)			
Bituminous				
Nova Scotia	1,266,089	–	2.7	–
New Brunswick	–	394,219	–	7.7
Alberta	1,856,480	3,691,887	12.2	38.4
British Columbia	1,269,846	9,584,775	20.5	26.0
Subbituminous				
Alberta	54,077	4,885,644	12.2	89.4
Lignite				
Saskatchewan	–	4,028,280	–	96.0
Canada 1973^p	4,446,492	22,584,805	11.8	53.9
1972	5,166,297	19,163,967	12.2	41.3
Total, all mines				
1973^p	27,031,297		47.0	
1972	24,330,264		35.1	

Source: Statistics Canada.
[1] Raw coal production only.
[2] Mine production and related employment only, excludes preparation plant workers, executive administrative, sales and office employees.
Man-day refers to approximately an eight-hour manshift.
^{p} Preliminary; ^{e} Estimated; – Nil.

annually. Shipments were to be increased in the latter part of 1973 with an annual rate of 1,500,000 long tons of clean coal to be achieved in June 1974. The contract, to be in effect until 1985, called for a base price in 1973 of $18.73 a long ton, fob Vancouver. The expansion required will involve the addition of more trucks and shovels for the surface mining operation, some increase in the preparation plant capacity and an increase of more than 50 per cent in the mine work force.

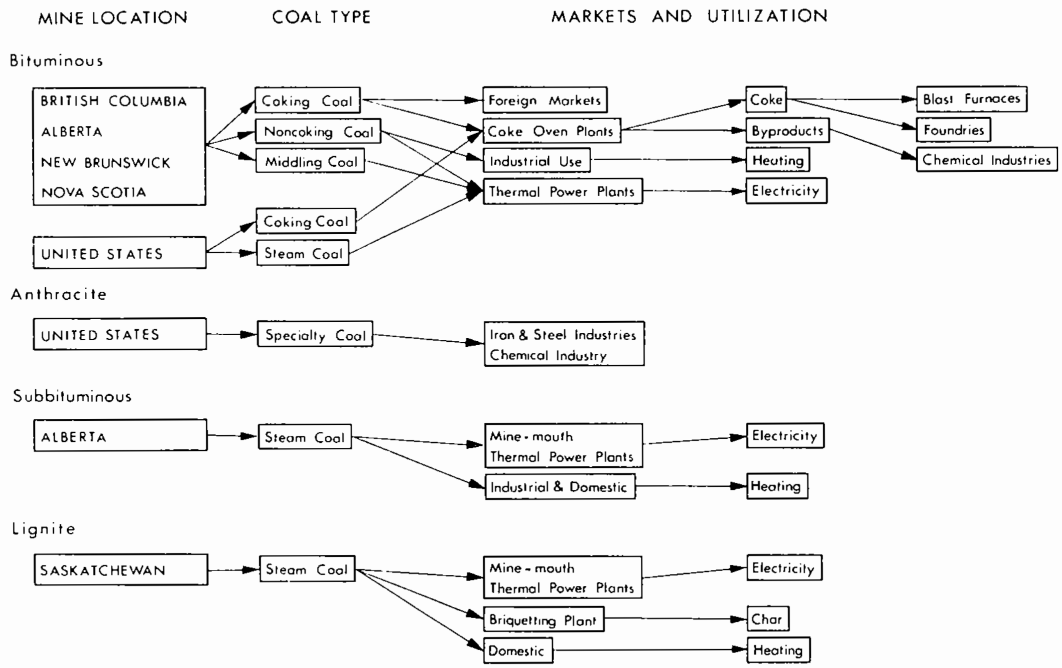
Coleman Collieries Limited operated two mines in the Crowsnest Pass area in 1973. In early 1973 the company implemented a revised mining plan at its Vicary South underground mining operation as a result of geological difficulties encountered in late 1972. Resumption of surface mining began at the Tent Mountain mine at the Alberta/British Columbia border after a period of detailed exploration. Because of the difficulties, Coleman and its Japanese consumers agreed to a temporary reduction in shipments covering the 18-month period ending March 1974. In addition, the Japanese agreed to price increases. Throughout 1973 the company continued to investigate new mining plans and the use of alternate mining methods, including hydraulic mining, in an effort to increase production capability and achieve contractual levels of exports to Japan.

The Canmore Mines, Limited, situated in the Cascade area near Canmore, continued to produce semi-anthracite and low-volatile bituminous coal from its No. 2 mining area during 1973. Most output is sold to Japan, although the company is also seeking markets in eastern Canada.

Exploration in Alberta was more active in 1973. Specifically, in the south, Consolidation Coal Company of Canada began an evaluation of the Grassy Mountain area on property optioned from Scurry Rainbow Oil Limited. Bralorne Resources Limited continued development plans for its Savanna Creek project. The Granby Mining Company Limited optioned several properties from Canpac Minerals Limited and concentrated its efforts at the Isolation Ridge deposit. To the north, Consolidation Coal reached an advanced stage of development at its Brazeau River coking coal project. At its Coalspur steam coal property, Denison Mines Limited carried

COAL'S ROUTE TO CONSUMPTION

MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES



out a drilling program. At year-end, Gregg River Resources Ltd. (Manalta Coal Ltd.) was near agreement with Japanese importers for coking coal from its property located near Cardinal River Coals Ltd. at Luscar.

Subbituminous production in Alberta is now essentially related to coal demand for mine-mouth power stations. Although production remained level in 1973 additional mine capacity was being prepared to meet future coal requirements. In the Wabamun Lake area west of Edmonton, where Calgary Power Ltd. operates two coal-fired power stations, Wabamun and Sundance, the Highvale mine was prepared for a doubling of annual capacity to nearly 3 million tons, as the second 300-megawatt unit at Sundance came on-stream in late 1973. At Forestburg, the capacity of two mines was being expanded to meet the addition of a 150-megawatt unit at Alberta Power Limited's Battle River coal-fired power station in late 1975.

Saskatchewan. In Saskatchewan, production of lignite comes from three surface mines in the Estevan-Bienfait region of southeastern Saskatchewan. Most production is sold to Saskatchewan Power Corporation (SPC), for use in its nearby power stations. The other important lignite market is Manitoba where shipments are made to two power stations. Sales are also made to industrial and local consumers.

The SPC Boundary Dam power station at Estevan, which added 150 megawatts of capacity in late 1973, consumed nearly 2.9 million tons of lignite in 1973.

During 1973, preproduction work continued at the new mine of Manitoba and Saskatchewan Coal Company (Limited) which is being developed adjacent to the Boundary Dam power station. The company has a 15-year contract to supply the power station with 1,650,000 tons annually from this mine, with deliveries starting in January 1974. Like the nearby Utility Coals Ltd. mine, the mine will be a captive supplier to the Boundary Dam power station.

The two-year drilling program undertaken by the Government of Canada and the Government of Saskatchewan to evaluate lignite resources in the southern and central parts of Saskatchewan was completed in 1973. An analysis of the results is to be completed by 1975.

New Brunswick. Coal is mined in New Brunswick in the Grand Lakes coal basin in the Minto-Chipman area by N.B. Coal Limited, a provincial crown company. Since 1971, when the last underground mine was closed, all production has been from surface mining.

In 1973 some 440,000 tons were mined from six locations. Most production is sold to the New Brunswick Electric Power Commission for use in its Grand Lakes power station near Minto. The remainder is sold to industrial and local domestic consumers. Although inventories were being built up through most of the year due mainly to decreased power demands at Grand Lakes during the first nine months of 1973, the sharp price rise of residual fuel oil towards the end of 1973 brought new demands for this coal. The dual-fired power station at Chatham was switched to coal, and sales to industrial users, particularly in Quebec, were being expanded.

In 1974, it is planned that a drilling program will be undertaken to evaluate deeper seams in the Grand Lakes basin and to test other designated areas of the province where coal may be present. Funding for various aspects of this program is to be supplied by the Government of Canada, the Government of New Brunswick and the New Brunswick Electric Power Commission.

Nova Scotia. In early March 1973, the Cape Breton Development Corporation (DEVCO) suffered an underground fire in its No. 12 Colliery at New Waterford. The mine, which had begun to show productivity improvements due to rehabilitation programs, was sealed off and it is unlikely to be reopened for production. This colliery operated for 66 years from 1907 to 1973. Rehabilitation programs continued at both the Princess and No. 26 collieries with the major efforts on No. 26, which is DEVCO's largest producer and the main supplier of coking coal to Sydney Steel Corporation (Sysco). At No. 26 emphasis was placed on changes and improvements to its underground haulage system. In mid-1973 underground workers at Princess were switched to a 10-hour workday, 4-day-week schedule, on a trial basis, in an attempt to improve productivity by having more time at the working faces. During 1973, DEVCO continued development of its new mine at Lingan. This mine, which is located between the No. 12 and No. 26 mines, is designed for annual production rate of from

Table 5. Producers' disposition of Canadian coal[1], 1973

	Originating Province					
Destination	Nova Scotia	New Brunswick	Saskatchewan	Alberta	British Columbia and Yukon	Canada
			(short tons)			
Railways in Canada	12,497	–	72,798	1,040	–	86,335
Newfoundland	1,407	–	–	–	–	1,407
Prince Edward Island	10,283	–	–	–	–	10,283
Nova Scotia	1,135,410	102,483	–	–	–	1,237,893
New Brunswick	22,536	219,533	–	–	–	242,069
Quebec	52,472	42,243	–	345	–	95,060
Ontario	4,557	–	23,192	20,812	–	48,561
Manitoba	–	–	698,752	107,817	–	806,569
Saskatchewan	–	–	3,229,382	69,385	–	3,298,767
Alberta	–	–	–	5,162,862	–	5,162,862
British Columbia	–	–	–	19,500	326,432	345,932
Total Canada	1,239,162	364,259	4,024,124	5,381,761	326,432	11,335,738
United States	–	–	5,811	228,418	217	234,446
Japan	–	–	–	3,805,816	7,300,509	11,106,325
Other	–	–	–	–	–	–
Total Shipments	1,239,162	364,259	4,029,935	9,415,995	7,627,158	22,676,509

Source: Statistics Canada.
[1] Saleable coal (raw coal, clean coal and middling sales).
– Nil.

Table 6. Canada, exports and imports of coal, 1972-73

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Exports				
Japan	8,322,937	103,835,000	11,712,105	160,046,000
Chile	101,099	1,260,000	114,980	1,369,000
Belgium-Luxembourg	77,827	716,000	–	–
United States	9,940	107,000	184,001	3,241,000
St. Pierre-Miquelon	1,585	35,000	854	19,000
United Kingdom	10	*	11,760	389,000
West Germany	5	*	–	–
Total	8,513,403	105,953,000	12,023,700	165,064,000
Imports (for consumption)				
Anthracite				
United States	379,344	5,945,704	460,599	5,625,000
Bituminous				
United States	18,885,546	172,341,144	16,014,841	160,824,000
Total	19,264,890	178,286,848	16,475,440	166,449,000

Source: Statistics Canada.
^p Preliminary; – Nil; * Less than $1,000.

Table 7. Canada, supply and demand of coal, 1962 and 1972

	1962	1972
	(short tons)	
Supply		
Production	10,216,618	20,709,316
Landed imports	12,321,377	18,558,034
Total inventory change	-775,148	+2,360,851
Total supply	23,313,143	36,906,499
Demand		
Domestic sales		
Electric utilities	3,725,005	16,766,778
Mining and manufacturing	6,973,865	2,034,496
Coke-making	5,452,320	7,337,062
Subtotal	16,151,190	26,138,336

	1962	1972
Demand	(short tons)	
Residential	3,540,615	209,395
Railways	386,834	118,626
Ship's bunker	246,524	117,309
Government and institutional	279,000	92,000
Subtotal	4,452,973	537,330
Coal mine and local use	825,780	380,128
Unaccounted for coal	989,281	1,337,302*
Total domestic demand	22,419,224	28,393,096
Exports	893,919	8,513,403
Total demand	23,313,143	36,906,499

Source: Statistics Canada.
* 1972-Includes coal in transit for export, 1,393,852 tons; coal unaccounted for -56,550 tons.

1.5 to 2.0 million tons from three advancing longwall operations when fully developed in 1975. The first two walls are scheduled to be started in 1974. Since late 1972, besides some developmental coal, Lingan has been producing coal from a room-and-pillar operation using continuous miners and shuttle cars. This operation will be phased out with implementation of longwall mining. In December, DEVCO opened a small surface mine at Alder Point in order to supplement coal deliveries in early 1974 to Nova Scotia Power Corporation for power station use.

During 1973, the Mines Branch of the Department of Energy, Mines and Resources continued research into lowering the sulphur content of Cape Breton coals. The two-year program is to be completed in early 1974. The Energy, Mines and Resources process will be considered in the design of the new preparation plant at Lingan.

In 1973, preparation began on the recovery and reclamation of the coal waste heaps at Stellarton. The project which is funded by the Government of Canada and the Government of Nova Scotia through Thorburn Mining Limited is expected to have official start-up in early 1974. The coal to be recovered from these waste heaps is to be sold to the Nova Scotia Power Corporation's power station at Trenton.

In the Cumberland region, Cumberland Mining Associates are planning a $400,000 coal-drilling program to commence in early 1974. A shared cost Government of Canada – Government of Nova Scotia, 3-year coal-drilling program is being considered for selected areas in the province with initial drilling expected to start by mid-1974.

Trade and markets

Exports. In 1973, a total of 12 million tons of bituminous coal having value of $165 million was exported to five countries. Imports totalled nearly

Table 8. Relative fossil fuel value by heat content

Cost per million btu	Bituminous Coal (short ton)	Subbituminous Coal (short ton)	Lignite (short ton)	Oil (barrel)	Natural Gas (Mcf)
$0.20	$5.00	$3.20	$2.60	$1.17	$0.20
.25	6.25	4.00	3.25	1.46	.25
.30	7.50	4.80	3.90	1.75	.30
.35	8.75	5.60	4.55	2.04	.35
.40	10.00	6.40	5.20	2.33	.40
.45	11.25	7.20	5.85	2.62	.45
.50	12.50	8.00	6.50	2.91	.50
.55	13.75	8.80	7.15	3.20	.55
.60	15.00	9.60	7.80	3.50	.60
.65	16.25	10.40	8.45	3.79	.65
.70	17.50	11.20	9.10	4.08	.70
.75	18.75	12.00	9.75	4.37	.75
.80	20.00	12.80	10.40	4.66	.80
.85	21.25	13.60	11.05	4.95	.85
.90	22.50	14.40	11.70	5.24	.90
.95	23.75	15.20	12.35	5.53	.95
1.00	25.00	16.00	13.00	5.83	1.00
1.10	27.50	17.60	14.30	6.41	1.10
1.20	30.00	19.20	15.60	6.99	1.20
1.30	32.50	20.80	16.90	7.57	1.30
1.40	35.00	22.40	18.20	8.16	1.40
1.50	37.50	24.00	19.50	8.74	1.50
1.60	40.00	25.60	20.80	9.32	1.60
1.70	42.50	27.20	22.10	9.90	1.70
1.80	45.00	28.80	23.40	10.49	1.80
1.90	47.50	30.40	24.70	11.07	1.90
2.00	50.00	32.00	26.00	11.65	2.00

Assumptions: Bituminous coal - 12,500 btu/lb; Subbituminous coal - 8,000 btu/lb; Lignite - 6,500 btu/lb; Fuel oil - 5,825,000 btu/bbl; Natural Gas - 1,000 btu/scf.

Mcf - Thousand cubic feet; btu - British thermal unit; bbl - barrel; scf - standard cubic foot; lb - pound.

16.5 million tons, valued at $166.4 million. Of total exports, nearly two thirds originated in British Columbia. The bulk of the rest originated in Alberta. Approximately 53 per cent of Canadian production was exported in 1973, but this proportion is expected to decrease in the short-term as production for domestic power generation increases at a faster rate than export growth. Japan received 11.7 million tons or about 97 per cent of exports compared to 8.3 million tons or 98 per cent in 1971. All shipments to Japan were of coking quality. Spot shipments, totalling about 300,000 tons of steam coal and coking coal, were made to Chile, St. Pierre-Miquelon, the United Kingdom and the United States.

Imports. Canada imported nearly 16.5 million tons of coal in 1973 of which some 16 million tons were bituminous coal and 460,000 tons anthracite. All imports were from the Appalachian region of the eastern United States. During 1973, imports were more in line with consumption requirements than in 1972 when stocks were being rebuilt as a consequence of the United States coal miners' strike in late 1971. This, coupled with reduced coal use by Ontario Hydro, led to a decline of imports of some 2.8 million tons in 1973. About 7.6 million tons or 48 per cent of bituminous coal imports were used for thermal power generation in Ontario with roughly about the same tonnage used for steelmaking purposes. The balance of imports were used for heating and specialty markets. Ontario Hydro has long-term agreements with United States coal companies for the bulk of its coal supplies while the steel companies have captive mines and long-term commitments with United States coal companies for virtually all of their import needs.

Thermal power industry

Coal used for the generation of electricity totalled 17.2 million tons in 1973 up slightly from 16.8 million tons in 1972. At the end of 1973, total capacity of power stations in Canada with a coal-fired capability stood at some 10,900 megawatts (MW). In addition, new coal-fired capacity under construction or being planned for installation by 1980 totalled some 5,375 MW. With the exception of 300 megawatts in Saskatchewan this expansion is roughly divided between Ontario and Alberta. Of the 17.2 million tons of coal used in 1973 approximately 9.6 million tons were of domestic coal and the remainder imported coal for Ontario.

Ontario Hydro is the largest consumer of coal for the generation of electricity in Canada. In 1973, it burned some 7.6 million tons of bituminous coal, all imported from the United States. Most Ontario Hydro coal requirements are met by long-term contracts with coal companies in West Virginia and Pennsylvania. During 1973, two more 500-MW units were added at the Nanticoke station on Lake Erie, bringing total capacity to 1,500 MW. When completed in 1977, Nanticoke will have a total capacity of 4,000 MW and will consume annually some 7.5 million tons of coal. It was announced in 1973 that as part of an experimental research program one of the eight coal-fired 300-MW units at the Lakeview station near Toronto would be converted from burning coal to burning garbage. If successful, this operation could be expanded to more units.

In late 1973 Ontario Hydro announced that it would be test-burning in 1974 some 500,000 tons of bituminous steam coal from western Canada. Byron Creek Collieries Limited of British Columbia is to supply 250,000 tons with the remainder to come from three or four other companies. During 1973, investigation continued into the feasibility of using Onakawana lignitic coal near James Bay, as a fuel for power generation in Ontario.

In Alberta, in the Wabamun area, Calgary Power Ltd. commissioned the second 300-MW unit at its Sundance station in late 1973, bringing total capacity to 600 MW. Three additional units of 375 MW each are scheduled to be on line by the end of 1977. With total capacity of 1,725 MW the Sundance station will require some 7 million tons of subbituminous coal annually from the nearby Highvale Mine.

At Grande Cache, Alberta Power Limited commissioned the 150-MW H.R. Milner power station in March 1973. However, the station, which was designed to burn middlings from the nearby preparation plant of McIntyre Porcupine Mines Limited, experienced continuing difficulties throughout the year due mainly to varying quality of the middling feed. At Forestburg, Alberta Power continued construction of a 150-MW addition at its Battle River station which is scheduled to be on line in late 1975. Plans are underway to add a 375-MW unit to this station for service by 1980.

A report released by the Alberta Energy Resources Conservation Board (AERCB) in 1973 projects an annual growth rate for electrical energy demand in excess of 8 per cent in the province to the year 2001. The analysis of the comparative costs and benefits to the province of using coal or gas as the plant fuel demonstrates that not only is coal likely to provide additional electric power at lower costs than gas throughout the forecast period, but the use of coal for this purpose would provide overall benefits to the province as well as conserving natural gas for those uses where gas is better suited. During 1973, the Electric Utility Planning Council of Alberta continued studies of five sites in the province where new coal-fired generation capability could be located. The Dodds-Round Hill and Battle River areas are considered the two best for future development.

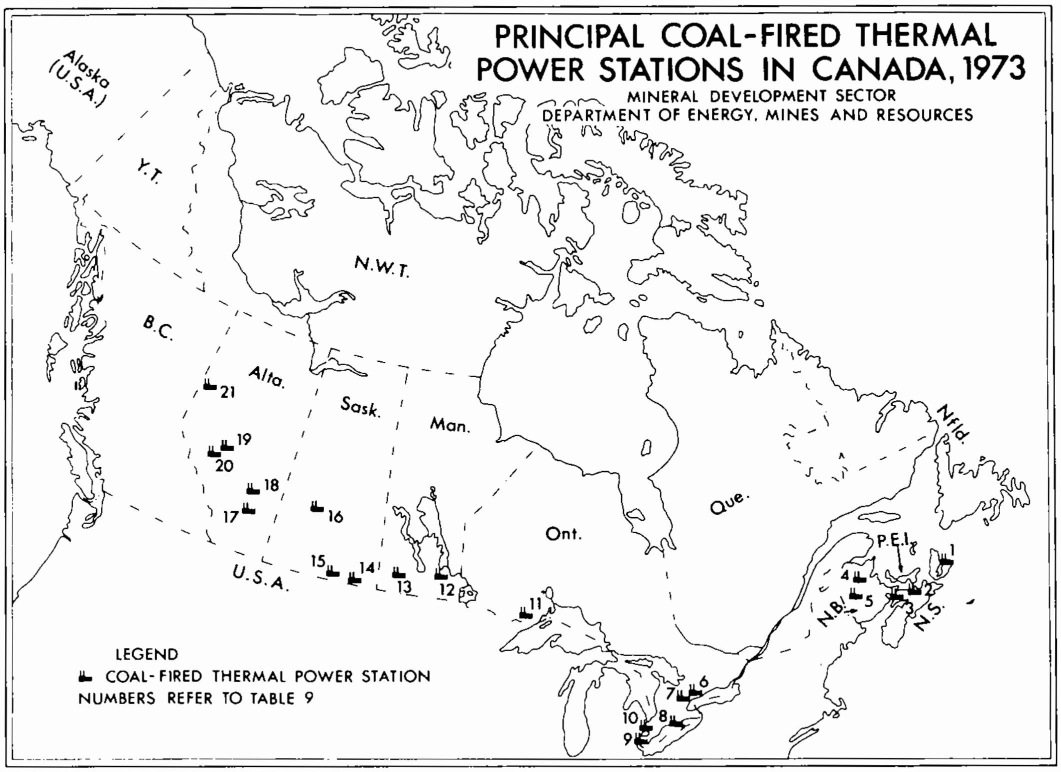
In Saskatchewan, another 150-MW unit was added in late 1973 to the coal-fired Boundary Dam power station at Estevan, bringing total capacity at Boundary Dam to 582 MW. The sixth and final unit is to be added in 1977 and will be a 300-MW unit. A new mine adjacent to the power station began operations in early 1974 and, like the nearby Utility Coals Ltd. mine, the new Manitoba and Saskatchewan Coal Company (Limited) mine will be a captive supplier for the Boundary Dam station. These two mines will have combined capacity of nearly 5 million tons annually. In its program of assessing future site for possible coal-fired power stations in the province, Saskatchewan Power Corporation conducted studies of lignite and water availability in the Coronach-Willow Bunch area during 1973.

In Manitoba, at Brandon and Selkirk two coal-fired stations of the Manitoba Hydro-Electric Board have a combined capacity of 392 MW and in recent

Table 9. Principal coal-fired thermal power stations in Canada, 1973

Utilities	Station	Total Station capacity	Remarks
Nova Scotia		(kilowatts)	
1. Nova Scotia Power Corporation	Glace Bay	111,000	
2. Nova Scotia Power Corporation	Trenton	210,000	
3. Nova Scotia Power Corporation	Harrison Lake	26,500	
New Brunswick			
4. New Brunswick Electric Power Commission	Chatham	32,500	
5. New Brunswick Electric Power Commission	Grand Lake No. 1	13,750	
New Brunswick Electric Power Commission	Grand Lake No. 2	85,000	
Ontario			
6. Ontario Hydro	Richard L. Hearn	1,222,500	
7. Ontario Hydro	Lakeview	2,422,500	
8. Ontario Hydro	Nanticoke	1,500,000	Five 500-MW units to be added by 1978
9. Ontario Hydro	J. Clark Keith	271,500	
10. Ontario Hydro	Lambton	2,022,500	
11. Ontario Hydro	Thunder Bay	128,300	
Manitoba			
12. Manitoba Hydro	Selkirk	155,800	
13. Manitoba Hydro	Brandon	237,000	
Saskatchewan			
14. Saskatchewan Power Corporation	Estevan	70,000	
15. Saskatchewan Power Corporation	Boundary Dam	582,000	300 MW-addition for 1977
16. Saskatchewan Power Corporation	Queen Elizabeth	232,000	
Alberta			
17. Alberta Power Limited	Drumheller	15,000	Operated only briefly in 1973
18. Alberta Power Limited	Battle River	212,000	150 MW-addition scheduled for 1975
19. Calgary Power	Wabamun	582,000	
20. Calgary Power	Sundance	600,000	Three 375-MW units to be added by 1978
21. Alberta Power Limited	H.R. Milner	150,000	Burns middlings

Source: Statistics Canada.



years have been using approximately 400,000 – 500,000 tons of Saskatchewan lignite annually.

In New Brunswick, the New Brunswick Electric Power Commission operates the 98,750-kilowatt (KW) Grand Lakes coal-fired power station on high-volatile bituminous coal from the nearby Minto coalfield. The dual-fired station at Chatham (32,500 KW) is capable of burning oil or coal and with the sharp price hikes for residual oil in late 1973 was being prepared to burn coal. However, deliveries to the station from Minto were being hampered by a shortage of rail cars.

The Nova Scotia Power Corporation operates three coal-fired stations in the province fuelled with high-volatile bituminous coal from Nova Scotia. The bulk of the coal comes from the mines of the Cape Breton Development Corporation (DEVCO). Consumption in 1973 amounted to some 750,000 tons.

Coke industry

In 1973, approximately 8.5 million tons of coking coal were carbonized to produce 5.9 million tons of coke. About 90 per cent of the coking coal used in Canada was imported from the United States. The three steel companies that operate coke oven plants in Hamilton, Ontario and Sault Ste. Marie, Ontario have captive United States mines and long-term contracts. In Sydney, Nova Scotia, the Sydney Steel Corporation uses a combination of Nova Scotia and United States coals to produce coke for its nearby steel mill.

Of the 7.7 million tons of coking coal imported from the United States in 1973 approximately 4.3 million tons or some 55 per cent came from captive mines. Approximately 4.9 million tons, or 83 per cent of coke produced in Canada was charged to blast furnaces for pig iron production. The remainder of the coke was consumed by foundries, chemical plants and nonferrous smelters. The market for coke byproducts such as gas, ammonia, tar and light oils is limited in Canada mainly because of competition from petroleum-based products. However, the integrated steel companies attempt to use as many coke byproducts as possible in their operations.

Coke trade has been small and has shown large yearly fluctuations, mainly because of cyclical demand. In 1973, shipments of some 406,000 tons, valued at $10.6 million, were exported to six countries with the bulk going to the United States. Imports of coke amounted to 394,000 tons in 1973, with shipments coming from the United States and Japan.

In 1973, an average of 1.43 tons of coking coal was required for each ton of coke produced in Canada. The coke rate, the amount of coke consumed per ton of pig iron produced in blast furnaces was 1,030 pounds, down 30 pounds from the rate in 1972. Based on the coking rate and the amount of coal required for each ton of coke it is estimated that in 1973 about 1,475 pounds (0.74 ton) of coking coal were required per ton of basic pig iron produced in Canada.

About 95 per cent of the coke produced in Canada is manufactured in standard slot-type ovens at coke oven plants in Ontario, Nova Scotia and Quebec. The three largest coke oven plants are owned and operated by integrated steel companies, The Algoma Steel Corporation, Limited, The Steel Company of Canada, Limited, and Dominion Foundries and Steel, Limited.

The Steel Company of Canada (Stelco) imports the bulk of its coking coal from subsidiary and joint-venture mines in the United States for its coke oven facilities in Hamilton, Ontario. With the addition of a new coke battery in 1972, the company has coke-producing capacity in excess of its present requirements at Hamilton. In 1973, some 3,349,000 tons of coking coal were used to produce 2,273,000 tons of coke.

Stelco's Madison mine in West Virginia which started production in 1972 of high-volatile bituminous coal, increased production to over 400,000 tons in 1973. The mine with design capacity of 700,000 tons annually is expected to reach full production in 1976. The new Beckley mine in West Virginia in which Stelco has a 12.5 equity participation is scheduled to begin production in mid-1974. Annual capacity of 1.5 million tons of low-volatile bituminous coal is scheduled to be reached in 1976 with Stelco's share to be a minimum of 187,500 tons yearly. At Stelco's Griffith iron ore mine in northwestern Ontario, a SL/RN direct reduction process is to be installed which will use Alberta subbituminous coal as the reducing agent in the production of metallic iron. Up to 400,000 tons of coal will be required annually. During 1973, Stelco bought 50,000 tons of low-volatile bituminous coking coal from McIntyre Porcupine Mines Limited in Alberta for use at Hamilton and will be buying some 200,000 tons in 1974. In addition, Stelco will be buying some 35,000 tons from Kaiser Resources Ltd. mine in British

Table 10. Coal used by thermal power stations in Canada, by provinces, 1958-1973

	Nova Scotia	New Brunswick	Ontario	Manitoba	Saskatchewan	Alberta	Total Canada
			(thousands of short tons)				
1958	431	144	317	98	375	–	1,365
1959	426	141	196	34	435	187	1,419
1960	494	202	118	56	770	206	1,846
1961	504	168	272	116	964	229	2,253
1962	515	121	1,493	111	1,129	356	3,725
1963	534	107	2,807	66	1,054	582	5,150
1964	584	245	3,081	145	1,109	1,101	6,265
1965	698	368	3,932	193	1,196	1,335	7,722
1966	881	324	3,858	87	1,230	1,499	7,879
1967	835	303	4,889	42	1,471	1,573	9,113
1968	712	264	6,088	197	1,492	2,346	11,099
1969	745	165	7,082	56	1,238	2,621	11,907
1970	604	125	8,483	555	2,170	3,253	15,190
1971	759	299	9,436	492	2,200	4,027	17,213
1972	731	310	8,376	452	2,364	4,534	16,767
1973^p	750	300	7,600	450	3,200	4,900	17,200

Source: Statistics Canada.
^{p} Preliminary; – Nil.

Table 11. Coke oven and other carbonization plants in Canada

Company	Battery and No. of Ovens	Oven Type	Year Built	1973 Plant Capacity (coal input)	1973 Coke Production	Byproducts
				(thousands of tpy)		
The Algoma Steel Corporation, Limited, Sault Ste. Marie, Ontario	No. 5 – 86	Koppers-Becker Underjet	1943	2,100	1,429	Naphthalene, light oil, gas, tar
	No. 6 – 57	Koppers-Becker Underjet	1953			
	No. 7 – 57	Wilputt Underjet	1958			
	No. 8 – 60	Wilputt Underjet	1967			
	No. 9 –		New battery under construction			
The Steel Company of Canada, Limited, Hamilton, Ontario	No. 3 – 61	Wilputt Underjet	1947	3,400	2,273	Tar, sulphate of ammonia, sodium phenolate, gas, light oil
	No. 4 – 83	Wilputt Underjet	1952			
	No. 5 – 47	Wilputt Underjet	1953			
	No. 6 – 73	Otto Underjet	1967			
	No. 7 – 83	Otto Underjet	1972			
Dominion Foundries and Steel, Limited, Hamilton, Ontario	No. 1 – 25	Koppers-Becker Gun Type Comb	1956	1,800	1,192	Tar, light oil, gas, ammonium sulphate, sulphur
	No. 2 – 35	Koppers-Becker Gun Type Comb	1951			
	No. 3 – 45	Koppers-Becker Gun Type Comb	1958			
	No. 4 – 53	Koppers-Becker Gun Type Comb	1967			
	No. 5 – 53	Koppers-Becker Gun Type Comb	1971			
Sydney Steel Corporation, Sydney, Nova Scotia	No. 5 – 53	Koppers-Becker Underjet	1949	900	439	Tar, crude oil, gas
	No. 6 – 61	Koppers-Becker Underjet	1953			
Gaz Metropolitain, inc., Ville La Salle, Quebec	No. 1 – 59	Koppers-Becker	1928	345	228	Tar, light oil, gas
	No. 2 – 15	Koppers-Becker	1947			
Manitoba and Saskatchewan Coal Company (Limited), Char and Briquetting Division, Bienfait, Saskatchewan	2 units	Lurgi carbonizing retort	1925	110	na (char)	Creosote, lignite tar, lignite pitch
Kaiser Resources Ltd., Natal, British Columbia	10 units	Curran-Knowles	1939	245	140	Crude tar, gas, coke breeze
	10 units	Curran-Knowles	1943			
	16 units	Curran-Knowles	1949			
	16 units	Curran-Knowles	1952			
	3 units	Mitchell	1963			

na – Not available.

Table 12. Canada, coal coke production and trade, 1972-73

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Production				
Ontario	4,457,591	*	5,038,112	*
Other provinces	696,669	*	881,147	*
Total	5,154,260	*	5,919,259	*
Imports				
United States	379,907	13,196,000	338,758	12,751,000
West Germany	128,091	4,499,000	55,666	1,747,000
Japan	1,025	41,000	–	–
United Kingdom	42	4,000	–	–
Total	509,065	17,740,000	394,424	14,498,000
Exports				
United States	170,803	4,022,000	303,504	9,313,000
West Germany	14,850	106,000	55,049	656,000
Romania	–	–	27,803	404,000
Netherlands	74,830	809,000	16,045	222,000
Belgium-Luxembourg	–	–	3,153	29,000
Greenland	–	–	4	1,000
Spain	2,180	22,000	–	–
St. Pierre-Miquelon	193	4,000	–	–
Panama	21	1,00^	–	–
Total	262,877	4,964,000	405,558	10,625,000

Source: Statistics Canada.
* Practically all coke production is used by producers in the iron and steel industry and is not given a value.
^{p} Preliminary; – Nil.

Columbia.

The Algoma Steel Corporation, Limited (Algoma), of Sault Ste. Marie, Ontario produced some 1,429,000 tons of coke in 1973 from 2,259,000 tons of coking coal. During 1973 Algoma completed new coal handling and storage facilities and construction continued on the new No. 9 coke battery which is scheduled to be on line in 1975. Algoma satisfies its coking coal requirements with imports from captive mines in the United States. The new Maple Meadow mine being developed at Fairdale, West Virginia-is scheduled to come on stream in mid-1974 with full capacity of 1,250,000 tons annually to be reached in 1978. Starting in 1976, 400,000 tons of annual production from this mine is to be sold to Stelco.

Dominion Foundries and Steel, Limited's (Dofasco) coke oven plant at Hamilton produced some 1,192,000 tons of coke in 1973. The annual coking coal requirements are approximately 1.8 million tons. Coking coal is imported from the United States with approximately 95 per cent of Dofasco's requirements provided through long-term agreements and the company's 9 per cent interest in Ittman Coal Company of West Virginia. Approximately one million tons annually is supplied by the Eastern Associated Coal Corp. and some 250,000 tons from Ittman. In 1974, Dofasco will be testing 25,000 tons of western Canadian coking coal purchased from Kaiser Resources Ltd.

On May 1, 1973 the Cape Breton Development Corporation (DEVCO) sold its coke oven plant at Sydney, Nova Scotia to the Sydney Steel Corporation (Sysco). During 1973, the plant produced 439,000 tons of coke. Of the 678,000 tons of coking coal that was consumed in the production of coke, approximately three quarters was supplied from DEVCO mines with the balance imported from the United States.

Table 13. Canada, coke production and trade, 1963-1973

	Production		Imports		Exports	
	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke
	(short tons)					
1963	4,280,797	199,636	234,610	369,037	136,316	18,016
1964	4,342,982	206,815	315,763	440,607	85,969	21,225
1965	4,368,791	242,813	569,905	413,047	71,531	17,101
1966	4,426,051	230,119	584,965	499,154	77,952	9,668
1967	4,430,299	227,886	387,049	565,836	65,292	18,641
1968	5,310,762	238,601	255,405	561,407	143,771	5,740
1969	5,002,275	231,679	280,905	703,582	272,997	2,606
1970	5,668,219	207,649	394,953	779,079	273,890	53,289
1971	5,105,792	206,439	646,428	733,890	317,765	12,314
1972	5,154,260	267,167	509,065	612,565	262,877	971
1973^p	5,919,259	315,845	394,424	702,904	405,558	2,167

Source: Statistics Canada.
^{p} Preliminary.

Table 14. World coal production

	1968	1969	1970	1971	1972^p
	(thousands of short tons)				
North America	570,615	584,376	619,929	583,284	627,057
South America	8,395	9,039	9,149	8,106	8,619
Europe	1,856,496	1,873,376	1,891,895	1,934,820	1,903,823
Africa	62,236	63,493	64,154	70,322	70,174
Asia	529,005	560,635	598,224	642,454	651,901
Oceania	73,325	81,020	86,200	82,883	94,251
World					
Lignite (estimate)	811,071	846,023	868,100	911,777	917,399
Bituminous and anthracite (by subtraction)	2,289,001	2,325,916	2,401,451	2,410,092	2,438,426
Total, all types	3,100,072	3,171,939	3,269,551	3,321,869	3,355,825

Source: U.S. Bureau of Mines.
^{p} Preliminary.

Cobalt

R.J. GOODMAN and M. A. BOUCHER

Cobalt production in 1973 by the three Canadian producers, The International Nickel Company of Canada, Limited (Inco), Falconbridge Nickel Mines Limited and Sherritt Gordon Mines, Limited increased by over 22 per cent from 3,351,108 pounds in 1972 to 4,100,000 pounds in 1973. Noncommunist production of cobalt was 12 per cent higher in 1973 than in 1972.

Demand for cobalt in 1973 was very strong, and the price of cobalt metal increased from $2.50 in January 1973 to $3.10 by year-end. However, increased world production and liberal sales by the United States General Services Administration eliminated any serious supply shortages and prevented the spectacular escalation of prices, characteristic of most metals during 1973. Demand for cobalt was particularly strong in the United States and Japan, with consumption in 1973 showing increases of 22 per cent and 95 per cent, respectively, over the previous year.

World cobalt production is highly inelastic, as virtually the whole of world production is obtained as a byproduct of the copper and nickel industries and hence supply at any time is largely controlled by supply-demand interactions in the copper and nickel markets. The Republic of Zaire accounts for about 65 per cent of noncommunist world production with Zambia, Canada, Morocco and Finland accounting for an additional 30 per cent.

Canadian production and developments

The three Canadian producers of cobalt in Canada, The International Nickel Company of Canada, Limited (Inco), Falconbridge Nickel Mines Limited, and Sherritt Gordon Mines, Limited produced a total of 4,100,000 pounds of contained cobalt in 1973, according to company sources, compared with 3,351,108 pounds in 1972. The largest producer of cobalt in Canada is Inco, which recovers cobalt in the form of crude oxide at its nickel refineries at Port Colborne, Ontario and Thompson, Manitoba. Upgraded cobalt oxides and salts are recovered at the company's nickel refinery at Clydach, Wales. On October 11, 1973, a new Inco nickel refinery was formally opened at Copper Cliff, Ontario. The refinery, which cost $14 million to construct, has an annual capacity of 100 million pounds of nickel pellets and 25 million pounds of nickel and nickel-iron powders. Electrolytic copper, cobalt carbonate and precious metal concentrates are recovered from the refinery residues. The expected capacity of the new refinery is half a million pounds of cobalt as high purity salts annually. During 1973, the company's cobalt production was 1,870,000 pounds compared with 2,210,000 pounds in 1972.

Falconbridge Nikkelverk Aktieselskap, a subsidiary of Falconbridge Nickel Mines Limited, resumed production of refined cobalt in early May from its cobalt refinery at Kristiansand, Norway. The refinery, which was extensively damaged by fire in 1972, has been completely rebuilt, and in the seven months of operation in 1973 it produced 1,614,000 pounds of cobalt. Falconbridge continued further construction on its new refinery complex at Becancour, Quebec. When completed in 1975 the refinery will produce 500,000 pounds of cobalt a year in high purity cobalt salts.

Sherritt Gordon Mines, Limited recovers metal powder from nickel refinery end-solutions at its hydrometallurgical refinery at Fort Saskatchewan, Alberta. The refinery treats nickel-copper concentrates from its Lynn Lake mine operation in Manitoba and also, on a toll basis, concentrates from the Giant Mascot Mines Limited mine near Hope, British Columbia and from Western Mining Corporation Limited's nickel operations in Western Australia. During 1973, Sherritt Gordon Mines refined 119,000 pounds of cobalt from its Lynn Lake concentrates and 497,000 pounds from purchased feed. This was a reduction of 25 per cent on the respective 1972 values of 117,000 pounds and 692,000 pounds and was due predominantly to reduced cobalt content in the refinery feed in 1973.

Table 1. Canada, cobalt production, trade and consumption, 1972-73

	1972		1973p	
	(pounds)	($)	(pounds)	($)
Production[1] (all forms)				
Ontario	2,593,814	6,387,560	3,126,000	9,125,000
Manitoba	582,236	1,514,774	779,000	2,425,000
British Columbia	155,739	372,216	41,000	117,000
Quebec	19,319	46,172	–	–
Total	3,351,108	8,320,722	3,946,000	11,667,000
Exports				
Cobalt Metal				
United States	809,647	1,972,000	1,165,775	3,530,000
Britain	3,019	13,000	12,261	53,000
Japan	5,868	25,000	9,311	49,000
France	26,617	70,000	13,743	44,000
South Africa	10,530	25,000	11,611	35,000
Belgium and Luxembourg	–	–	628	3,000
Argentina	4,400	12,000	–	–
West Germany	300	1,000	–	–
Other Countries	100	1,000	1,045	6,000
Total	860,481	2,119,000	1,214,374	3,720,000
Cobalt and Oxides and Salts[2]				
Britain	1,386,200	2,072,000	954,500	1,601,000
United States	229,500	306,000	175,100	325,000
Total	1,615,700	2,378,000	1,129,600	1,926,000
Consumption[3]				
Cobalt contained in:				
Cobalt Metal	141,740	. .		
Cobalt Oxide	67,089	. .		
Cobalt Salts	72,252	. .		
Total	281,081	. .	. .	. .

Source: Statistics Canada.
[1] Production (cobalt content) from domestic ores. [2] Gross weight. [3] Available data reported by consumers.
pPreliminary; – Nil; . . Not available.

World development

New developments throughout the noncommunist world ensures increases in the supply of cobalt over the next few years, with major projects assigned for commencement of production in 1974.

There was no United States domestic mine production of cobalt in 1973, since cobalt-bearing pyrite concentrate output was discontinued at the end of 1971. American Metal Climax, Inc. (Amax), through a new division, Amax Nickel, continued rehabilitation of its Port Nickel refinery near Braithwaite, Louisiana, and is scheduled for production of nickel and byproduct cobalt in 1974. Initially the refinery will commence processing of nickel-copper matte smelted in Botswana, Africa, but other feed materials will also be processed as they are acquired by Amax. Significant cobalt production in the form of metal, oxide powder and metal briquettes is expected from this project in 1974.

In the Philippines, design and construction of Marinduque Mining and Industrial Corporation's lateritic nickel project, in which Sherritt Gordon Mines has a 10 per cent equity interest, is continuing to progress on schedule and commencement of operations is expected on July 1, 1974. The smelter-refinery complex on Nonoc Island will produce 3.3 million pounds of cobalt a year in the form of mixed sulphide concentrates, nickel briquettes and powder. The re-

Table 2. Canada, cobalt production, trade and consumption 1964-1973

		Exports		Imports		
	Production[1]	Cobalt Metal	Cobalt Oxides and Salts[2]	Cobalt Ores[2]	Cobalt Oxides[2]	Consumption[3]
1964	3,184,983	593,607	1,654,900	..	..	365,851
1965	3,648,332	292,191	1,414,200	..	..	366,036
1966	3,511,169	627,990	1,308,300	..	..	392,177
1967	3,603,773	1,498,559	1,934,500	..	..	293,086
1968	4,029,549	1,210,909	1,646,500	..	..	358,098
1969	3,255,623	1,155,291	1,199,800	..	..	393,658
1970	4,561,213	839,849	1,845,000	..	..	327,030
1971	4,323,318	748,502	2,466,500	..	..	220,994
1972	3,351,108	860,481	1,615,700	..	..	281,081
1973p	3,946,000	1,214,374	1,129,600	..	..	..

Source: Statistics Canada.
[1]Production from domestic ores, cobalt content. From 1967, production includes cobalt content of Inco and of Falconbridge shipments to overseas refineries, but prior years exclude Inco shipments to Britain. [2]Gross weight. [3]Consumption of cobalt in metal, oxides and salts.
pPreliminary; – Nil; . . Not available.

finery will employ Sherritt Gordon Mines, Limited's laterite metallurgical process and, according to company sources, it has firm contracts for the sale of its whole cobalt output over the first ten years of operation.

The development of an additional nickel-cobalt deposit on Palawan Island was the subject of continuing negotiations between Soriano Company of the Philippines and a Japanese consortium comprised of Sumitomo Metal Mining Co. Ltd., Pacific Metals Co. Ltd. and Nissho-Twai Ltd. Successful conclusion of these negotiations would ensure an additional source of 1 million tons of ore a year by 1976-1977.

In the Zaire Republic, La Generale Congolaise des Minerais (GECOMIN) continued its expansion program, which calls for progressively increasing output to 16,000 short tons of cobalt annually by 1974.

Current negotiations between the Government of Zaire and a Japanese consortium, centre on the construction of approximately 550 miles of rail line, including an unbroken stretch from the interior cobalt mines to the coast. The consequent reduction in shipping time from 30 days to three weeks would allow an increase of over 50 per cent in the quantity of ore exported by 1980.

Also in Zaire, in 1973 GECOMIN announced the discovery of a new copper-cobalt deposit near Dikuluwe-Mashamba, southwest of Kolwezi with proven reserves estimated to be 121.5 million tons of ore, averaging 3.8 per cent copper and 0.40 per cent cobalt. In addition, in 1973, Société Minière de Tenke-Fungurume of Zaire, in which Standard Oil Company (Indiana) holds a 28 per cent interest, announced the delineation of proven ore reserves of 45.7 million tons of oxide, sulphide and mixed ore grading 5.5 per cent copper and 0.44 per cent cobalt in the Province of Shaba. Production from this deposit is scheduled for commencement in early 1975.

In Queensland, Australia, the Greenvale project is scheduled to commence production of nickel and byproduct cobalt from laterite ore towards the end of 1974. The Greenvale operation is a joint-venture of Freeport Queensland Nickel, Inc. and Metals Exploration Queensland Pty., Ltd. and capital costs to bring this mine to the production stage have been estimated at about $A230, of which $A50 provided for railway construction and provision of associated rail stock. Ore reserves at Greenvale have been calculated to be 40 million tons of high-grade nickel laterite, averaging 1.57 per cent nickel and 0.12 per cent cobalt. Projected plant throughput is 2.5 million pounds of cobalt a year in the form of nickel-cobalt sulphide concentrate, with entire production destined for the Japanese market.

Western Mining Corporation Limited and Sherritt Gordon have entered into a joint agreement to each purchase half of the expected 12,000 tons of nickel concentrate to be produced annually at the Poseidon N.L.'s western Australia mining operation when it commences production in late 1974. The nickel concentrate will be converted to nickel matte at Western Mining Corporation's new nickel smelter at

Kalgoorlie, and some of the matte will be shipped to Fort Saskatchewan for refining, where cobalt will be obtained as a byproduct.

In New Caledonia, Inco has made a firm commitment to bring its large laterite deposit into production by 1977 with an annual productive capacity of 45 million pounds of metallic nickel and 3 million pounds of metallic cobalt as a byproduct. Construction of the plant is expected to commence in 1974, and Inco's reduction acid leaching process for laterites will be used to effect recovery of the nickel and cobalt.

In Indonesia, P.T. International Nickel Indonesia, a subsidiary of Inco, signed a participation and sales agreement with a Japanese consortium with respect to Inco's nickel project on the Island of Sulawesi. The agreement will initially provide the Japanese consortium with a 25 per cent equity interest, but, as a result of an agreement between Inco Indonesia and the Indonesian government, eventual equity participation will be 60 per cent Inco, 20 per cent the Japanese consortium and 20 per cent by Indonesians. It is expected that production capacity will be 30 million pounds of contained nickel and cobalt in the form of nickel matte, with envisaged commencement of production in the late 1970s.

Also, in Indonesia, the P.T. Pacific Nikkel Indonesia project, in which Sherritt Gordon has an 11 per cent equity interest, was the subject of further development work in 1973. A feasibility study on the mining and processing facilities to produce over 100 million pounds of nickel and 4 million pounds of cobalt annually has been completed, but no production decision has yet been made. The economic viability of the operation is now under close scrutiny because of sharply increasing fuel costs. A definite decision is expected to be announced in 1974.

In Japan, the construction of a cobalt refinery by Sumitomo Metal Mining Co. Ltd. is scheduled for commencement in early 1974 with production beginning in August 1975 at the rate of about 2 million pounds of cobalt annually. The Sumitomo refinery will refine cobalt material imported from the Marinduque mine in the Philippines. Nippon Mining Co. Ltd. is also planning construction of a new cobalt refinery in late 1974 or early 1975 from nickel-cobalt ore imported from the Greenvale mine in Australia.

Table 3. World production of cobalt, 1971-73

	1971	1972	1973^e
	(short tons of contained cobalt)		
Republic of Zaire*	13,228	14,330	15,400
Zambia	2,293	2,263	2,300
Canada	2,162	1,676	1,973
U.S.S.R.	1,750	1,800	. .
Cuba	1,700	1,700	. .
Finland	1,400	1,400	. .
Morocco	1,078	1,261	1,300
Australia	343	815	1,000
Norway	. .	. .	
Total	23,954	25,245	27,573**

Source: U.S. Bureau of Mines, *Minerals Yearbook* Preprint for 1971-72; for 1973, U.S. *Commodity Data Summaries,* January 1974; for Canada, Statistics Canada.
*Changed from Democratic Republic of the Congo (Kinshasa) on October 27, 1971.
**Totals include estimates for unavailable figures, 1973 = 5,600.
. . Not available; ^{e}Estimated.

United States consumption

The United States is the world's largest consumer of cobalt. Consumption in the United States increased by 33 per cent to an estimated 18.8 million pounds of cobalt in 1973, compared with 14.1 million pounds in 1972. Total imports of cobalt-bearing materials was an estimated 18.7 million pounds in 1973, compared with 13.92 million pounds in 1972. End-use consumption is now quite evenly divided between the four principal markets with 30 per cent now consumed in nonmetallic uses, 25 per cent in the magnetic industry, 25 per cent in the tool and wear-resistant industries and 20 per cent in the superalloy industry. The end-use consumption pattern in the United States has not changed appreciably in the past 15 years, except that proportion of cobalt consumption in magnetic alloys declined from 25.6-30.2 per cent in 1959-1961 to 16.6-18.0 per cent in 1969-1971. However, due to increasing acceptance of the new cobalt-rare-earth high energy magnets, magnet alloys have again regained 25 per cent of the total United States market. In the short-term, the fields of nonmetallic uses and magnetic alloys appear to offer the greatest growth potential in terms of cobalt consumption.

United States government stockpile

In 1973, the United States General Services Administration (GSA) sales of stockpile cobalt were 6.98 million pounds compared with 8.32 million pounds in 1972, a decrease of 15 per cent. However, GSA sales still comprised 13 per cent of the total free world's supply in 1973 alleviating any serious world shortages. The GSA offered its cobalt for sale on a monthly sealed-bid basis at prices varying from $2.39-$2.99 compared with $2.20-$2.385 during 1972. The government stockpile as of January 1, 1973, was about 68.5 million pounds with an objective stockpile of 38.2 million pounds, leaving a residual amount of 30.3 million pounds available for eventual disposal. As of November 11, 1973, the government stockpile was reduced to 60.1 million pounds of contained Co and the stockpile objective was reduced to 11.9 million pounds. Thus, there remains 48.2 million pounds available for disposal. A similar pattern of cobalt disposal is expected to prevail in 1974 with the GSA again offering about three-quarters of a million pounds of cobalt for sale each month.

Table 4. United States, consumption of cobalt by uses, 1971-72

	1971	1972
	('000 lbs cobalt content)	
Steel (Ingots and castings)		
High-speed and tool	318	361
Stainless steel	50	39
Alloy (excluding stainless and tool)	197	227
Cutting and wear-resistant materials		
Cemented or sintered carbides	1,230	1,273
Other materials	2,454	3,523
Welding and hardfacing rods, materials	246	199
Magnetic alloys	2,278	3,441
Non-ferrous alloys	532	651
Electrical materials	. .	. .
Chemical and Ceramic uses		165
Catalysts	474	702
Ground coat frit	137	144
Glass decolorizer	60	61
Pigments	146	165
Other	102	173
Miscellaneous and unspecified	1,532	315
Salts and driers: lacquers, varnishes, paints, inks, pigments, enamels, feeds, electroplating (estimate)	2,744	2,691
Total	12,500	14,130

Source: U.S. Bureau of Mines, *Minerals Yearbook, 1971* and preprint from the U.S. Bureau of Mines, *Minerals Yearbook, 1972.*
. . Not available.

Current technology and uses

The major applications of cobalt materials are currently divided between four principal markets; the fields of heat-resisting and superalloys; the permanent magnet materials; tool, die and wear-resistant alloys; and nonmetallic uses.

The largest application is in high temperature cobalt-base alloys used in such parts as nozzle guide vanes and turbine rotor blades in the gas turbine industry. Cobalt-base superalloys are continuing to increase in importance in the field of industrial and marine turbine applications, especially with the increasing development of high chromium compositions yielding high oxidation and corrosion resistance. Continuing development of the superalloy field is strongly dependent on the aerospace industry and increasing applicability in the pyrometallurgical and chemical industries.

The use of cobalt in various magnetic materials continues to expand, especially in the electronic and electrical industries. The principal types of cobalt-containing magnet materials are the magnet steels used for soft and permanent magnets, with cobalt contents varying from a fraction of one per cent to more than 50 per cent. The Alnico steels containing aluminum, nickel and cobalt are used extensively in d.c. electrical motors and generators, where they compete directly with another group of cobalt-containing materials called ferrites – magnetic iron oxides – such as $CoFe_2O_4$. The most recently developed permanent magnet alloys are cobalt-rare earths permanent high-energy magnets containing 60 to 70 per cent cobalt. Samarium-cobalt alloys are most extensively used at present, but their widespread replacement by Mischmetal appears to be imminent. Mischmetal is a naturally occurring combination of the light rare earth elements such as cerium, lanthanum, neodymium, praeseodymium and traces of samarium. Mischmetal costs $3 per pound. The cost of samarium metal is $60 a pound. These high-energy metals are presently finding applications in microwave devices, d.c. motors and generators, frictionless bearings, watches, gyroscopes and the aerospace industry. Other future possibilities include their use in the levitation of high-speed trains and the use of high-magnetic fields in pollution control for filtering out particles.

Other uses of metallic cobalt are the production of wear-resistant alloys for high-speed tools, cemented carbides, glass-metal seal alloys in the scientific and engineering industries and springs and balance wheels in precision instruments such as watches. Certain Co-Cr alloys are also finding increased acceptance in the dental and surgical fields as prosthetic devices and in surgical implants.

Nonmetallic uses of cobalt are also increasing and now consume 30 per cent of total cobalt production in such uses as driers in paints, varnishes, printing inks and enamels, in chemicals, pigments and animal feeds. Increasing applications are being found for cobalt as catalysts, especially the new cobalt-molybdenum catalyst used for the desulphurization of oil and gas. These catalysts are presently employed by the United States Bureau of Mines in the processing of oil shales. The radioisotope cobalt-60 is used in therapeutic medicine and also for the investigation of physical strains in metals.

Prices

Prices for cobalt underwent several increases in 1973 allegedly due to increased mining and refining costs and currency realignments subsequent to devaluation of the U.S. dollar in February 1973. African Metals Corporation, the supplier of Belgian refined cobalt from Zaire, effected the first price increase on February 12, 1973, from $2.45 to $2.70 a pound to cover increases in production and processing costs. This was followed by a further 30 cent increase to $3.00 on February 14, 1973, resulting from major currency realignment between the Belgian franc and U.S. dollar following the U.S. devaluation. Sherritt Gordon matched the new prices for cobalt on February 20, 1973, by increasing the price of its high purity 'S' grade powder by 30 cents a pound to $3.00 and other Sherritt products such as special powders and strip were also increased by 30 cents. Also, on February 20, 1973, Outokumpu Oy: 17 raised the price of its powder and briquettes to $3.20 and $3.23 a pound, respectively.

In August 1973, the price of refined cobalt was raised to $3.30 by African Metals Corporation, but towards the end of 1973 the cobalt price receded to $3.10 largely reflecting an increase in the strength of the U.S. dollar in world monetary markets. Sherritt Gordon also increased the price of its cobalt powder from $3.00 to $3.50 in August and Falconbridge Nickel, which by now had resumed its cobalt sales, increased the price of its cathode to $3.30. The price hikes by the Canadian producers remained in effect for the rest of the year.

Thus, throughout 1973, cobalt experienced an overall price increase of 25-30 per cent, indicating a position of relative stability compared to the astronomical escalations in the price of most metalliferous commodities in 1973. This was due largely to the stabilizing forces generated by the releases of cobalt in various forms from the United States government stockpile.

Future trends

In the short-term, cobalt can be expected to remain in quite tight supply, but overall demand-supply conditions in the cobalt market should approach equilibrium if, as expected, the GSA continues its liberal sales of cobalt materials. Demand is expected to increase in the short-term with superalloys, high-energy magnets and catalysts being important fields of anticipated strong growth. To counter-balance increased demand, substantial new sources of supply have been unveiled,

Prices of cobalt in U.S. currency:

	Dates of Price Changes			
	Nov. 17 1969	Dec. 27 1971	Dec. 1972	1973
	(U.S. $)	(U.S. $)	(U.S. $)	(U.S. $)
Cobalt metal per lb fob New York, Chicago				
Shot 99%+				
less than 50 Kg			2.55	3.30
50-Kg drums			2.50	3.25
250-Kg			2.45	3.20
Powder, 99%+, 300 and 400 mesh				
50-Kg drums			3.24	4.17
extra fine, 125-Kg drums			3.89	4.95
S grade, 10-ton lots			2.55	3.50
Fines, 95-96% per lb contained Co				
regular, 500 lb			..	..
300-mesh			..	..
Briquettes, 10-ton lots, per lb contained			2.58	..
Cobalt oxide, per lb, 250 lb				
Ceramic, delivered, 5¢ more west of Mississippi				
70-71%	2.20	..	..	..
72 1/2-73 1/2%	2.26	..	..	..
Metallurgical, fob N.Y.,				
75-76% (per lb contained)	2.85	..	..	..

Source: *Engineering Mining Journal*, December 1972 and 1973.
.. Not available.

especially as a byproduct of copper production in the Zaire and as a byproduct of major lateritic nickel deposits in Australia and the Philippines. These new projects are expected to commence production in 1974-1975 and, with an additional 8 million pounds of cobalt annually from the GSA, should alleviate the development of any serious supply conditions.

In the long-term, the demand-supply conditions of the cobalt market are clouded with uncertainties, brought about by the aftermath of the energy crisis and the speculation enveloping ocean floor nodule production. The whole economics of lateritic nickel ore processing has been thrown into turmoil by severe escalations in world oil prices. Certainly, many of the marginal projects may now be deemed uneconomic propositions, because of large increases envisaged in operating costs, more specifically, fuel costs. In addition, changes in technology and pricing structures of ferronickel and nickel and nickel oxide sinters may well indicate that future lateritic nickel deposits will produce these less pure forms of nickel rather than pure nickel metal. In particular, the widespread acceptance of the argon-oxygen furnace, in stainless steel making, ensures future dependence on less pure forms of nickel, and this will have a serious adverse effect on the production of cobalt as a byproduct, as cobalt is normally only recovered from nickel ores in the processing of pure nickel.

The potential of ocean floor nodules as an important source of manganese, copper, nickel and cobalt has long been known, but both technology and political factors have hindered their rapid development. Technology has now reached an advanced stage, where it will be economically feasible to mine these nodules by the late 1970s. However, the political procrastinations, especially the ownership enigma remain to be solved and the obstacles here could easily delay nodule mining until well into the 1980s. The impact of nodule mining on cobalt production is far more severe than on any other metal as it would require only about twelve deep-sea mining operations to double the entire world's production. Present estimates regarding commencement of sea-floor mining operations vary from 3-7 full scale operations by 1980. In terms of cobalt production this would entail additional production capacity of 18 million to 42 million pounds of cobalt, or sufficient to meet 20-55 per cent of anticipated demand in 1980. However, the upper figure appears optimistic at this stage and it is likely that by 1980 there will still be no full-scale sea-floor mining operations. The political overtones are particularly sensitive at this time, both from the viewpoint of ownership of the resources and deleterious effects on the economies of the underdeveloped countries, such as Zaire, and these issues are seen as major obstacles to production in the foreseeable future.

Under the present pricing structure the demand for cobalt is likely to remain relatively inelastic, resulting in an average annual growth rate probably around 5 per cent over the next five years.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
33200-1	Cobalt ore	free	free	free
35103-1	Cobalt metal, excluding alloys, in lumps, powders, ingots or blocks	free	free	25
35110-1	Cobalt metals, in bars	free	10	25
92824-2	Cobalt oxides	free	10	20
92824-1	Cobalt hydroxides	10	15	25
	(From July 15, 1971 to February 28, 1976)	free	15	25

Tariffs (concl'd)

United States

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
601.18	Cobalt ore	free		
632.20	Cobalt metal, unwrought, waste and scrap	free		
		On and After Jan. 1, 1971		On and After Jan. 1, 1972
		(%)		(%)
632.84	Cobalt metal alloys, unwrought	10.5		9
633.00	Cobalt metal, wrought	10.5		9
418.68	Cobalt compounds other than cobalt oxide and cobalt sulphate	7		6
426.24 426.26	Cobalt salts	7		6
418.60 418.62	Cobalt oxide and Cobalt sulphate	0.9c per lb		0.7c per lb

Sources: Canada – The Customs Tariff and Amendments, Department of National Revenue Customs and Excise Division, Ottawa, United States – Tariff Schedules of the United States Annotated (1972) TC Publication 452.

Columbium (Niobium), Tantalum and Cesium

R.J. GOODMAN, M.A. BOUCHER and J.G. GEORGE

COLUMBIUM

Canada remained the world's second largest producer of columbium in 1973, with the entire Canadian production being accounted for by St. Lawrence Columbium and Metals Corporation with its mine and mill near Oka, Quebec. St. Lawrence Columbium is one of only two mines in the world producing pyrochlore concentrates as a primary product and in 1973 produced an estimated 2,867,000 pounds of contained columbium pentoxide valued at $3,720,000 compared with 3,873,787 pounds valued at $3,868,448 in 1972.

World demand for columbium in 1973 remained at a high level, increasing by some 15 per cent over 1972. Despite the large increase in demand, world production of columbium concentrates fell by 20 per cent compared with 1972 production. Sales of columbium from the United States government stockpile and inventories made up the short fall. The large increase in demand for columbium in world markets was due primarily to increased acceptance of high-strength low-alloy (HSLA) steels especially in oil and natural gas pipelines and structural steel. The impact of the energy crisis has further propagated a strong demand for pipeline steel in the medium term, ensuring a 10-15 per cent growth rate for the next several years.

During 1973 the United States government General Services Administration offered a total of 2.32 million pounds of columbium metal for sale, compared with 2.07 million pounds in 1972.

Prices for columbium remained strong throughout the year, with prices for columbite exhibiting a progressive 25 per cent increase by year-end. Ferrocolumbium prices also showed a marked increase of 10-12 per cent, whereas pyrochlore concentrate prices showed only a marginal increase. The increased competitiveness and indicated preference for columbite concentrates and ferrocolumbium was due to an increasing awareness in the consuming nations of the adverse environmental effects of radioactive pyrochlore concentrates.

Minerals and Canadian occurrences

The predominant commercial minerals of columbium and tantalum are the columbite-tantalite mineral series and the pyrochlore-microlite series. The columbite-tantalite series has the theoretical composition (Fe,Mn) O Cb_2O_5 and (Fe Mn) O Ta_2O_5 and occurs as accessory minerals in pegmatites and residual placer deposits. The pyrochlore-microlite series has theoretical compositions $(Na,Ca)_2$ OF Cb_2O_5 and $(Na,Ca)_2$ OF Ta_2O_5, often exhibiting pronounced enrichment in rare earths and radioactive minerals, and occurs almost exclusively in carbonatite-alkalic rock complexes.

The major source of the world columbium supply is from columbium-bearing pyrochlore occurring as an accessory mineral in the carbonatite complexes in Canada and Brazil. Alternative sources of columbium as columbite and tantalite are recovered as coproducts of tin from alluvial deposits, notably in Nigeria, where concentrates containing 65 per cent or more of the combined oxides of columbium and tantalum are obtained.

There are 30 or more known carbonatite occurrences in Ontario, and several in Quebec, Labrador, British Columbia and the Northwest Territories. The major occurrence of columbium minerals in carbonatite complexes include:

in *Quebec*, near Oka, the columbium-pyrochlore producing mine of St. Lawrence Columbium and Metals Corporation, the property of Columbium Mining Products Ltd., the property of Main Oka Mining Corporation, and the property of Quebec Columbium Limited; and, near Chicoutimi, the St. Honoré deposits of Quebec Mining Exploration Company (SOQUEM) and Copperfields Mining Corporation Limited.

in *Ontario*, the James Bay property of Imperial Oil Enterprises Ltd., and Consolidated Morrison Explorations Limited and associated companies; the Manitou Island deposit of Nova Beaucage Mines Limited near North Bay; the Lackner Lake property of Multi-Minerals Limited near Chapleau; and the Nemegosenda Lake property of Dominion Gulf Company near Chapleau.

Canadian production and developments

In 1973, St. Lawrence Columbium and Metals Corporation with mine, mill and concentrator near Oka, Quebec, continued to be Canada's sole producer of columbium and, along with the larger operation of Companhia Brasileira de Metalurgia e Mineraçao

Table 1. Canada, columbium (niobium) and tantalum production, trade and consumption, 1972-73.

	1972		1973ᵖ	
	(pounds)	($)	(pounds)	($)
Production				
Columbium (Cb_2O_5 content of shipments)	3,873,787	3,868,448	2,867,000	3,720,000
Tantalum (Ta_2O_5 content of shipments)	41,120	246,658	115,000	785,000
Imports[1] from United States				
Columbium and columbium alloys wrought	1,633	49,346	2,636	27,847
Tantalum and tantalum alloys wrought, nes.	1,160	75,946	5,437	341,624
Tantalum and tantalum alloys, unwrought waste and scrap	3,175	24,730	–	–
Tantalum and tantalum alloy powder	1,446	46,107	16,527	212,957
Exports[2] to United States				
Columbium ore and concentrates	65,113	52,030	667	530
Consumption by the steel industry				
Ferrocolumbium and ferrotantalum-columbium (Cb and Ta-Cb content)	580,000	. .	. .	. .

Source: Statistics Canada, except otherwise noted.
[1] From U.S. Department of Commerce, Export of Domestic and Foreign Merchandise, Report FT 410. Values in U.S. currency. [2] From U.S. Department of Commerce, Imports of Merchandise for Consumption, Report FT 135. Values in U.S. currency.
ᵖPreliminary; . . Not available; – Nil.

Table 2. Canada, columbium (niobium) and tantalum production, trade and consumption, 1963-73

	Production[1]		Imports[2], from U.S.					
	Cb_2O_5 Content	Ta_2O_5 Content	Columbium and Alloys, Wrought	Tantalum and Alloys, Wrought	Tantalum and Alloys, unwrought, Waste and Scrap	Tantalum and Alloys, Powder	Exports[3], Columbium Ores and Conc., to U.S.	Consumption, Ferro. and ferrotantalum-columbium Cb and Ta-Cb Content
	(pounds)							
1963	1,393,444	–	–	–	–	–	823,202	34,000
1964	2,163,359	–	–	–	–	–	1,940,133	74,000
1965	2,333,967	–	–	721	–	–	1,860,631	58,000
1966	2,637,997	–	–	1,533	–	2,730	1,524,279	40,000
1967	2,159,557	–	185	1,245	34,914	1,155	890,884	78,000
1968	2,181,304	–	375	1,972	3,433	1,830	295,333	288,000
1969	3,414,495	130,298	1,178	1,871	4,405	7,488	919,577	244,000
1970	4,694,239	317,024	–	854	1,870	2,480	1,270,362	292,000
1971	2,332,663	449,610	5,061	1,487	14,237	3,100	341,237	292,000ʳ
1972	3,873,787	41,120	1,633	1,160	3,175	1,446	65,113	580,000
1973ᵖ	2,867,000	115,000	2,636	5,437	–	16,527	667	. .

Source: Statistics Canada, unless otherwise noted.
[1] Producers' shipments of columbium and tantalum ores and concentrates and primary products, Cb_2O_5 and Ta_2O_5 content. [2] From U.S. Department of Commerce, Exports of Domestic and Foreign Merchandise, Report FT410. Quantities in gross weight of material. [3] From U.S. Department of Commerce, Imports of Merchandise for Consumption, Report FT135. Quantities in gross weight.
ᵖPreliminary; . . Not available; – Nil.

(CBMM) at Araxà Brazil, it remains one of the only two mines in the world producing columbium in pyrochlore concentrates as a primary product. Canada's production (shipments) of columbium as contained Cb_2O_5 in concentrates in 1973 was 2.867 million pounds valued at $3.72 million compared with 3.874 million pounds of Cb_2O_5 valued at $3.87 million in 1972.

During the fiscal year ended on September 1973, 612,487 tons of ore were processed at the Oka mill of St. Lawrence Columbium and Metals Corporation, compared with 589,147 tons in the previous fiscal year. Temporary metallurgical difficulties reduced production in the last quarter of fiscal 1973, but these difficulties were overcome in the first quarter of fiscal 1974 and mine and plant were restored to full operating capacity. Operating capacity of the mill in 1973 was 2,200 tons of ore a day with an increase to 3,000 tons a day envisaged for the first quarter of fiscal 1975. A development program continued in 1973 to increase the proportion of mine output being processed to ferrocolumbium.

Proven ore reserves on the St. Lawrence property to the end of September 1973 were reported by the company to be 7.4 million tons; however, the grade was not mentioned. In addition, reserves on the leased Main Oka property at the western end of the company's present workings indicate a further 1.9 million tons averaging 0.46 per cent Cb_2O_5. The Main Oka property is currently being developed by St. Lawrence Columbium and Metals Corporation and production from this ore zone is scheduled for commencement in 1974, according to the company's annual report.

During 1973, development work progressed to the advanced stage on the St. Honoré columbium pyrochlore deposit, some 8 miles north of Chicoutimi, Quebec. This deposit, which is a joint venture between Copperfields Mining Corporation Limited and Quebec Mining Exploration Company (SOQUEM), is scheduled for production in 1976 with an annual output rate of 5.50 million pounds of Cb_2O_5 a year. Ore reserves within the block drilled to a depth of 850 feet (280 metres) have indicated 40 million tons grading 0.76% Cb_2O_5, using 0.50% Cb_2O_5 as a cut-off grade.

Development on the site commenced in 1973, and the mill has been designed for an initial capacity of 1,500 tons of ore a day, with provision for rapid expansion to 2,000 tons a day should future demand requirements dictate.

The project will be brought into production under a new company called Niobec Inc. Niobec will be

Table 3. Production of columbium (Cb) and tantalum (Ta) concentrates, 1970-72[1,2]

	1970			1971			1972^p		
	Cb	Ta	Cb-Ta	Cb	Ta	Cb-Ta	Cb	Ta	Cb-Ta
	(thousands of pounds, gross)								
Brazil									
pyrochlore	29,288	–	–	13,435	–	–	21,242	–	–
columbite-tantalite	90	461	–	139	639	–	140^e	640^e	–
Canada									
pyrocholore	9,838	–	–	4,889	–	–	8,173	–	–
tantalite	–	594	–	–	843	–	–	609	–
Nigeria	3,563	10	–	3,040	9	–	2,961	2	–
Zaire	–	–	322	–	–	234	–	–	265
Mozambique									
columbite-tantalite	–	–	163	–	123	11	–	93	–
microlite	–	140	–	–	117	–	–	134	–
Malaysia	–	–	134	–	–	54	–	–	60^e
Thailand	–	–	126	–	–	93	–	–	29
Portugal	–	9	–	–	24	–	–	. . .	–
Rwanda	–	–	66	–	–	80	–	–	80
South Africa (Rep. of)	–	7	–	–	2	–	–	1	–
Australia	–	–	222	–	–	165	–	–	420^e
Other countries[3]	–	–	116	–	–	117	–	–	104
Total	42,779	1,221	1,149	21,503	1,757	754	32,516	1,479	958

Source: U.S. Bureau of Mines *Minerals Yearbook 1972* Preprint.
[1]Excludes tin slag bearing columbium-tantalum. [2]Concentrates containing important amounts of both elements are shown under Cb-Ta when composition date is insufficient. [3]Other countries that produce columbium and/or tantalum minerals include: Argentina, Ivorý Coast, Uganda.
^{p}Preliminary; – Nil; ^{e}Estimated; . . . Less than one thousand pounds.

owned by Soquem (50%), Copperfields Mining Corporation Limited (25%) and Teck Corporation Limited (25%).

Firm long-term sales contracts have already accounted for 95 per cent of expected production, with more than 50 per cent destined for Continental Alloys S.A. (CASA) in Luxembourg. CASA is jointly owned by Arbed of Europe's major steel producers and Continental Ore group, a New York subsidiary of International Minerals and Chemical Corporation (IMC), and is a supplier of high-quality ferroalloys throughout Europe. The balance (45% of the pyrochlore concentrates) has been sold on a contract basis to Japan and the United States.

World production and development

Total world production of columbium pentoxide, excluding byproduct Cb_2O_5 from tin smelter slags, was an estimated 15 million pounds of contained Cb_2O_5 in 1973. This was approximately a 20 per cent decrease compared with the 1972 figure of 18.7 million pounds. Brazil remained the dominant world producer accounting for over 70 per cent of total production, with Canada accounting for a further 19 per cent and Nigeria 10 per cent. Minor quantities continued to be produced in Zaire, Mozambique, Australia, Thailand and Malaysia as joint columbite-tantalite byproducts.

Since 1966 the largest world producer of pyrochlore concentrates continues to be Companhia Brasileira de Metalurgia e Mineraçao (CBMM) at its open-pit mine near Araxa, Brazil. Reserves are estimated at 300 million tons of ore grading 3 to 4.5 per cent Cb_2O_5. The company's production of columbium pentoxide has increased from 1.4 million pounds of contained Cb_2O_5 in 1965 to a high of 17 million pounds in 1970. Current production is around 13 million pounds of Cb_2O_5 contained in pyrochlore concentrates, which is well below installed mill capacity of 20 million pounds of Cb_2O_5 a year. CBMM is jointly owned by Brazilian interests (50.5 per cent), Molybdenum Corporation of America (33 per cent), and Pato Consolidated Gold Dredging, Limited (16.5 per cent) and has a long-term arrangement with the state-owned Companhia Agricola de Mina Gerais (CAMIG) for the joint mining of the pyrochlore deposit.

The Tanzanian government has announced that a niobium deposit that had been discovered in the early 1960s was being re-examined. The deposit is reported to contain 2 zones of sovite ore grading 0.57% and 0.72% Cb_2O_5.

Also in 1973, Quebec Iron and Titanium Corporation (QIT), a subsidiary of Kennecott Copper Corporation, announced plans to dispose of its columbite mine in Nigeria. Agreement was expected to be reached with Mitsubishi Corporation and Sumitomo Metal Mining Co. Ltd. to purchase the mine, subject to the approval of the Nigerian government on transfer of ownership.

World demand for columbium reached record levels in 1973, and consumption was about 15 per cent above the 1972 level. This was thought to be due primarily to a large increase in demand for HSLA steels in Europe and Japan, particularly, for oil and natural gas pipelines and structural buildings. Current world demand is thought to be apportioned about 55 per cent Western Europe, 20 per cent United States, 15 per cent Canada and 10 per cent Japan.

United States developments

Consumption of columbium increased by 8.5 per cent in the United States in 1973, from 3.69 million pounds of contained columbium in 1972 to 4.01 million pounds in 1973. Most of this increase could be accounted for by the steel industry which consumed about 2.91 million pounds, or 84 per cent, of the total United States consumption of columbium. Annual imports of columbium concentrates decreased 11 per cent in 1973, from 3.6 million pounds gross weight of concentrate in 1972 to 3.23 million pounds in 1973. Brazil remained the largest supplier of the United States columbium requirements in 1973, accounting for 86 per cent of all United States imports of pyrochlore and ferrocolumbium. Malaysian columbite provided 10 per cent of the United States columbium imports with the residual 4 per cent provided by Canada and Nigeria.

In terms of end-use consumption, carbon and HSLA steels accounted for 57 per cent of total columbium consumption, stainless steel for 17 per cent, full alloy steel for 10 per cent, superalloys 14 per cent and miscellaneous uses 2 per cent.

In 1973 the United States government General Services Administration (GSA) sold a total of 2,319,464 pounds of contained columbium metal. Ores and concentrates accounted for 76 per cent of the total, ferrocolumbium 20 per cent and oxide powder 4 per cent. The United States GSA plans to continue its depletion of stockpile columbium throughout fiscal 1973 (July 1 to June 30) at the rate of 2.5 million pounds of contained columbium a year with a similar quantity destined for disposal in fiscal 1974. Thus, GSA disposal plans will have a significant impact on world supplies in the immediate years ahead. As of December 1973 the GSA government stockpile was estimated to stand at approximately 5 million pounds of contained columbium metal.

Prices

Pyrochlore prices remained firm throughout 1973 with contract-rate prices for standard-grade Canadian and Brazilian pyrochlore, fob mine and mill, showing only a five-cent-a-pound increase from January to December 1973. Canadian pyrochlore at $1.44 remained two cents a pound above the price of Brazilian pyrochlore by year-end, though the disparity in prices was expected to increase in early 1974. Columbite ore, cif U.S. ports, increased markedly throughout the year from a low of $1.05-$1.15 in January to $1.35-$1.45 in December 1973. The shift in demand to columbite reflected in a pronounced price increase was due to more environmentally sensitive consuming nations and the increasing awareness of the radioactive hazards of pyrochlore concentrates. To circumvent this problem, both Brazil and St. Lawrence Columbium and Metals Corporation have been increasing their processing capacity of pyrochlore to ferrocolumbium for export to more environment-conscious consuming nations. This was also reflected in a 10 per cent price increase in standard ferrocolumbium throughout the year, from a low price of $2.80 to a high of $3.10 in December 1973.

Current technology and uses

The steel industry is the predominant consumer of columbium in the form of ferrocolumbium, which is used as an additive agent in the production of four major classes of steel; namely, high-strength low-alloy (HSLA) carbon steel, stainless steels, low-alloy steels and superalloys. Pre-eminent among these steels in terms of present columbium consumption are the HSLA steels, in which the addition of 0.03-0.07 per cent columbium controls and refines the grain size effecting improved impact properties and increase in tensile strength to 60,000-70,000 psi. HSLA steels have found widespread applicability in the construction of oil and gas transmission pipelines. Canadian natural gas pipelines commonly use Arctic grade X65 HSLA steel containing 0.06 per cent columbium and 0.042 per cent carbon, which yields high-strength-to-cost ratio and excellent weldability properties.

HSLA steels are also finding increasing application as structural steels in stadiums, bridges, and buildings such as the World Trade Centre in New York. HSLA steels are used in various permutations with other additive materials such as molybdenum, cerium and vanadium in the construction of ships, storage tanks, highway guard rails, railroad cars and electrical transmission poles.

Columbium is also used as a carbide stabilizer in chromium-nickel stainless steels to resist the detrimental effects of remanent carbon formation on corrosion resistance. Although improved metallurgical techniques have accelerated the obsolescence of columbium for this function, new uses have emerged accentuating the superior corrosion resistance, high strength, improved weldability and heat resistance imparted by columbium. Thus, such corrosion resistant stainless steels have become widely accepted in the chemical process industry and marine environment applications. In terms of marine applications it has been estimated that 43 million tons of columbium stainless steel will be consumed in the next ten years in Japan alone.

Alloy steels containing columbium are also used in the machinery, forgings, oil drilling, mining, automotive and other transportation industries. The recent development of interstitial free (IF) steel by Armco Steel Corporation in the United States represents a major technological breakthrough in the metal drawing operations. This steel greatly facilitates the fabrication of deep-drawn parts such as oil pans, and automotive parts with severe bends such as headlight moldings.

Both columbium metal and ferrocolumbium have found applicability in superalloys of the iron-nickel-cobalt types, due to the formation of a nickel columbium precipitate imparting high temperature creep resistance. Superalloys are now widely used in gas turbine engines, rocket engines, nuclear reactors and as thermal shields for re-entry spacecrafts.

Future trends and growth

Demand for columbium in both the short and long run appears to be strong, and the industry appears to be assured of a 10-15 per cent annual growth rate as the further acceptance of columbium ferroalloys increases and fundamental technological development creates new fields of applicability.

World columbium resources in Brazil, Canada and Africa are sufficient to preclude any supply problems in the long run, thus ensuring consumers of columbium long-term stability in prices and input markets. Brazil remains the world's leading producer of pyrochlore concentrates with current production being markedly below installed mill capacity. Companhia Brasileira de Metalurgia e Mineraçao (CBMM) at Araxa operates the world's largest and highest grade deposit with its pre-eminence assured for many years. Reported reserves are 300 million tons of columbium pentoxide with an average grade of 3.0-4.5 per cent Cb_2O_5. Open-pit mining techniques are employed to recover the ore, ensuring low unit costs and continuance of relatively stable price levels in future years.

Both CBMM and St. Lawrence Columbium and Metals Corporation in Canada are in a position to expand their production facilities to meet increasing demand, and future supply will also be bolstered in 1976 by production from the St. Honoré columbium deposit in Quebec, and the Jos columbite mine in Nigeria.

The major factor influencing the long-run growth rate of the columbium market will be the demand for HSLA steel and the specifications for structural and pipeline steel. The aftermath of the energy crisis has assured a strong demand for oil and natural gas pipeline construction in 1974, and total world pipeline construction (excluding Russia and China) is expected to rise by 11-12 per cent from 24,160 miles in 1973 to a forecast 26,855 miles in 1974. Major pipeline projects in 1974 are planned in the U.S.A., Canada, Australia, Iraq and Iran, and this strong demand for pipeline steel is expected to continue for several years.

Increasing consumption of columbium alloys are forecast for the automobile industry with the use of

Cb-HSLA steel being used for various automobile components such as bumpers, wheels, back-up bars and automobile bodies. Dominion Foundries and Steel, Limited (Dofasco) foresee an increase in the use of Cb-HSLA steel in automobiles from 50 pound per car unit in 1973 to 450 pounds in 1978. A similar pronounced growth rate is envisaged for Armco's interstitial free (IF) steel for cold-work formability in such components as oil pans.

The increased use of superalloys is expected to establish a strong long-run growth rate, especially in the expanding fields of nuclear and aerospace technology.

Ultimately, one of the largest future applications of columbium could prove to be the field of cryogenic superconductivity. Columbium retains its superconductivity properties up to 9.5°K, the highest temperature of any known metal and this effects major cost savings in any superconductivity applications. The ability of superconductors to create intense magnetic fields opens up wide areas of applicability in underground electrical transmission lines, magnetic suspension trains, generators, magnetohydrodynamics and, eventually, the control of thermonuclear fusion.

Long-term growth will become increasingly dependent on the price structure of columbium and columbium products, as rapid escalations of price will invite substitutability by alternate additive materials such as vanadium. An increase in the productive capacity of vanadium at more competitive prices becomes reality with the imminent development of the immense oil reserves in the Athabasca tar sands and vanadiferous titanomagnetite deposits in Australia and South Africa. Nevertheless, sound pricing policies for columbium by world producers should ensure excellent long-term growth, especially if the present disparity in prices between vanadium and columbium is maintained.

TANTALUM

Canada's tantalum shipments by the Tantalum Mining Corporation of Canada Limited (TANCO) were higher in 1973 than in 1972, but still remained at a low level. Despite strong demand for tantalum throughout 1973, the TANCO mill and mine at Bernic Lake, Manitoba was operational for only the first four months of 1973, due to excess industry inventories, the oversupply of tantalum concentrates in 1972-73 and prices that were appreciably lower than those at which TANCO was prepared to sell its concentrate. Of the total world consumption in 1973, only 50 per cent originated from new production.

Prices for tantalum concentrate remained at 1972 prices of \$5.25-\$6.25 a pound of contained Ta_2O_5 for most of 1973, but increased markedly at the end of 1973 to \$7.50-\$8.50 in response to higher prices demanded for tantalum material sold by United States General Services Administration (GSA). TANCO maintained a price-level of \$10 a pound of contained Ta_2O_5 for contract sales of concentrate for the latter part of 1973.

Available evidence suggests that the demand for tantalum will continue to increase and a growth rate of 7.8 per cent a year appears realistic in the medium-term, with most of this growth originating from the increased demand for tantalum in the electronic and chemical processing industries.

Minerals and Canadian occurrences

The principal commercial mineral of tantalum is tantalite, the tantalum-rich end member of the columbite-tantalite mineral series with a theoretical chemical composition of $(Fe, Mn) O (Ta, Cb)_2O_5$. The other important commercial source of tantalum is microlite, the tantalum-rich end member of the pyrochlore-microlite mineral series with theoretical composition of $(Na,Ca)_2OF(Cb,Ta)_2O_5$.

Other less common tantalum minerals are of economic significance in certain tantalum bearing pegmatitic deposits, such as wodgenite with a chemical composition of $(Ta,Cb, Sn_{2x})_2 (Mn_2, FeSn_x)O_6$ and tapiolite, which is chemically identical to tantalite but with differing crystallographic properties.

Canada's sole commercial producer of tantalum is the Tantalum Mining Corporation of Canada Limited (TANCO), a wholly owned subsidiary of Chemalloy Minerals Limited, at its Bernic Lake property in Manitoba. The tantalum occurs in a complex zoned pegmatite lens containing a wide variety of minerals including commercially recoverable amounts of tantalum, cesium and lithium. Most of the tantalum in the ore deposit occurs as staniferous tantalite (wodgenite), consisting of approximately 70 per cent Ta_2O_5, 13.2 per cent of SnO_2 and 1.3 per cent of Cb_2O_5, with additional subsidiary tantalum being recovered from tantalite, microlite and tapiolite (in order of importance). The Central Intermediate section of the pegmatite lens is the tantalum bearing zone and, to date, two separate tantalum lenses have been delineated, 800 feet apart with a maximum thickness of 150 feet.

Other occurrences of tantalite-columbite occur in pegmatite deposits in the Yellowknife district of the Northwest Territories. One of these deposits, on the north shore of the Great Slave Lake was mined during 1954 and 1955 by Boreal Rare Metals Limited. During that period the mine produced 42,000 pounds of tantalite-columbite concentrate, before a fire brought production to a premature conclusion in 1955.

Canadian production and developments

The Tantalum Mining Corporation of Canada Limited (TANCO) with its 500-ton-a-day mill and mine at Bernic Lake, located some 154 miles northeast of Winnipeg, Manitoba remains the sole producer of tantalum concentrates in Canada. Production commenced in 1969 and, up to the present time, the whole of the tantalum production of 1,380,436 lbs. Ta_2O_5 has been from the shaft area ore deposit. On April 1, 1973 production of tantalum ore and concentrates was suspended because accumulated inventories were sufficient for forward sales. In June 1973 all sales were suspended indefinitely due to a depression of market prices below the $10 per pound of Ta_2O_5, set by TANCO as a minimum selling price.

Total shipments by TANCO during 1973 amounted to 115,000 pounds of Ta_2O_5 valued at $785,000 compared with 41,120 pounds of Ta_2O_5 valued at $246,658 in 1972.

Estimated reserves of tantalum at Bernic Lake as of January 1, 1973 were quoted by the company to be 1,419,576 tons grading 0.224 per cent Ta_2O_5, of which 388,460 tons grading 0.23 per cent Ta_2O_5 were in pillars. Current reserves are estimated to be sufficient to last approximately ten years at the present rate of production, and the recent discovery of a new tantalum-rich mineral zone should appreciably increase both reserves and life-span of the mine.

World production and reserves

Precise statistical information on world production, shipments and trade of tantalum bearing materials are not well documented at present and columbium-tantalum statistics are often quoted in terms of combined metal content and not reduced to the individual metal figures. However, the Tantalum Producers International Study Centre (TIC) has recently been established in Brussels, Belgium to promote research and statistical compilation for the tantalum industry. It is hoped this group will propagate a more accurate insight into world production, consumption and trade of tantalum bearing materials.

Production of tantalum in the noncommunist world declined to 1.4 million pounds of tantalum pentoxide in concentrates in 1973, from 1.6 million pounds of contained Ta_2O_5 in 1972. Preliminary estimates for the major world producers in 1973 were: Thailand 650,000 pounds; Brazil, 160,000 pounds; Australia, 150,000 pounds; Zaire, 120,000 pounds; Canada 55,000 pounds; and others, including Spain, Portugal, Malaysia approximately 150,000 pounds.

In contrast to reduced production, the processing of Ta_2O_5 increased by 14 per cent in 1973 to approximately 2.50 million pounds of Ta_2O_5 compared with 2.13 million pounds in 1972. The apparent paradox in the directional trends of production and processing was due to processors drawing on inventories accumulated during the economic recession of 1970-71. The United States processed 70 per cent of all tantalum processed in 1973, with Western Europe and Japan accounting for the residual processing capacity.

World reserves of tantalum, according to United States Bureau of Mines sources have been estimated at 110 million pounds of Ta_2O_5 in ore in 1971. With projected world cumulatory demand conservatively estimated at 150 million pounds of Ta_2O_5 between 1971 and 2000, it may be concluded that long-run supply problems will arise unless large new reserves of tantalum are discovered in the interim period. However, world reserve statistics of tantalum have not been accurately delineated for many deposits, especially the low-grade tantalum bearing placers of South-East Asia and Africa and potential reserves could be appreciably higher than presently known reserves.

World consumption

The U.S.A. accounts for 70 per cent of world consumption, with the bulk of the remainder being consumed in Western Europe and Japan. Tantalum demand in Japan increased by 11 per cent in 1972 to 175,000 pounds, with the carbide industry accounting for 45 per cent of Japan's total consumption in 1972. Capacitors consumed a further 35 per cent of tantalum in 1972, and the large growth potential of this area of applicability ensures a strong demand for tantalum in the Japanese industry in forthcoming years.

United States

Demand for tantalum increased by 28 per cent in 1973 to a record level of 1.4 million pounds of contained tantalum, compared with consumption of 1.1 million pounds in 1972. United States imports of tantalum bearing materials declined by 20 per cent from 1.1 million pounds (gross weight) in 1972 to just over 900,000 pounds in 1973. The predominant supplies of tantalum concentrates to the United States in 1972 compared with 1971 (in brackets) were: Canada 25 (9) per cent; Australia 23 (30) per cent; Zaire 22 (–) per cent and Brazil 17 (32) per cent.

United States shipments of primary tantalum in 1973 were a record 1,484,000 pounds, an increase of 28% over the previous year's shipments of 1,159,000 pounds. The increase was due predominantly to a large increase in demand for capacitor-grade powder which accounted for 49 per cent of total shipments in 1973. Primary tantalum sheet, wire and tube mill products accounted for a further 20 per cent; oxides, salts, alloy additives, ingot and scrap a further 20 per cent and carbides 11 per cent. The value of all tantalum processed in the United States in 1973 was $45 million.

The United States General Services Administration (GSA) exerted strong pressure on market prices and supply-demand interactions prevailing throughout 1973. This was largely a result of its decision in April 1973 to dispose of 3.6 million pounds of tantalum deemed in excess of stockpile requirements, and that it would offer 756,000 pounds of tantalum for sale in fiscal 1974 (July 1, 1973 to June 30, 1974). However, in June 1973 GSA modified its decision on the release of material in fiscal 1974 and reduced its disposal rate from 756,000 pounds of tantalum to 400,000 pounds, to prevent disruptions in commercial prices and markets.

The first 100,000 pounds of tantalum was made available on a sealed-bid basis by GSA in September 1973. Nine companies responded with bids ranging from \$5.51 to \$7.926, but only one lot price of 9,732 pounds of tantalum was sold at \$7.926 a pound as GSA rejected all other bids as being too low. Subsequently, in November 1973 GSA offered a total of 196,860 pounds of tantalum for sale and the whole was awarded to four American companies at a price of \$7.69 to \$8.21 a pound. Similar action by GSA can be expected to continue into 1974, assisting in raising prices of tantalum to what most producers would regard as more realistic levels.

Technology and uses

The major fields of application of tantalum-bearing materials are the chemical and electronics industries, with over 90 per cent of tantalum applications emanating from four fundamental physical characteristics; namely, the outstanding dielectric properties of its anodic film for capacitors; its high melting point (2996°C) for high temperature parts and alloys; its extreme degree of corrosion resistance for chemical equipment and the high melting point and hardness of tantalum carbide in cemented carbides.

Major applications in the United States are currently divided between four principal markets, the largest being the manufacture of tantalum powder and wire for electronic capacitors constituting 65 per cent of total use. A further 20 per cent is used in corrosion resistant chemical equipment, 10 per cent in superalloys and the residual 5 per cent in the carbide field.

In past years the bulk of tantalum capacitors have been used in devices destined for the military market, but recently tantalum has made accelerating inroads into the computer, telecommunications and other industrial applications. Furthermore, a lowering of the price of tantalum capacitors through the use of high surface area powders has placed them into direct competition with aluminum capacitors in the consumer market of stereo, colour television, radio equipment and automobiles. With increasing application of electronic fuel saving and electronic starting devices, further expansion of tantalum capacitors into this market is predicted. In addition to tantalum capacitors, the electronic industry consumes minor quantities of tantalum in other applications such as filaments and grid coil springs of electronic tubes.

The growth rate of tantalum continues to accelerate in the chemical process industry where it is used for its anticorrosive properties in crucibles, spatulas and other corrosion and heat resisting laboratory equipment. Recent developments in the explosive bonding of thin gauge tantalum sheet represents a major technological breakthrough, permitting the extensive use of tantalum as a construction material for large vessels and, hence, stimulating strong demand in the corrosive chemical industry.

Tantalum is also used as thermocouples and as containers for antimony control rod shields in nuclear industry, as well as in superalloys in the aerospace industry. The carbide industry also consumes tantalum in the form of tantalum carbide blended with tungsten or titanium carbides to produce different grades of cemented carbides used in cutting tools, mining tools, wear parts, tire studs and dies.

Future trends

Demand for tantalum in 1974 is expected to remain at a high level, and the growth rate is expected to accelerate in the immediate years ahead. The largest growth areas in the tantalum market will continue to be the electronic and chemical process industries. The derived demand for tantalum through the increasing use of semiconductors in microcircuitry will ensure a strong growth contribution from electronic applications. Furthermore, technological innovations in the use of high-surface area tantalum powders have resulted in price decreases for tantalum capacitors and have stimulated a large growth potential in the consumer industries. The development of explosive bonding of thin-gauge tantalum sheet to steel in the chemical process industry is also expected to contribute substantially to the future growth pattern in the medium term.

In the short-run, the controlled disposal of tantalum from the United States General Services Administration stockpile will alleviate any serious supply problems in 1974 but, in 1975, tighter supply conditions may be expected to prevail resulting in price escalations and providing the industry with a more realistic reflection of prevailing demand-supply conditions in world markets. The resultant creation of more equitable demand-supply conditions may restore greater price stability in 1974 and succeeding years and alleviate the chronic swings of oversupply and undersupply that have characterized the markets of the early 1970's. However, counterbalancing these stabilizing influences will be the increased reliance of the tantalum consuming countries on tantalum supplies derived as byproducts of tin smelter slags. As tantalum production from these sources is largely determined by the world demand for tin, the inelasticity of supply of tantalum can be expected to exert destabilizing influences on tantalum prices in short-run situations. In the long-run, new reserves of tantalum must be unveiled to alleviate chronic shortages in supply by the end of the century.

Prices

U.S. spot prices for tantalite – 60 per cent combined columbium and tantalum pentoxides – increased from \$5.25-6.25 a pound of contained Ta_2O_5 in 1972 to \$7.50 to \$8.50 by year-end. TANCO increased its price levels from \$7 a pound of contained Ta_2O_5 at the beginning of 1973 to \$10 a pound by year-end, for contract sales of Ta_2O_5 concentrates. For September 1973 the GSA also demanded higher quotations for

Prices

United States prices in U.S. currency, quoted in Metals Week of December 28, 1973
(1972 year-end prices are shown in brackets when differing)

	($)
Columbium ore	
Columbite, per lb pentoxide, nominal spot cif U.S. ports	1.35-1.45 (1.10-1.15)
Pyrochlore, per lb Cb_2O_5	
Canadian fob mine or mill, contract only	1.44 (1.39)
Brazilian, fob shipping point contract only	1.42 (1.37)
Ferrocolumbium per lb Cb, ton lots, fob shipping point	
Low-alloy, standard grades	3.10 (2.80)
High-purity grades (incl. Ni)	(5.00-5.26)

Columbium metal, per lb 99.5-99.8% free alongside, U.S. shipping port

	Powder, roundel	Ingot
	($)	($)
Reactor	12-23	17.50-28
Metallurgical	11-22	16 -27

	($)
Tantalum metal, per lb	
Powder, fob shipping point, depending on size of lot	30.00-37.00 (38.50-47.00)
Sheet and rod, depending on grade	36-60

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(%)	(%)
32900-1	Columbium and tantalum ores and concentrates	free	free	free
315120-1	Columbium (niobium) and tantalum metal and alloys in powder, pellets, scrap, ingots, sheets, plates, bars, rods, tubing or wire for use in Canadian manufacture (expires 31 Oct. 1973)	free	free	25
37506-1	Ferrocolumbium, ferrotantalum, ferro-tantalum-columbium	free	5	5

United States

Item No.		Effective on and After Jan. 1 1972	1973
		(%)	(%)
601.21	Columbium ores and concentrates	free	free
601.42	Tantalum ores and concentrates	free	free
628.15	Columbium metal, unwrought, waste and scrap (duty on waste and scrap suspended to June 3, 1973)	6	5
628.17	Columbium, unwrought alloys	9	7.5
628.20	Columbium metal, wrought	10.5	9
629.05	Tantalum metal, unwrought, waste and scrap; (duty on waste and scrap suspended to June 3, 1973)	6	5
629.07	Tantalum, unwrought alloys	9	7.5
629.10	Tantalum metal, wrought	10.5	9

Sources: Canada – The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. United States – Tariff Schedules of the United States Annotated (1972) TC Publication 452.

tantalum materials offered for sale, resulting in the acceptance of only one bid of $7.926 by Kennametal for one lot of 9,732 pounds only of the 100,000 pounds of tantalum offered for sale. The unsold balance was released for sale again in November 1973, when a total of 196,860 pounds of tantalum was awarded to four American companies: Kawecki Berylco Industries Inc., Kennametal Inc., Samincorp and Philipp Brothers (Division of Engelhard Minerals & Chemical Corporation) at $7.69 to $8.21 a pound of tantalum.

Prices are expected to continue to escalate in 1974, with spot tantalite prices possibly exceeding $12 a pound of contained tantalum by year-end, dependent in part upon the selling pattern established by GSA in depleting its excess inventories of tantalum materials during the remaining part of fiscal 1974.

CESIUM

Cesium is a soft, silvery white, ductile metal with a melting point of 28.7°C, a boiling point of 705°C and a density of 1.87 grams per cubic centimetre at 20°C. It is not radioactive. It is the eighth lightest metallic element but, of the five naturally occurring alkali metals, cesium is the most electropositive, has the highest density, highest vapour pressure, lowest boiling point and lowest ionization potential. Because of these properties cesium is used in preference to other alkali metals in such space-age applications as space-propulsion and energy conversion.

Cesium emits electrons when exposed to visible light, ultra-violet light or infrared light. Precautions must be taken in handling, transporting and storing cesium metal because in air or water it is very reactive chemically; and when exposed to a combination of air and water it reacts violently. It is an efficient scavenger for traces of oxygen in highly evacuated containers. It resembles potassium and rubidium in the metallic state and is similar in chemical behaviour to potassium and rubidium but oxidizes more readily than any of the other alkali metals.

Occurrences and recovery

Of the naturally occurring alkali metals, cesium is the least abundant. It is, however, widely distributed in the earth's crust and, usually, in low concentrations. It occurs in certain granites and granitic pegmatites, with granites having been estimated to contain an average of about 1 part per million of cesium. Greater concentrations of cesium are found in lepidolite, carnallite, beryl, leucite, spodumene, petolite and related minerals. Although commercial quantities of cesium have been obtained from both lepidolite and carnallite, the most important economic source of the metal is the rare mineral pollucite. Pollucite is usually found in complex, generally well-zoned pegmatite dykes that are rich in lithium minerals, especially lepidolite.

Pollucite, a mineral resembling quartz in lustre and transparency, is a cesium aluminum silicate with the theoretically pure mineral containing 45 per cent cesium oxide (Cs_2O). Naturally occurring pollucite usually contains from 6 to 32 per cent Cs_2O. The higher grade variety of pollucite has a specific gravity of 2.9 and a hardness of 6.5 on Mohs' scale. It is colourless to white, or greyish or pinkish white.

The largest known reserves of pollucite are: 50,000 tons* in the Karibib area in the Territory of South-West Africa, 150,000 tons in the Bikita district of Rhodesia, and 460,000 tons at the mine of Chemalloy Minerals Limited at Bernic Lake in southeastern Manitoba, Canada, about 100 miles northeast of Winnipeg. Mozambique also has pollucite but the quantity and grade of the reserves are not known. A second Canadian occurrence is at the Valor property in Lacorne Township, northwestern Quebec, formerly owned by Massval Mines Limited.

The only known Canadian cesium-bearing deposit of economic importance is that of Chemalloy Minerals Limited. The property is operated by Tantalum Mining Corporation of Canada Limited which is 50.1 per cent owned by Chemalloy Minerals Limited; 24.9 per cent by Kawecki Berylco Industries, Inc.; the remaining 25 per cent interest being held by the Manitoba Development Corporation (MDC) which is the investment agency of the Manitoba government. The pollucite ore zone is separate from the company's tantalum and lithium orebodies (although these do contain low cesium values) which are contained in the same deposit. The pollucite unit consists of three sheet-like bodies, the largest of which ranges up to 45 feet in thickness and lies in the southeast quadrant of the pegmatite. A substantial portion of the lenticular unit is nearly pure pollucite. It is gently dipping and, in general, concordant with the overall attitude of the pegmatite in which it occurs. As of July 31, 1973 the company's cesium reserves consisted of 300,000 tons of pollucite averaging 23 per cent Cs_2O in the main zone and 160,000 tons averaging 5 per cent Cs_2O in the lower and western zones. The main zone is open to the south and could be extended by further drilling. In addition, there are large areas of the pegmatite body containing quantities of pollucite averaging 1 to 3

* The term "ton" refers to the short ton of 2,000 pounds avoirdupois.

pounds of Cs_2O a ton which have not yet been assessed for ore reserves. Also, deeper holes below the main pegmatite body have indicated a second sill approximately 100 feet below the main body which contains pollucite, tantalite and spodumene mineralization.

At the Valor property in northwestern Quebec, masses of pollucite up to 5 feet in maximum exposed dimension are scattered through part of a lenticular core zone of a complex zoned dyke. The zone consists chiefly of quartz, cleavelandite and spodumene, with irregular masses and disseminations of lepidolite.

Ores naturally rich in pollucite have been upgraded experimentally with some success, but satisfactory methods to concentrate pollucite economically from low-tenor ores have not yet been developed. The United States Bureau of Mines has, however, developed experimentally a froth flotation process for concentrating pollucite ore. When applied to a low-grade cesium ore from the state of Maine grading about 8 per cent Cs_2O, the ore was upgraded to over 21 per cent Cs_2O with a cesium recovery of almost 87 per cent.

Thermochemical and hydrometallurgical methods are used for the production of cesium salts and compounds from pollucite ore. Cesium metal can be produced by direct thermochemical reduction of pollucite ore under vacuum or in an atmosphere of an inert gas (argon or helium) or by thermochemical reduction of a cesium compound under vacuum. Cesium metal has also been produced on a laboratory scale by electrolysis but this method of recovery has not yet proved economically feasible.

Production and consumption

Little statistical data is available on the production and consumption of pollucite or cesium metal and compounds. Annual world mine production of pollucite ore was estimated at only 20 tons as recently as 1968. Since then, an increasing demand has resulted in a significantly greater output of pollucite. Up to the end of August 1973, pollucite shipments from Chemalloy's Bernic Lake property totalled some 1,000 tons with the grade averaging about 28 per cent Cs_2O. In 1973, a total of 250 tons of pollucite, averaging 25 per cent Cs_2O, was mined and shipped by Chemalloy. A substantial quantity of the material, all in the form of crushed ore, was shipped to Russia; the remainder was exported to Europe, the United States and Japan.

Up until about 1968, world consumption of cesium metal and compounds was probably less than 10 tons a year. In the past few years, however, there has been a major increase in consumption mainly because of the increasing quantities of cesium compounds used in experimental magnetohydrodynamic (MHD) electrical power generators.

Uses

At present there are no large-scale commercial uses for cesium. Most of the metal and its compounds are currently consumed in the developmental research of thermionic power conversion units, ion propulsion, and MHD electrical power generators. In MHD pilot plants, which make use of cesium's ionization potential, a fuel (coal, oil or gas) is burned. The hot gas is seeded with an easily ionized element such as cesium or potassium, or mixed cesium-potassium, in the form of carbonates to increase its conductivity. The gas is accelerated through a chamber surrounded by a strong magnetic field resulting in the generation of electricity which is drawn off through electrodes placed in the channel. Major increases in efficiency and cheaper power with little or no pollution (cesium carbonate when used as the "seed" is said to scrub out the harmful sulphur oxides produced by the burning coal or char) can be expected from MHD generators. Cesium salts as well as the metal are possible additives for MHD applications which are still in the research and development phase. While alternative materials may be used in the process, present knowledge is that cesium compounds are the most efficient.

In thermionic converters, the heat from nuclear reaction radiates to a surrounding metal (cathode) which emits large masses of electrons. The electrons travel through a space filled with a gas such as cesium vapour to an anode which then has a potential with respect to the cathode and electricity can flow through a circuit joining the anode and cathode.

In the ion-propelled engine, or ion thrusters, vapourized cesium is ionized while passing through a heated porous plate. The cesium ions become positively charged and an electric field accelerates the positive ions to a velocity of some 300,000 miles per hour. The high-velocity ions are exhausted through a nozzle to develop thrust. In recent years ion engines have offered attractive theoretical propulsion systems for spacecraft from an earth orbit to distant planets.

Commercial applications for cesium include its use in photomultiplier tubes, vacuum tubes, scintillation counters, magnetometers, infrared lamps, time and frequency standards, pharmaceuticals and as reagents in microanalysis. Another commercial outlet is in photoelectric cells, developed in the early 1930's where the photoemissive properties of cesium are utilized. Cesium and many of its alloys are photoelectric. An alloy of cesium and silver is used in the emitron or "electric eye" used in television. Other uses are in biological research, medicine and as a catalyst in chemical processes. Cesium bromide is used in the manufacture of optical crystals. Cesium fluoride is used as a fluoridating agent in organic syntheses and cesium hydroxide for electrolyte in alkaline-type storage batteries. The metal may also act as a scavenger of gases and other impurities in chemical processing and in both ferrous and nonferrous metallurgy. Rubidium can be substituted for cesium in some of its applications.

Outlook

So far, the market for cesium metal and compounds has been quite limited as its high cost and extreme reactivity restricts its use to applications where its unique properties are important. Its relatively high cost also encourages the substitution of other materials wherever possible. The greatest potential for sharply increased consumption of cesium appears to be in a technological breakthrough in the research and development of a power generating process using cesium.

Grades, specifications and prices

Cesium metal is usually marketed in two main grades: (a) Standard, with a minimum cesium content of 99.5 per cent; and (b) High purity, with a minimum cesium content of 99.9 per cent. Cesium salts are also available and include: acetate, bromide, carbonate, chloride, chromate, fluoride, hydroxide, iodide, nitrate and sulphate. Cesium is also available in a series of oxides.

A recent nominal quotation for raw pollucite ore of good grade and quality is about 75¢ per pound of contained Cs_2O. Cesium salts sell for about $25 to $75 a pound depending on the type of salt, grade and quantity purchased. Cesium metal of 99+ per cent purity has been quoted at $100 to $375 a pound depending on the quantity and grade purchased.

Copper

C.J. CAJKA

The production of recoverable copper from Canadian mines in 1973, as estimated by Statistics Canada, attained a new record of 899,475 tons*, an increase of 106,172 tons from 1972. The value of this production showed a marked increase, from $806,427,128 in 1972 to an estimated $1,147,629,000 in 1973. Annual growth in production value (42%) was substantially higher than the increase in production volume (13%) because of much improved copper prices towards the latter part of the year, which in turn reflected a world-wide growing demand for copper products. Several large new mines in British Columbia that started mining during 1972 achieved rated capacity, and these were largely responsible for the improvement in Canadian mine output. Canada retained its third-place ranking among copper producing nations in 1973, with some 10.8 per cent of world mine production. Since 1970, Canada has advanced from fifth place to fourth position in 1971 and third place, after the United States and the U.S.S.R., in 1972. Mine production in Canada is expected to grow by 3 per cent in 1974, but may decline by 6 per cent in 1975 as a result of anticipated low copper prices. Chile's mine production is expected to show good gains in 1974, with the result that Canada will likely fall to fourth place in 1974 among world copper producing nations.

Output of refined copper from the two domestic refineries increased by only 1,803 tons in 1973 to 548,488 tons. This amounted to 79 per cent of year-end rated capacity as compared with the 88 per cent rate obtained in 1972. Over 140,000 tons of new capacity has been added to Canadian refineries since 1971 and, because added capacity was not operative for each full calendar year, the apparent utilization of capacity has lagged nominal capacity at each year-end. In addition, new smelting facilities have encountered technical problems in achieving planned output and this, along with a railroad strike, resulted in a shortfall of blister copper feed to the refineries during 1973. Many of the smelter-refinery problems that plagued the Canadian industry in 1972 and 1973 are expected to be resolved in 1974 and a more respectable utilization of capacity should become apparent in that year.

Producers' domestic shipments of refined copper increased substantially in 1973 by 25,706 tons to 254,613 tons. Increasing domestic sales reflected the renewed growth in copper demand that was particularly evident in the second half of 1973. Exports of refined copper showed a marginal decrease in 1973, from 323,441 tons in 1972 to 319,655. Two Canadian sellers of refined copper could not meet all contract commitments during the second half of the year and, consequently, invoked *force majeure* on part of their delivery schedule to foreign customers.

World copper supply in 1973 shifted unexpectedly from ample stocks at the beginning of the year to levels that approached shortages by year-end. Refined copper stocks held in London Metal Exchange (LME) warehouses were a record 200,000 tons in January but declined to less than 20,000 tons by December 1973. An impressive surge in copper consumption by all industrial nations in the world was the chief reason for the major reversal in copper inventories, while refined production did not show a corresponding increase. On a world scale, copper consumption increased 8 per cent from an estimated 8.7 million tons in 1972 to 9.4 million tons in 1973, while world refined copper production increased less than 4 per cent from an estimated 8.9 million tons in 1972 to 9.2 million tons in 1973. World mine production in 1973 of 8.3 million tons was 6.6 per cent above 1972 production of 7.8 million tons. All producer countries showed a gain in mine production during 1973 except Zaire and Japan, which had small decreases. Papua New Guinea, which became a major world producer in 1972 when a new mine at Bougainville reached production, showed good gains in 1973 as the mine attained rated production capacity.

The price of refined copper during 1973 reflected the relative scarcity of copper as inventories declined through the year. The LME cash price of wirebar copper increased from 47.59 cents a pound in January to a high of $1.20 a pound in early December and back down to 91.55 cents a pound at the end of

* The short ton (2,000 pounds) is used throughout unless otherwise stated.

December. The U.S. producer price for copper wirebar was 50.50-50.75 cents in January, and through a series of four price changes, was quoted at 68.15-69.25 cents a pound by the end of 1973. The Canadian producer price followed a similar pattern, opening 1973 at 50.50 cents and rising to 74.00 cents in five increases.

Table 1. Canada, copper production, trade and consumption, 1972-73

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Production				
British Columbia	233,506	237,840,823	354,271	452,015,000
Ontario	289,722	293,493,836	277,261	353,750,000
Quebec	176,432	179,709,867	155,344	198,205,000
Manitoba	59,832	60,943,496	74,121	94,570,000
Yukon	874	890,286	10,794	13,771,000
Saskatchewan	12,546	12,779,314	10,395	13,262,000
New Brunswick	10,311	10,502,113	9,823	12,533,000
Newfoundland	9,513	9,689,977	6,616	8,441,000
Northwest Territories	567	577,416	835	1,064,000
Nova Scotia	–	–	15	18,000
Total	793,303	806,427,128	899,475	1,147,629,000
Refined	546,685		548,488	
Exports				
Copper in ores, concentrates and matte[1]				
Japan	229,607	189,579,000	328,877	430,100,000
Norway	25,961	21,317,000	24,993	23,908,000
United States	12,099	8,871,000	14,831	15,199,000
West Germany	20,703	14,388,000	10,038	13,051,000
Belgium and Luxembourg	478	264,000	1,558	1,742,000
Britain	1,803	1,653,000	1,141	1,285,000
Italy	350	160,000	399	88,000
Other countries	6,997	7,054,000	–	–
Total	297,998	243,286,000	381,837	485,373,000
Copper in slag, skimmings and sludge				
Britain	20	6,000	2,195	6,478,000
France	–	–	495	495,000
United States	88	34,000	51	32,000
Other countries	38	10,000	79	40,000
Total	146	50,000	2,820	7,045,000
Copper scrap (gross weight)				
United States	7,721	6,716,000	11,268	15,911,000
Norway	2,514	2,062,000	2,587	4,501,000
West Germany	3,185	2,756,000	2,713	2,888,000
Belgium and Luxembourg	874	557,000	2,766	2,851,000
Spain	1,607	953,000	1,949	2,735,000
South Korea	1,129	895,000	2,148	2,643,000
Japan	3,007	2,423,000	1,789	1,894,000
Britain	283	98,000	1,302	1,058,000
Netherlands	–	–	289	380,000
Italy	443	365,000	260	280,000
Other countries	214	147,000	418	417,000
Total	20,977	16,972,000	27,489	35,558,000

Table 1. (cont'd)

	1972		1973^p	
Exports (cont'd)	(short tons)	($)	(short tons)	($)
Brass and bronze scrap (gross weight)				
United States	11,141	7,712,000	11,630	11,578,000
West Germany	183	137,000	4,131	4,388,000
Japan	3,865	2,647,000	2,783	2,299,000
Britain	331	211,000	1,945	1,891,000
Italy	1,345	854,000	1,387	1,216,000
Belgium and Luxembourg	335	86,000	1,268	1,141,000
South Korea	86	61,000	734	607,000
Other countries	309	136,000	722	681,000
Total	17,595	11,844,000	24,600	23,801,000
Copper alloy scrap, nes (gross weight)				
Belgium and Luxembourg	69	23,000	817	850,000
United States	218	166,000	640	559,000
Japan	41	27,000	354	366,000
Britain	–	–	397	354,000
South Korea	–	–	331	216,000
Other countries	42	11,000	255	261,000
Total	370	227,000	2,794	2,606,000
Copper refinery shapes				
United States	133,800	132,349,000	126,467	156,179,000
Britain	118,698	116,689,000	103,253	135,256,000
West Germany	30,811	30,083,000	29,798	39,587,000
France	9,495	9,245,000	14,742	20,553,000
Japan	909	932,000	11,511	13,906,000
Belgium and Luxembourg	7,987	7,449,000	7,461	10,261,000
Italy	4,863	4,729,000	7,297	9,633,000
Sweden	4,521	4,365,000	4,443	6,113,000
Switzerland	2,026	1,941,000	3,737	5,682,000
Portugal	3,454	3,369,000	3,549	4,752,000
Spain	1,383	1,391,000	1,729	2,053,000
Brazil	1,311	1,225,000	1,275	1,719,000
Greece	2,153	2,157,000	1,242	1,532,000
Other countries	2,030	1,972,000	3,151	4,897,000
Total	323,441	317,896,000	319,655	412,123,000
Copper bars, rods and shapes, nes				
United States	2,513	3,353,000	4,643	6,908,000
Lebanon	2,315	2,277,000	2,368	3,192,000
Switzerland	1,483	1,430,000	2,341	3,146,000
Iran	331	368,000	1,454	2,567,000
Norway	2,939	2,877,000	2,020	2,765,000
Denmark	1,402	1,472,000	1,543	1,940,000
Britain	1,971	2,076,000	1,274	1,731,000
Pakistan	–	–	1,598	1,633,000
Dominican Republic	929	987,000	1,103	1,607,000
Other countries	5,311	5,370,000	6,033	8,956,000
Total	19,194	20,210,000	24,377	34,445,000

Table 1. (cont'd)

	1972		1973p	
Exports (cont'd)	(short tons)	($)	(short tons)	($)
Copper plates, sheet, strips and flat products	7,673	10,695,000	7,430	12,915,000
United States	271	414,000	457	719,000
Britain	274	429,000	338	593,000
Venezuela	26	39,000	47	91,000
New Zealand	–	–	29	51,000
Australia	–	–	19	38,000
Norway	22	31,000	26	37,000
United Arab Republic	74	110,000	54	67,000
Other countries	8,340	11,718,000	8,400	14,511,000
Total				
Copper pipe and tubing				
United States	10,699	12,423,000	11,604	15,272,000
Britain	1,084	1,528,000	6,401	10,991,000
New Zealand	528	938,000	755	1,626,000
Israel	509	668,000	564	850,000
Venezuela	282	529,000	200	391,000
West Germany	–	–	153	295,000
South Africa	160	228,000	88	186,000
Other countries	1,110	1,692,000	952	1,687,000
Total	14,372	18,006,000	20,717	31,298,000
Copper, wire and cable (not insulated)				
United States	185	250,000	936	1,061,000
Colombia	–	–	274	340,000
Bangladesh	–	–	140	202,000
Britain	–	1,000	35	77,000
Other countries	405	502,000	165	326,000
Total	590	753,000	1,550	2,006,000
Copper alloy refinery shapes				
United States	11,661	14,067,000	11,628	17,113,000
Japan	23	20,000	960	1,083,000
Britain	2	2,000	318	507,000
Venezuela	140	195,000	176	309,000
New Zealand	24	36,000	82	147,000
Brazil	–	–	110	145,000
Australia	12	16,000	80	120,000
Other countries	153	219,000	238	288,000
Total	12,015	14,555,000	13,592	19,712,000
Copper alloy pipe and tubing				
United States	3,163	3,814,000	3,029	4,910,000
India	374	575,000	181	260,000
New Zealand	83	138,000	72	173,000
Britain	97	138,000	76	158,000
Venezuela	99	112,000	30	73,000

Table 1. (cont'd)

	1972		1973p	
	(short tons)	($)	(short tons)	($)
Exports (concl'd)				
Copper alloy pipe and tubing (concl'd)				
Japan	11	25,000	30	70,000
Australia	5	9,000	19	36,000
Other countries	515	775,000	48	96,000
Total	4,347	5,586,000	3,485	5,776,000
Copper alloy wire and cable (not insulated)				
United States	81	168,000	127	233,000
New Zealand	2	4,000	7	21,000
Australia	11	44,000	6	19,000
Venezuela	26	35,000	4	7,000
Other countries	6	11,000	4	18,000
Total	126	262,000	148	298,000
Copper alloy fabricated materials, nes				
United States	1,133	1,490,000	644	1,172,000
Indonesia	–	–	200	498,000
Britain	46	84,000	70	90,000
Philippines	10	17,000	37	68,000
Taiwan	13	17,000	29	42,000
Other countries	352	764,000	83	159,000
Total	1,554	2,372,000	1,063	2,029,000
Wire and cable insulated[2]				
United States	8,074	12,073,000	9,195	15,331,000
India	10,280	18,749,000	1,461	2,909,000
Dominican Republic	600	1,082,000	859	1,370,000
West Germany	538	615,000	697	944,000
Panama	115	171,000	366	649,000
Bermuda	172	243,000	261	371,000
Australia	42	77,000	177	343,000
Turkey	501	829,000	125	277,000
Greenland	28	71,000	139	245,000
Jamaica	50	92,000	92	235,000
Guyana	40	71,000	260	233,000
Kenya	–	–	140	216,000
Other countries	2,522	4,138,000	1,317	2,321,000
Total	22,962	38,211,000	15,089	25,444,000
Total exports of copper and products		701,948,000		1,102,025,000
Imports				
Copper in ores, concentrates and scrap	17,776	11,725,000	52,319	54,045,000
Copper refinery shapes	17,840	18,010,000	18,937	25,605,000
Copper bars, rods and shapes, nes	347	402,000	346	537,000
Copper plates, sheet strip and flat products	630	1,016,000	816	1,582,000
Copper pipe and tubing	4,096	5,995,000	6,184	11,138,000

Table 1. (concl'd)

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Imports (concl'd)				
Copper wire and cable, except insulated	253	601,000	369	955,000
Copper alloy scrap (gross weight)	3,864	2,469,000	5,922	5,290,000
Copper powder	403	567,000	555	1,029,000
Copper alloy refinery shapes, rods and sections	10,036	10,463,000	9,420	12,358,000
Brass plates, sheet and flat products	4,140	4,680,000	3,929	5,880,000
Copper alloy plates, sheet, strip and flat products	613	1,478,000	910	2,400,000
Copper alloy pipe and tubing	1,699	2,990,000	1,943	3,939,000
Copper alloy wire and cable, except insulated	566	1,079,000	682	1,562,000
Copper alloy castings	281	543,000	283	591,000
Copper and alloy fabricated material, nes	2,243	3,252,000	2,252	4,053,000
Insulated wire and cable	. .	16,018,000	. .	21,755,000
Copper oxides and hydroxides	229	286,000	326	405,000
Copper sulphate	1,732	643,000	1,430	561,000
Total imports of copper and products	. .	82,217,000	. .	153,685,000
Consumption[3]				
Refined	228,907	. .	254,613	. .

Source: Statistics Canada.
[1] Blister copper plus recoverable copper in matte and concentrate exported. [2] Includes also small quantities of non-copper wire and cable, insulated. [3] Producers' domestic shipments, refined copper.
^{p} Preliminary; – Nil; . . Not available; nes Not elsewhere specified.

1974 is expected to be a very good year for Canadian copper producers because high copper prices are likely to prevail during the first half of the year, demand for copper concentrate and refined copper is expected to remain strong and newly installed smelter-refining capacity should be in operation for most of the year. Several mine labour contracts in western Canada are due for renewal in 1974 and failure to successfully renegotiate these could result in reduced output from this region. A world copper shortage could develop in 1974 if the U.S. copper industry is struck for a prolonged period. Most copper industry labour contracts in the United States expire at mid-year. On the other hand, if there is no industry-wide strike in the United States in 1974 or if there is a quick settlement of labour disputes, the forecast is for production to exceed consumption, with inevitable replenishment of inventories and declining copper prices by the end of 1974. World demand for copper is expected to remain strong for the first half of 1974 but to show weakness in the second half as world economies enter a period of slow growth rates.

During December 1973, the United States Armed Services Committee approved a bill to dispose of 251,600 tons of copper held in federal stockpiles and President Nixon signed the bill into law at year-end. This copper will probably be released over a span of several months, with the first allotment reaching markets early in 1974.

Table 2. Canada, copper production, trade and consumption, 1964-73

	Production		Exports				
	All Forms[1]	Refined	Ore and Matte	Refined	Total	Imports Refined	Consumption[2] Refined
				(short tons)			
1964	486,900	407,942	104,550	224,273	328,823	6,771	202,225
1965	507,877	434,133	87,000	199,830	286,830	5,747	224,684
1966	506,076	433,004	94,888	190,691	285,579	10,492	262,557
1967	613,314	499,846	128,976	275,919	404,895	5,310	219,680
1968	633,313	524,474	161,835	276,619	438,454	5,824	250,104
1969	573,246	449,232	157,816	210,034	367,850	18,137	226,281
1970	672,717	543,727	177,888	292,403	470,291	14,542	237,916
1971	721,430	526,403	225,006	314,728	539,734	21,899	221,053
1972	793,303	546,685	297,998	323,441	621,439	17,840	228,907
1973[p]	899,475	548,488	381,837	319,655	701,492	18,937	254,613

Source: Statistics Canada.
[1] Blister copper plus recoverable copper in matte and concentrates exported. [2] Producers' domestic shipments, refined copper.
[p] Preliminary.

Canadian supply and demand

Mines. The dominant feature of Canadian mine production in 1973 was the continuing growth of mine output in western Canada, where five large new mines, that achieved initial production in 1970-72, gradually worked up to rated capacity. Mine production of copper in British Columbia increased from 233,506 tons in 1972 to 354,271 tons in 1973, which placed British Columbia as the top-ranking province in the country for the first time.

Two small copper-zinc producing mines were reopened in eastern Canada; one large copper-zinc mine, a small copper mine and two copper-nickel mines began production in 1973. The largest mine to be opened was the 10,000-ton-a-day Ruttan mine of Sherritt Gordon Mines, Limited, in Manitoba. Two small copper-zinc mines and two copper-nickel mines closed during 1973. High metal prices have prolonged the life of several mines, one of which is the famous Horne mine. Nevertheless, three mines are scheduled for closure in 1974. Two new copper mines, one copper-zinc, one copper-lead-zinc mine and two copper-nickel mines are planned for production in 1974. While most are small, the rich copper-lead-zinc mine of Sturgeon Lake Mines Limited and the 4,000-ton-a-day Levack West copper-nickel mine of The International Nickel Company of Canada, Limited (Inco) are major developments. Two small copper mines and one copper-nickel mine are scheduled to resume production in 1974, following a period when they were idle because of unsatisfactory market conditions. In total, nine mines are scheduled to initiate or resume production in 1974, an improvement that can be attributed to the much higher metal prices of 1973.

Lengthy mine strikes in 1973 reduced output at five copper producing mines. The Buchans, Madeleine, Geco, Brenda, and Craigmont mines were struck for periods that lasted from six weeks to seven months.

Rotating strikes in 1973 on Canadian railroads developed into a month-long nation-wide strike. These railroad service interruptions caused delays in moving concentrate from the mines and blister copper from the smelters, thereby tending to constrain mine output. Transportation delays were still being felt well into the last quarter of the year because of an apparent shortage of rail cars and temporarily "lost" shipments.

There were no reports of difficulties in marketing copper concentrate during 1973, mainly because of the strong international demand for copper and high copper prices.

Table 3. Producing copper mines in Canada, 1973 and (1972)

Company and Location	Mill or Mine Capacity*	Grade of Ore: Copper	Grade of Ore: Zinc	Grade of Ore: Nickel	Grade of Ore: Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Newfoundland								
American Smelting and								
Refining Company,	1,250	1.00	11.51	–	3.45	124,000	1,109	Production suspended for 7
Buchans	(1,250)	(1.13)	(12.89)	–	(3.73)	(291,000)	(3,017)	months due to labour strike.
Consolidated Rambler Mines								
Limited,								
East mine	–	0.92	–	–	–	81,636	668	Exploration continuing.
Ming mine	1,200	3.05	–	–	0.46	210,375	5,601	
East and Ming mines	(1,200)	(1.84)	–	–	(0.35)	(386,205)	(6,933)	
Baie Verte								
Nova Scotia								
Dresser Minerals	120	0.27	1.00	–	5.43	8,178	22	Ore reserves depleted.
Division of Dresser Industries, Inc.,	–	–	–	–	–	–	–	
Walton								
New Brunswick								
Anaconda Canada Limited,	1,000	3.4	3.0	–	–	45,000	960	Open-pit mine was re-
Caribou mine	(1,000)	–	–	–	–	–	–	opened in September.
Restigouche county								
Brunswick Mining and Smelting	9,850	0.34	7.00	–	2.53	3,288,081	4,283	Progress was made to in-
Corporation Limited,	(9,850)	(0.32)	(7.15)	–	(2.43)	(3,257,559)	(6,682)	crease production from
No. 6 and No. 12 mines								No. 12 mine during 1973.
Bathurst								
Heath Steele Mines Limited,	3,100	0.86	4.90	–	1.83	1,077,816	6,167	Currently sinking a new
Newcastle	(3,000)	(1.13)	(3.93)	–	(1.70)	835,867	6,297	shaft to 3,000 foot level.
								Expanding concentrator to
								4,000 tpd by 1976.
Nigadoo River Mines Limited,	1,000	. .	. .	–	. .	. .	. .	Tune-up of mill started late
Robertville	(1,000)	–	–	–	–	–	–	1973 with nominal amount of
								ore mined.

Quebec								
Bouzan Joint Venture, (Patino Mines (Quebec) Ltd. –Kerr Addison Mines Ltd., Chibougamau	.. –	1.81 –	– –	– –	– –	13,444 –	.. –	Underground production commenced in 1973.
Campbell Chibougamau Mines Ltd., Cedar Bay, Henderson and Main mines Chibougamau	4,000 (4,000)	1.30 (1.48)	– –	– –	0.24 (0.24)	1,186,842 (987,266)	14,273 (13,601)	Some open-pit production from the Merrill Island property and the Kokko Creek zone.
Falconbridge Copper Limited, Lake Dufault Division Norbec and Millenbach mines Noranda	1,500 (1,500)	3.65 (3.16)	4.41 (4.39)	– –	1.41 (1.40)	555,292 (561,625)	18,892 (16,425)	Both surface and underground exploration continuing.
Opemiska Division Perry and Springer mines Chapais	3,000 (3,000)	2.14 (2.20)	– –	– –	0.34 (0.33)	1,062,818 (1.156,864)	21,576 (24,048)	Robitaille orebody mined out in 1972. New surface plant at Cooke mine for 1974 production.
Gaspé Copper Mines, Limited, Needle Mountain and Copper Mountain mines Murdochville	33,750 (11,000)	0.62 (0.91)	– –	– –	0.05 (0.15)	6,729,078 (3,939,738)	28,295 (33,940)	Mill expansion completed.
Icon Sullivan Joint Venture, Chibougamau	650 (650)	2.80 (3.13)	– –	– –	.. ..	210,516 (208,471)	5,734 (6,378)	
Joutel Copper Mines Limited, Joutel	700 (700)	1.93 (1.90)	– –	– –	.. ..	49,495 (149,651)	972 (2,453)	Excludes 151,427 tons of zinc ore mined during 1973. Ore reserves will be depleted in 1974.
Louvem Mining Company Inc., Louvicourt	800 (850)	1.81 (1.51)	– –	– –	0.28 (0.24)	253,281 (272,736)	4,365 (3,896)	Development of a 200,000 ton zinc orebody located 2,500 feet west of shaft.
Madeleine Mines Ltd., Ste. Anne des Monts	2,500 (2,500)	1.31 (1.42)	– –	– –	.. (0.30)	713,980 (729,608)	8,748 (9,725)	Following strike settlement operation recommenced in February 1973.
Mattagami Lake Mines Limited, Matagami	3,850 (3,850)	0.57 (0.56)	7.4 (7.4)	– –	0.84 (0.88)	1,387,251 (1,370,167)	5,919 (6,270)	

Table 3. (cont'd)

Company and Location	Mill or Mine Capacity*	Grade of Ore: Copper	Zinc	Nickel	Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Quebec (concl'd)								
Noranda Mines Limited,	3,200	2.51	–	–	0.56	485,783	11,608	Mine scheduled to close
Horne Division	(3,000)	(2.30)	–	–	(0.49)	(686,566)	(14,604)	in 1975.
Normetal Mines Limited,	1,000	1.38	4.86	–	1.37	297,889	3,750	Ore will be depleted in 1974.
Normetal	(1,000)	(1.73)	(5.29)	–	(1.43)	(326,475)	(5,256)	
Orchan Mines Limited,	2,000	1.16	5.77	–	0.69	450,230	4,248	Garon Lake ore trucked
Orchan and Garon Lake mines	(2,000)	(1.05)	(10.60)	–	(1.10)	(376,840)	(3,243)	to Orchan mill.
Matagami								
Patino Mines (Quebéc) Limited,	2,800	1.61	–	–	0.19	973,395	14,989	Jaculet mine to resume
Copper Rand, Copper Cliff	(2,800)	(1.77)	–	–	(0.19)	(1,018,633)	(17,352)	production in 1974.
and Portage mines								
Chibougamau								
Rio Algom Mines Limited,	1,800	2.42	–	–	–	638,883	14,543	
Mines de Poirier mine	(1,800)	(2.22)	–	–	–	(651,713)	(13,438)	
Joutel								
Société Minière d'Exploration	250	0.5	–	1.5	–	90,000	170	Mine closure in January 1974.
Somex Ltée,	–	–	–	–	–	–	–	
Lac Edouard								
Sullivan Mining Group Ltd.,								
Stratford Centre								
Cupra Division	1,500	2.41	4.88	–	1.09	89,814	2,007	
	(1,500)	(2.24)	(3.97)	–	(0.99)	(117,339)	(2,530)	
D'Estrie Mining Company Ltd.	–	2.74	3.16	–	1.23	130,265	3,323	Ore trucked to Cupra mill.
	–	(2.70)	(3.28)	–	(1.21)	(109,138)	(2,840)	
Weedon Mines Ltd.	–	2.17	0.59	–	0.33	50,591	1,050	Ore depleted and mine
	–	(1.82)	(0.76)	–	(0.35)	(177,248)	(3,074)	closed.
Ontario								
Ecstall Mining Limited,	10,000	1.61	9.78	–	3.72	3,609,657	55,769	Expanding production to
Kidd Creek mine	(10,000)	(1.44)	(10.14)	–	(4.35)	(3,628,501)	(47,915)	5 million tons a year.

Timmins								Installation of underground crusher and related equipment was completed in 1973. Underground mining commenced.
Falconbridge Nickel Mines Limited, East, Falconbridge, Fecunis, Hardy Open Pit, Longvack South, North, Onaping, and Strathcona mines Falconbridge	3,000 (Falconbridge) 2,500 (Fecunis) 6,600 (Strathcona)	. . . .	– –	. . . .	. . . .	4,292,900 (4,199,000)	26,862[d] (28,232)[d]	Boundary mine closed in November; Hardy pit mining commenced. Hardy concentrator closed in 1972.
The International Nickel Company of Canada, Limited, Clarabelle, Coleman, Copper Cliff North, Copper Cliff South, Creighton, Frood-Stobie, Garson, Kirkwood, Levack, Little Stobie, Maclennan and Victoria mines Sudbury	35,000 (Clarabelle) 24,000 (Frood-Stobie) 11,400 (Levack)	. . . .	– –	. . . .	. . . .	15,966,093 (15,894,577)	163,560[d] (154,100)[d]	Plan to re-open Crean Hill mine in 1974. Production from Victoria mine began in 1973.
Shebandowan Mine Shebandowan	2,500 (2,500)	. . . .	– –	. . . .	. . . .	594,993 (. .)	163,560[d] (154,100)[d]	
Mattabi Mines Limited, Sturgeon Lake	3,000 (3,000)	1.10 (1.27)	11.37 (11.97)	– –	5.31 (4.99)	1,111,765 (438,838)	9,966 (4,281)	Mill operated at full capacity throughout 1973, its first full year of production. Improvements in the copper-lead separation process were made.
Noranda Mines Limited, Geco Division Manitouwadge	5,000 (5,200)	1.70 (2.12)	4.53 (4.30)	– –	1.63 (1.93)	1,463,585 (1,815,164)	22,920 (35,985)	Copper concentrate drying plant completed. Strike lasted 2 months.
Pamour Porcupine Mines, Limited, Schumacher Division Schumacher	2,100 (2,100)	0.63 (0.65)	– –	– –	0.12 (0.11)	777,670 (758,380)	4,541 (4,621)	Previously reported under "McIntyre Porcupine Mines Limited".

Table 3. (cont'd)

Company and Location	Mill or Mine Capacity*	Grade of Ore: Copper	Zinc	Nickel	Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Ontario (cont'd)								
Selco Mining Corp. Ltd., South Bay Division Uchi Lake	500 (500)	1.86 (2.10)	13.04 (12.00)	– –	3.18 (3.20)	191,614 (183,000)	3,195 (3,561)	Decline being extended to 900 ft. level.
Tribag Mining Co., Ltd., Batchawana Bay	. . (500)	. . (1.26)	– –	– –	. . . .	. . (190,949)	. . (2,323)	Milled at 550 tpd. Ownership transferred to Prace Mining Limited in November, 1973.
Willroy Mines Limited, Manitouwadge	1,700 (1,700)	0.98 (1.10)	2.74 (3.27)	– –	1.42 (1.41)	430,486 (431,067)	3,793 (4,380)	
Manitoba								
Dumbarton Mines Limited, Bird River	. . (1,100)	0.30 (0.28)	– –	0.76 (0.86)	– –	331,851 (325,766)	881 (831)	Established a new zone known as the "F-Zone". Ore trucked to Werner Lake mill.
Falconbridge Nickel Mines Limited, Manibridge mine Wabowden	1,000 (1,000)	. . . .	– –	. . . .	. . . .	135,716 166,399	. . . .	A tight cut-and-fill system initiated for better ground control.
Hudson Bay Mining and Smelting Co., Limited, Anderson, Chisel, Dickstone, Flin Flon, Ghost, Osborne, Schist, Stall and White Lake mines Flin Flon and Snow Lake	8,500 (6,800)	2.45 (2.67)	3.61 (3.28)	– –	0.75 (0.59)	1,815,027 (1,847,903)	42,100 (47,472)	Development of Centennial Mine started.
The International Nickel Company of Canada, Limited, Birchtree, Pipe and Thompson mines Thompson	18,400 (18,400)	. . . .	– –	. . . .	– –	3,444,210 (3,043,648)	163,560[d] (154,100)[d]	

Sherritt Gordon Mines,								
Limited,	3,500	0.39	–	0.84	–	675,907	2,140	
Farley Mine	(3,500)	(0.38)	–	(0.67)	–	(995,000)	(3,171)	
Lynn Lake								
Fox Mine	3,000	2.01	2.01	–	–	963,416	17,310	Plan to deepen below
Lynn Lake	(3,000)	(2.86)	(1.54)	–	–	(1,022,000)	(27,519)	2,000 level by decline.
Ruttan Mine	10,000	1.14	..	–	–	1,518,052	18,650	Production began April 1973.
Ruttan	–	–	–	–	–	–	–	Two parallel declines being
								driven for underground
								mine.
Saskatchewan		See Manitoba which includes production						
Hudson Bay Mining and		from both Manitoba and Saskatchewan mines.						
Smelting Co., Limited,								
Flin Flon mine								
Flin Flon								
British Columbia								
Anaconda Canada Limited,	3,000	1.45	–	–	..	548,801	7,740	No. 11 Winze installed to
Britannia mine	(3,000)	(1.38)	–	–	(0.27)	(765,517)	(9,990)	mine ore 400 ft. below shaft.
Britannia Beach								
Bethlehem Copper Corporation Ltd.,	16,000	0.58	–	–	1.61	6,339,122	33,543	Production largely from
Heustis, Iona and Jersey mines	(16,300)	(0.54)	–	–	–	(5,964,696)	(29,111)	Huestis pit. New ore found
Highland Valley								in Jersey pit. Development
								ore from Iona zone.
Bralorne Resources Limited,	500	0.43	4.57	–	4.88	98,471	259	Operations suspended
Bradina Joint Venture	(600)	(0.42)	(4.45)	–	(5.31)	(111,024)	(364)	Aug. 31 because of labour
Houston								shortage and uneconomic
								operations.
Brenda Mines Ltd.,	24,000	0.20	–	–	..	8,867,800	16,201	A 2 year labour agreement
Peachland	(24,000)	(0.21)	–	–	–	(9,503,190)	(17,846)	ended a 41 day work
								stoppage.
Craigmont Mines Limited,	5,300	1.39	–	–	–	1,429,556	18,725	Installation of automatic con-
Merritt	(5,000)	(1.36)	–	–	–	(1,894,260)	(24,275)	trols on grinding circuit in-
								creased mill throughput 5%.
								Strike began in Sept. and
								was still in progress at year-end.

Table 3. (cont'd)

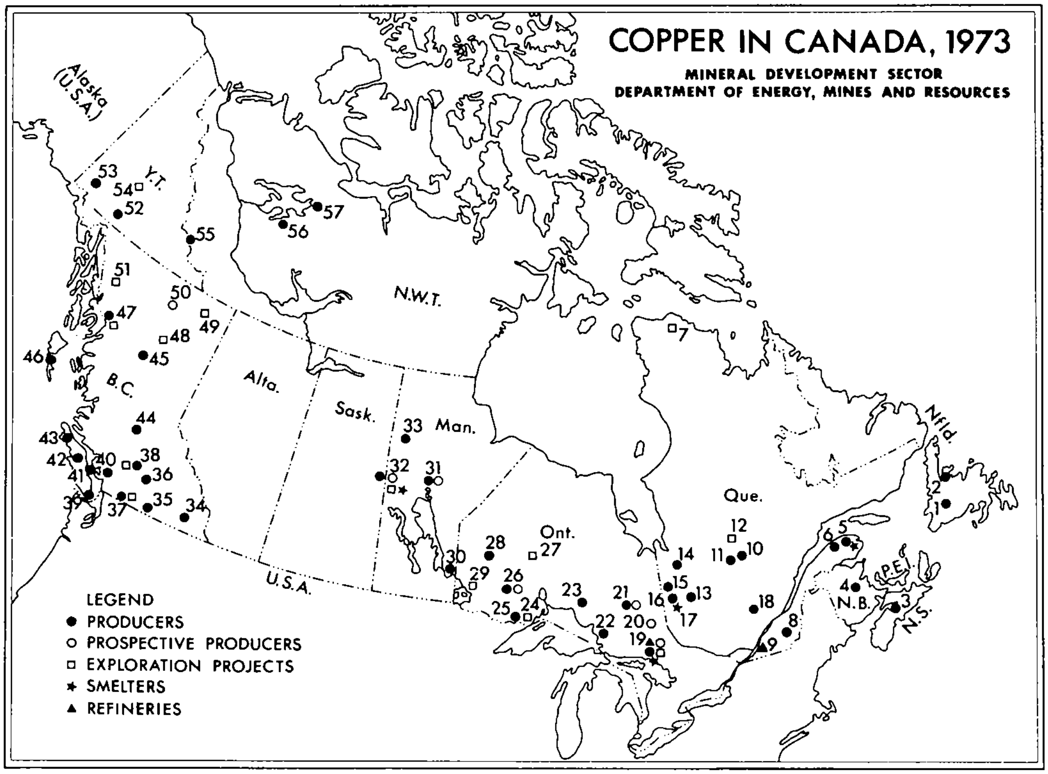
Company and Location	Mill or Mine Capacity*	Grade of Ore Copper	Zinc	Nickel	Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
British Columbia (cont'd)								
Falconbridge Nickel Mines Limited, Wesfrob mine Tasu Harbour, Q.C.I.	3,000 (3,000)	0.41 (0.47)	– –	– –	– –	762,978 (595,505)	2,824 (2,705)	Commenced development of access to the underground ore body.
Giant Mascot Mines Limited, Hope	1,800 (1,875)	0.24 (0.38)	– –	0.58 (0.68)	– –	352,758 (389,894)	893 (1,353)	Possible suspension of operations by end of 1974. Nickel concentrate to Sherritt Gordon, copper concentrate to Japan.
Gibraltar Mines Ltd., McLeese Lake Cariboo District	40,000 (38,000)	0.48 (0.45)	– –	– –	.. ..	15,082,231 (11,243,221)	60,900 (41,025)	Mill attained 43,000 tpd.
The Granby Mining Company Limited, Granisle Mine Babine Lake	13,000 (14,000)	0.47 (0.55)	– –	– –	0.09 –	4,565,105 (2,537,138)	17,874 (12,376)	Ore production increased.
Phoenix Copper Division Greenwood	2,750 (2,600)	0.50 (0.68)	– –	– –	0.18 (0.26)	1,003,815 (873,982)	4,087 (5,154)	Increased mill capacity. Milling stockpiled ore.
Granduc Operating Company, Stewart	8,000 (7,500)	1.25 (1.35)	– –	– –	.. ..	2,797,949 (2,089,865)	33,533 (27,031)	Mill averaged 7,666 tpd. Improved flotation circuit.
Jordan River Mines Ltd., Sunro Mine Jordan River, V.I.	1,250 (1,500)	1.02 ..	– –	– –	.. ..	273,628 ..	2,631 ..	Developing Cave "A" orebody.
Lornex Mining Corporation Ltd. Highland Valley	38,000 (38,000)	0.42 (0.43)	– –	– –	.. (0.03)	13,986,958 (5,468,794)	52,992 (20,525)	Average daily milling rate for the year was 38,320 tons.

Noranda Mines Limited,	11,300	0.59	–	–	–	4,114,000	17,023	
Bell Copper Division	(10,000)	(0.66)	–	–	–	(767,270)	(4,163)	
Babine Lake								
Placid Oil Company,	750	2.4	–	–	0.71	206,812	3,607	
Bull River Mine	(700)	(1.32)	–	–	(0.38)	(206,331)	(2,366)	
Cranbrook								
Similkameen Mining Company								
Limited,	15,000	0.45	–	–	–	5,356,829	20,570	
Ingerbelle pit	(15,000)	(0.44)	–	–	–	(2,992,664)	(11,500)	
Princeton								
Texada Mines Ltd.,	5,000	(0.31)	–	–	(0.05)	1,090,000	2,224	
Vanada	(4,500)	(0.31)	–	–	(0.02)	(1,200,429)	(2,179)	
Utah Mines Ltd.,	33,000	0.50	–	–	..	12,071,000	52,300	
Island Copper Mine,	(33,000)	(0.53)	–	–	..	(7,980,429)	(37,672)	
Coal Harbour, V.I.								
Western Mines Limited,	1,000	..	..	–	..	354,240	4,643	A 2,300 ft. exploration
Lynx and Myra mines	(1,100)	(1.85)	(6.02)	–	..	(374,022)	(6,577)	tunnel on Price property,
Buttle Lake, V.I.								east of Myra Falls mine,
								was completed.
Yukon Territory								
Hudson-Yukon Mining Co.,	600	1.45	–	2.49	–	76,760	939	Closed in July 1973 be-
Limited,	(600)	(1.35)	–	(2.05)	–	(112,451)	(1,258)	cause operation was
Wellgreen mine								uneconomical.
Kluane Lake								
Whitehorse Copper Mines Ltd.,	2,400	1.83	–	–	..	700,054	11,782	First full year of production
Little Chief mine	(2,000)	(1.92)	–	–	(0.40)	(10,707)	(173)	since development of under-
Whitehorse								ground mine. Developing
								Middle Chief orebody.
Northwest Territories								
Canada Tungsten Mining	600	..	–	–	–	164,900	99	Open-pit reserves will be
Corporation Limited,	(575)	(0.14)	–	–	–	(172,828)	(122)	exhausted in 1974.
Tungsten								Preparing for underground
								mining.
Echo Bay Mines Ltd.,	150	1.25	–	–	84.0	37,393	430	Copper recovered in a
Port Radium	(100)	(1.14)	–	–	(67.0)	(37,290)	(393)	silver-copper concentrate.

Table 3. (cont'd)

Company and Location	Mill or Mine Capacity*	Grade of Ore				Ore Produced	Contained Copper Produced	Remarks
		Copper	Zinc	Nickel	Silver			
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Northwest Territories (concl'd)								
Terra Mining and Exploration Limited,	175	0.7	–	–	35.4	41,116	250	Major underground development expected to prove high grade reserves in No. 10 vein.
Camsell River mine	(175)	(0.38)	–	–	(81.63)	(24,723)	(94)	
Great Slave Lake								

Source: Company reports and technical press.
*Mill capacity in short tons of ore a day; . . Not available; – Nil; tpd Tons per day; [d]Deliveries.



Producers

(numbers correspond to those on the map)

1. American Smelting and Refining Company
2. Consolidated Rambler Mines Limited
3. Dresser Minerals Division of Dresser Industries, Inc.
4. Anaconda Canada Limited (Caribou mine)
   Brunswick Mining and Smelting Corporation Limited (No. 6 and No. 12 mines)
   Heath Steele Mines Limited
   Nigadoo River Mines Limited
5. Gaspé Copper Mines, Limited
6. Madeleine Mines Ltd.
8. Sullivan Mining Group Ltd. (Cupra, D'Estrie Weedon mines)
   Bouzan Joint Venture
10. Campbell Chibougamau Mines Ltd. (Cedar Bay, Henderson, Main mines)
    Icon Sullivan Joint Venture
    Patino Mines (Québec) Limited (Copper Rand, Copper Cliff, Jaculet, Portage mines)
11. Falconbridge Copper Limited, Opemiska Division (Perry, Springer mines)
13. Louvem Mining Company Inc.
14. Joutel Copper Mines Limited
    Mattagami Lake Mines Limited
    Orchan Mines Limited (Orchan, Garon Lake mines)
    Rio Algom Mines Limited (Mines de Poirier mine)
15. Normetal Mines Limited
16. Falconbridge Copper Limited, Lake Dufault Division (Norbec, Millenbach mines)
    Noranda Mines Limited (Horne Mine)
18. Société Minière d'Exploration Somex ltée
19. Falconbridge Nickel Mines Limited (East, Falconbridge, Fecunis, Hardy, Longvack, South, North, Onaping, Strathcona mines)
    The International Nickel Company of Canada, Limited (Clarabelle, Coleman, Copper Cliff North, Copper Cliff South, Creighton, Frood Stobie, Garson, Kirkwood, Levack, Little Stobie, MacLennan, Victoria mines)
21. Ecstall Mining Limited (Kidd Creek mine)
    Pamour Porcupine Mines, Limited
22. Tribag Mining Co., Limited
23. Noranda Mines Limited, Geco Division
    Willroy Mines Limited (Willecho, Willroy mines)
25. The International Nickel Company of Canada, Limited (Shebandowan)

Producers (cont'd)

26. Mattabi Mines Limited
28. Selco Mining Corporation Limited, South Bay Division
30. Dumbarton Mines Limited
31. Falconbridge Nickel Mines Limited (Manibridge mine)
    The International Nickel Company of Canada, Limited (Birchtree, Pipe and Thompson mines)
32. Hudson Bay Mining and Smelting Co., Limited (Anderson, Chisel, Dickstone, Flin Flon, Ghost, Osborne, Schist, Stall, White Lake mines)
33. Sherritt Gordon Mines, Limited (Farley, Fox and Ruttan mines)
34. Placid Oil Company (Bull River mine)
35. The Granby Mining Company Limited, Phoenix Copper Division
36. Brenda Mines Ltd.
37. Giant Mascot Mines Limited
    Similkameen Mining Company Limited (Ingerbelle and Similkameen deposits)
38. Bethlehem Copper Corporation Ltd. (Huestis, Iona and Jersey mines)
    Lornex Mining Corporation Ltd.
    Craigmont Mines Limited
39. Jordan River Mines Ltd. (Sunro mine)
40. Anaconda Britannia Mines Ltd. (Britannia mine)
41. Texada Mines Ltd.
42. Western Mines Limited (Lynx, Myra mines)
43. Utah Mines Ltd. (Island Copper mine)
44. Gibraltar Mines Ltd.
45. Bradina Joint Venture
    The Granby Mining Company Limited (Granisle mine)
    Noranda Mines Limited, Bell Copper Division
46. Falconbridge Nickel Mines Limited (Wesfrob mine)
47. Granduc Operating Company
52. Whitehorse Copper Mines Ltd. (Little Chief mine)
53. Hudson-Yukon Mining Co., Limited (Wellgreen mine)
55. Canada Tungsten Mining Corporation Limited
56. Terra Mining and Exploration Limited
57. Echo Bay Mines Ltd.

Prospective producers

4. Heath Steele Mines Limited (Little River mine)
10. Campbell Chibougamau Mines Ltd., Grandroy Division
    Patino Mines (Québec) Limited (Lemoine ML, Jaculet)
11. Falconbridge Copper Limited, Opemiska Division (Cooke mine)
14. Orchan Mines Limited (Norita, Radiore No. 2 mines)
19. Falconbridge Nickel Mines Limited (Lockerby, Thayer Lindsay mine)
    The International Nickel Company of Canada, Limited (Crean Hill, Levack West, Murray, Totten mines)
20. Kanichee Mining Incorporated
21. Ecstall Mining Limited
26. Sturgeon Lake Mines Limited
31. The International Nickel Company of Canada, Limited (Soab mine)
32. Freeport Canadian Exploration Company and Beth-Canada Mining Company (Reed Lake)
    Hudson Bay Mining and Smelting Co., Limited (Centennial, Western Arm mines)
44. Cuisson Lake Mines Ltd.
50. Consolidated Churchill Copper Corporation Ltd. (Churchill mine)

Exploration projects

7. New Quebec Raglan Mines Limited
12. Selco Mining Corporation Limited and Muscocho Explorations Limited
14. Phelps Dodge Corporation of Canada, Limited
16. Copperfields Mining Corporation Limited and Iso Mines Limited
    New Insco Mines Ltd. and others
19. Falconbridge Nickel Mines Limited (Fraser, Onex mines)
    The International Nickel Company of Canada, Limited (Cryderman, Whistle mine)
24. Great Lakes Nickel Limited
27. Union Minière Explorations and Mining Corporation Limited
29. Maybrun Mines Limited
32. Hudson Bay Mining and Smelting Co., Limited (Hudvam, Rail, Reed, Wim mines)
    Stall Lake Mines Limited
37. Adonis Mines Ltd.
    Giant Mascot Mines Limited (Giant Copper (Canada) mine)
38. Afton Mines Ltd.,
    Bethlehem Copper Corporation Ltd. (J-A, Maggie, Lake and Iona zones)
    Highmont Mining Corp. Ltd.
    Leemac Mines Ltd.
    Valley Copper Mines Limited
47. Citex Mines Ltd.
48. Falconbridge Nickel Mines Limited
49. Davis-Keays Mining Co. Ltd.
51. Liard Copper Mines Ltd.
    Stikine Copper Limited
54. Silver Standard Mines Limited and Asarco Exploration Company of Canada Limited
    United Keno Hill Mines Limited – Falconbridge Nickel Mines Limited – Canadian Superior Exploration Limited

Smelters

5. Gaspé Copper Mines, Limited
17. Noranda Mines Limited
19. Falconbridge Nickel Mines Limited
    The International Nickel Company of Canada, Limited
32. Hudson Bay Mining and Smelting Co., Limited

Refineries

9. Canadian Copper Refiners Limited
19. The International Nickel Company of Canada, Limited

Table 4. Prospective[1] copper producers

Company and Location	Mill Capacity[2] and Ore Grade	Year Production Expected	Destination of Copper Concentrates	Remarks
New Brunswick	(%)			
Heath Steele Mines Limited,	–	1976	Murdochville	Present mill capacity to be
Little River mine	Cu(. .)			increased from 3,000 to
Newcastle	Zn(. .)			4,000 tpd.
Quebec				
Falconbridge Copper Limited,	–	1974	Noranda	Production at 300 tpd to be
Opemiska Division	Cu(1.46)			trucked to Opemiska mill.
Cooke mine	Au(0.30 oz)			
Chapais				
Orchan Mines Limited,	–			
Norita mine	Cu(0.70)	1976	Noranda	900 tpd to be trucked to
Matagami	Zn(7.60)			Orchan mill.
Radiore No. 2	Cu(2.1)	1974	Noranda	Ore to be trucked to
Matagami	Zn(1.0)			company's Orchan mill.
Campbell Chibougamau	–			
Mines Ltd.,	Cu(1.5)	1974	Noranda	200 tpd to be trucked to
Grandroy division				the Main mill.
Patino Mines (Québec) Limited,	–	1976	Noranda	Shaft sinking planned for 1974.
Lemoine M.L.	Cu(4.5)			
	Zn(10.8)			
Jaculet	. .	1974	Noranda	Production to resume.
Chibougamau				
Ontario				
Ecstall Mining Limited,	–	1974	Noranda	Expanding annual production
Timmins	Cu,Pb,Zn			from 3.6 to 4.0 million tons of
				ore and later to 5 million tons.
Falconbridge Nickel Mines	–			
Limited,	Cu(. .)			
Lockerby mine	Ni(. .)	. .	Falconbridge	Development in progress. Ore
Falconbridge				to be milled at Strathcona mill.
Thayer Lindsley mine		. .	Falconbridge	
Falconbridge				
The International Nickel Company	–			
of Canada, Limited,	Cu(. .)			
Crean Hill mine	Ni(. .)	1974	Copper Cliff	Will resume production at 4,000 tpd.
Levack West mine		1974	Copper Cliff	Production scheduled at 4,000 tpd.
Murray mine		. .	Copper Cliff	On standby.
Totten mine		. .	Copper Cliff	On standby.
Kanichee Mining Incorporated,	500	1974	Falconbridge	Production scheduled for
Temagami	Cu(0.75)			January 1974.
	Ni(0.42)			

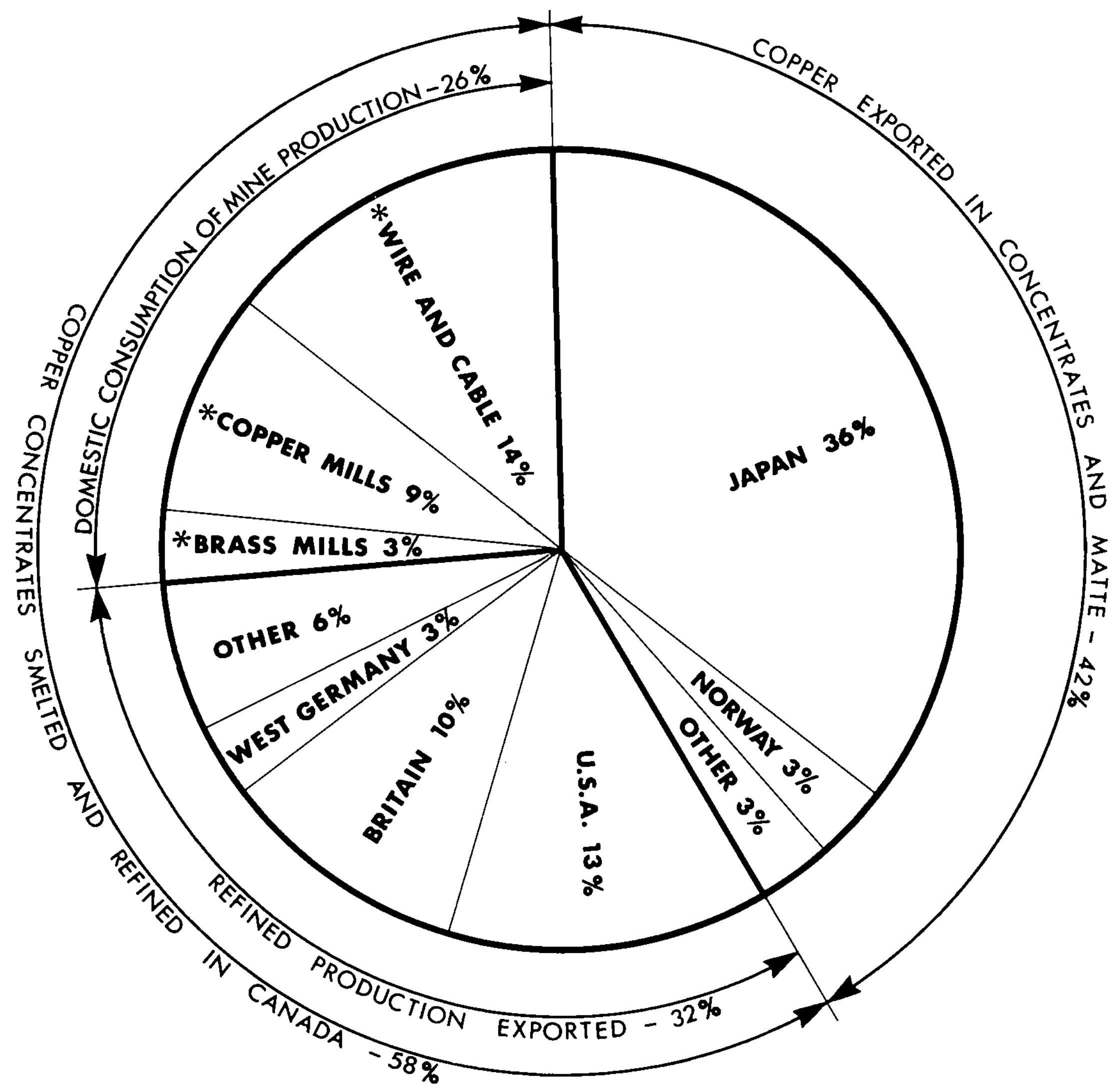
Table 4. (concl'd)

Company and Location	Mill Capacity[2] and Ore Grade	Year Production Expected	Destination of Copper Concentrates	Remarks
Ontario (concl'd)	(%)			
Sturgeon Lake Mines Limited, Sturgeon Lake	1,200 Cu(2.98) Pb(1.47) Zn(10.64)	1974	. .	Pit area cleared and access road completed.
Manitoba				
Hudson Bay Mining and Smelting Co., Limited, Centennial mine Flin Flon	– Cu(2.06) Zn(2.60)	1975	Flin Flon	Decline to 470 ft. and an internal shaft to deeper levels.
Westarm mine Schist Lake	Cu(4.63)	. .	Flin Flon	Development to be started in 1974.
The International Nickel Company of Canada, Limited, Soab mine Thompson	– Cu(. .) Ni(. .)	. .	Copper Cliff	On standby.
British Columbia				
Consolidated Churchill Copper Corporation Ltd., Churchill mine Fort Nelson	750 Cu(3.4)	1974	Japan	Plan to resume mining in January 1974 after having been closed since 1971.
Cuisson Lake Mines Ltd., Cariboo district	– Cu(0.386)	1975	. .	Gibraltar Mines Ltd. to mine and mill orebody.

[1]Only mines with announced production plans; [2]Mill capacity in tpd of ore.
– Nil; . . Not available.

DISPOSITION OF CANADIAN MINE PRODUCTION OF COPPER, 1973

MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES



*** Based on 1972 consumption**

Table 5. Copper exploration projects

Company and Location	Indicated Ore Tonnage	Grade of Ore	Remarks
	(tons)	(%)	
Quebec			
Copperfields Mining Corporation Limited and Iso Mines Limited, Magusi River property Noranda	4,100,000	Cu (1.2) Zn (3.6)	Partly amenable to open-pit mining.
New Insco Mines Ltd. and others Hebecourt property Noranda	1,164,446	Cu (2.4)	Leased to Noranda Mines Limited.
New Quebec Raglan Mines Limited, Wakeham Bay	16,050,000	Cu (0.71) Ni (2.58)	
Phelps Dodge Corporation of Canada, Limited, Gasset Lake property Matagami	1,500,000	Cu (1) Zn (4)	Exploration continuing.
Selco Mining Corporation Limited, and Muscocho Explorations Limited, Frotet Lake	1,200,000	Cu (1.8) Zn (3.7)	Feasibility study and drilling in progress.
Ontario			
Falconbridge Nickel Mines, Limited Falconbridge			
Fraser mine	..	Cu(. .)	Development work deferred at both mines.
Onex mine	..	Ni(. .)	
Great Lakes Nickel Limited, Pardee Township	32,800,000	Cu (0.36) Ni (0.20)	Tentative plans to mine 1.8 million tons of ore a year.
The International Nickel Company of Canada, Limited, Sudbury			
Cryderman mine	..	Cu (. .)	
Whistle mine	..	Ni (. .)	
Maybrun Mines Limited, Kenora	1,500,000	Cu (1.5)	Reserves available for underground mining.
Union Minière Explorations and Mining Corporation Limited, Thierry deposit Pickle Crow	10,000,000	Cu (1.60) Ni (0.29)	Production-size shaft being completed to 2,000 feet.

(continued on next page)

Table 5. (cont'd)

Company and Location	Indicated Ore Tonnage	Grade of Ore	Remarks
	(tons)	(%)	
Manitoba			
Freeport Canadian Exploration Company and Beth-Canada Mining Company, Snow Lake Reed Lake property	1,000,000	Cu (2) Zn (4)	Drilling in progress.
Hudson Bay Mining and Smelting Co., Limited Flin Flon and Snow Lake			
Hudvam mine	400,000	Cu (1.50) Zn (1.70)	
Rail Lake mine	325,000	Cu (3.00)	
Reed Lake mine	1,142,000	Cu (2.18)	
Wim mine	1,090,000	Cu (2.91)	
Stall Lake Mines Limited, Snow Lake	672,000	Cu (5.38) Zn (2.28)	
British Columbia			
Adonis Mines Ltd.	41,000,000	Cu (0.48)	Drilling in progress.
Summers Creek	6,400,000	Cu (0.47)	
Princeton	16,000,000	Cu (0.56)	
Afton Mines Ltd., Kamloops	30,000,000	Cu (1.06)	Feasibility study.
Bethlehem Copper Corporation, Ltd. Highland Valley			
J-A zone	286,000,000	Cu (0.43)	
Maggie zone	200,000,000	Cu (0.40) equiv.)	
Lake zone	190,000,000	Cu (0.48)	
Iona zone	20,000,000	Cu (0.40)	Exploration and development.
Citex Mines Ltd., Stewart Red Cliff property	. .	. .	Tentative plant to mine at 200 tpd.
Davis-Keays Mining Co. Ltd., Fort Nelson	1,375,000	Cu (3.38)	Proposed to mine at 500 tpd.
Falconbridge Nickel Mines Limited, Sustut Peak	. .	Cu (1.25)	Amenable to open-pit mining.
Giant Mascot Mines Limited, Hope Giant Copper (Canam) mine	2,600,000	Cu (1.28)	
Highmont Mining Corp. Ltd., Highland Valley	145,000,000	Cu (0.27) MoS_2 (0.45)	Previous proposal to mine at 25,000 tpd.

Table 5. (concl'd)

Company Location	Indicated Ore Tonnage	Grade of Ore	Remarks
British Columbia (concl'd)	(tons)	(%)	
Leemac Mines Ltd., Highland Valley Trojan property	..	Cu (1.56)	Plan to mine by open pit at 500-1,000 tpd.
Liard Copper Mines Ltd., Schaft Creek	294,000,000	Cu (0.40) MoS_2 (0.036)	
Stikine Copper Limited, Stikine River area	59,000,000 79,000,000	Cu (1.20) Cu (1.00)	Surface drilling.
Valley Copper Mines Limited, Highland Valley	600,000 per vertical feet	Cu (0.48)	
Yukon Territory			
Silver Standard Mines Limited and Asarco Exploration Company of Canada, Limited, Carmacks Minto property	3,586,000	Cu (2.12)	Surface drilling.
United Keno Hill Mines Limited, Falconbridge Nickel Mines Limited and Canadian Superior Exploration Limited, Carmacks DEF property	..	Cu (. .)	Surface drilling.

. . Not available.

Information pertaining to individual mines can be obtained from accompanying tables. Table 3 lists all mines that produced copper in 1973, production statistics, and a brief description of events. The statistics used have largely been obtained directly from each company. Table 4 lists the mines for which production plans have been announced. Table 5 lists those properties that have undergone exploration and appear to have potential as new producers in the near future.

Smelters and refineries. A summary of five Canadian smelters that treat copper-bearing materials is given in Table 6. Inco's Coniston smelter, which suspended operations in 1972, is no longer included in the table because there are no indications of resuming production at this smelter.

The operations of the two Canadian copper refineries are summarized in Table 7.

At Murdochville, the Gaspé Copper Mines, Limited smelter expansion, which will increase capacity from 70,000 to 100,000 tons of anode copper annually, encountered construction delays and start-up problems with new facilities. A protracted shutdown was necessary to tie in the new smelting equipment. All smelter construction was completed by the end of 1973 and the new installations are expected to be operational in 1974. An acid-leach plant that will treat 5,000 tons of oxide ore daily is scheduled for completion in May 1974. Copper anode production at Murdochville in 1973 declined by 23 per cent from 1972 output and 33 per cent from 1971 output to 48,860 tons.

Noranda Mines Limited placed its Continuous Smelting Process reactor into operation at the Noranda smelter in 1973, thereby increasing annual capacity in the plant by 55,000 tons of blister copper. Tests have shown that capacity in the reactor can be doubled through the use of oxygen, which can result in a 90 per cent reduction in fuel consumption. To this end, plans are under way to install an oxygen plant and slag milling facilities. A 450,000-ton-a-year sulphuric acid plant will be installed to treat reactor gases.

Noranda's Canadian Copper Refiners Limited (C.C.R.) at Montreal East increased its capacity by 60,000 tons of refined copper to 480,000 tons, making C.C.R. the world's largest copper refinery. The company added new firing systems on the oil-fired anode furnaces in 1973 and plans to evaluate oxygen

(text continued on page 171)

Table 6. Canadian copper and copper-nickel smelters, 1973

Company and Location	Product	Rated Annual Capacity	Remarks	Ore and Concentrate Treated	Blister or Anode Copper Produced
		(tons)		(tons)	(tons)
Falconbridge Nickel Mines Limited Falconbridge, Ont.	Copper-nickel matte	650,000[1]	Copper-nickel ore and sintered concentrate smelted in blast furnaces; converted to produce matte for shipment to company's electrolytic refinery in Norway.	. .	. .
Gaspe Copper Mines, Limited Murdochville, Que.	Copper anodes	370,000[1]	One reverberatory furnace for green-charge concentrates, 2 Pierce-Smith converters, 1 anode furnace, 1 walker casting wheel. Also smelts custom concentrates.	276,700 (of which 99,800 were custom concentrates)	48,860
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Manitoba	Blister-copper cakes	575,000[1]	Roasting furnaces, 1 reverberatory furnace, 3 converters. Treats own and custom copper concentrates along with zinc plant residues in conjunction with slag-fuming furnaces.	399,269 (of which 82,923 were custom and purchased concentrates)	59,908
The International Nickel Company of Canada, Limited Copper Cliff, Ont.	Blister copper, nickel sulphide and nickel sinter for company's refineries; nickel oxide sinter for market. Soluble nickel oxide for market.	4,000,000[1]	Oxygen flash-smelting of copper sulphide concentrate; converters for production of blister copper. Roasters, reverberatory furnaces for smelting of copper-nickel ore and concentrate; converters for production of copper-nickel Bessemer matte. Production of matte followed by matte treatment, flotation, separation of copper and nickel-sulphides then by sintering to make sintered-nickel products for refining and marketing. Electric-furnace melting of copper sulphide and conversion of blister copper. Also custom smelting.	. .	. .

Table 6. (cont'd)

Company and Location	Product	Rated Annual Capacity	Remarks	Ore and Concentrate Treated	Blister or Anode Copper Produced
		(tons)		(tons)	(tons)
Noranda Mines Limited Noranda, Que.	Copper anodes	1,700,000[2]	Roasting furnaces; 2 hot-charge and 1 green-charge reverberatory furnaces; 5 converters; 1 continuous reactor. Also smelts custom material.	1,550,000 (of which 825,000 were custom concentrates)	260,000

Source: Company Reports
. .Not available. [1] Ores and concentrates. [2] Ores, concentrates and scrap.

Table 7. Copper refineries in Canada, 1973

Company and Location	Rated Annual Capacity	Output	Remarks
	(tons)	(tons)	
Canadian Copper Refiners Limited Montreal East, Que.	480,000	383,000	Refines anodes from Noranda and Gaspé smelters, blister copper from Flin Flon smelter, and purchased scrap. Copper sulphate recovered by vacuum evaporation. Precious metals, selenium and tellurium recovered from anode slimes. Produces C.C.R. brand electrolytic copper wire bars, ingot bars, ingots, cathodes, cakes and billets.
The International Nickel Company of Canada, Limited Copper Refining Division, Copper Cliff, Ont.	212,000	163,560	Refines blister copper from Copper Cliff smelter. Precious metals, selenium and tellurium are recovered from anode slimes. Recovers and electrowins copper from Copper Cliff nickel refinery residue. Produces ORC brand electrolytic copper, cathodes, wirebars, cakes, billets, ingots and ingot bars.

Source: Company reports.

– as a means of shortening the process cycle in these furnaces. Orders have been placed for semi-continuous cast equipment for cakes and billets.

Falconbridge Nickel Mines Limited announced the beginning of a six-year renovation and pollution control program at the Falconbridge smelter. This project involves conversion to fluid bed roasting and electric smelting. A sulphuric acid plant will be included in the new installations.

Hudson Bay Mining and Smelting Co., Limited completed the outer concrete shell of a new 825-foot smokestack at its smelter at Flin Flon. The smokestack should be operational by late 1974. New anode casting facilities, to further process blister copper on site, and the first of two reverberatory boilers are to be completed in 1974.

At Sudbury, Inco's 1,250-foot smokestack had its first full year of operation and the new Copper Cliff nickel refinery, which includes a copper electrowinning circuit, was officially opened. During 1973, Inco installed facilities for semi-continuous casting of large copper billets and cakes at the Copper Cliff electrolytic copper refinery.

Sherritt Gordon Mines, Limited and Cominco Ltd. announced plans to build a pilot plant, based on a pollution-free hydrometallurgical process to recover copper at Fort Saskatchewan, Alberta. Completion is scheduled for late 1974.

Four companies sell refined copper in Canada. They are Noranda Mines Limited, The International Nickel Company of Canada, Limited (Inco), Texasgulf Inc., and Hudson Bay Mining and Smelting Co., Limited. Noranda sells copper that it produces from concentrates obtained from its own and affiliated companies, from concentrates treated on a custom basis, from purchased concentrates and from scrap. Inco sells copper produced from its nickel-copper mines at Sudbury and Shebandowan, Ontario, and Thompson, Manitoba. Texasgulf produces copper concentrates at its Ecstall mine at Timmins, Ontario; these are smelted and refined by Noranda on a toll basis. Hudson Bay Mining sells copper produced from concentrates, obtained from its own mines in the Flin Flon, Manitoba region, and from custom and purchased concentrates. Noranda also toll refines blister copper from the Hudson Bay smelter at Flin Flon, Manitoba.

Table 8. Canada, consumption of primary copper in manufacture of semifabricated products, 1971-73

	1971	1972	1973
	(short tons)		
Copper mill products – sheet, strip, bars, rods, pipe, tubes, etc.	61,131	60,183	. .
Brass mill products – plate, sheet, strip, rods, bars, rolls, pipe, tubes, etc.	19,951	23,621	. .
Wire and rod mill products	99,682	107,540	. .
Miscellaneous	1,636	2,131	. .
Total	182,400	193,475	. .

Source: Statistics Canada.
. . Not available.

Consumption. Eight fabricating and semifabricating companies use 90 to 95 per cent of the refined copper sold in Canada. Four of these companies are rod rollers that make wire rod for their own and other wire drawing operations. The other four companies own copper and brass mills that make sheet, strip, bars, pipe, tubes, etc.

Of the copper reported to have been consumed by the fabricating and semifabricating companies, about half is used for wire and cable, a third for copper mill products, and a sixth for brass mill products. Less than 1 per cent is used for miscellaneous items that include chemicals.

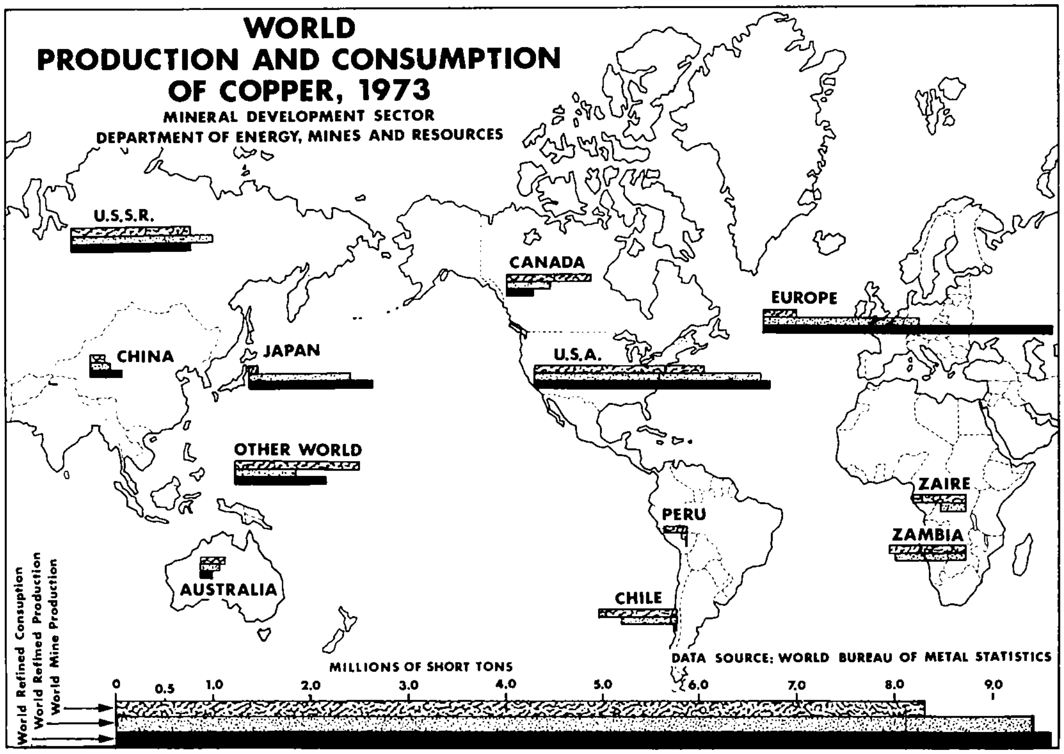
Canadian consumption of copper in 1973 was considerably higher compared to previous years, largely because of the increased demand for copper products in 1973 on both the domestic and foreign markets.

World supply and demand

Mines. World mine production of copper for 1972 and 1973 is shown in Table 9.

Production from all countries, except Japan and Zambia, rose during 1973; the most impressive gains, in absolute terms, were made in Canada, the United States, Papua New Guinea, Zaire and Australia. In terms of annual growth over the previous year, the leading producer nations were Papua New Guinea, Australia, Yugoslavia, Canada and Zaire. Preliminary statistics indicate that Canadian production was well ahead of Chile and Zambia, and placed Canada in third place among world producers for the second consecutive year. Japan's mine production has been declining because of dwindling economical reserves. Political conflict between Zambia and Rhodesia led to the closing of the border which joins these two countries. Hence, Zambian copper producers ceased shipments through Rhodesia and, with less dependable alternative routes, delays arose in moving materials to the copper operations and delivering copper to markets.

Production in Chile has been constrained by a shortage of skilled technicians and replacement equip-



ment since the major copper mines were nationalized in 1971. Additional production set-backs in early 1973 were caused by strikes at the El Teniente and Chuquicamata mines. On September 11, the military took control of the Chilean government and soon afterwards reorganized CODELCO, the state run copper corporation. A marked improvement in copper production was reported after the military coup.

In Peru, mine strikes during September reduced output from several copper producing mines but the principal producer, Southern Peru Copper Corporation, reported its output was maintained. At the end of 1973, Peru nationalized Cerro de Pasco Corporation, a subsidiary of U.S.-owned Cerro Corporation. Cerro de Pasco accounts for some 25 per cent of mine, 45 per cent of smelter and 100 per cent of refinery production of copper in Peru.

United States mine production increased by 62,200 tons, a 3.7 per cent growth over 1972 output. Mine production was held in check to a large extent because of mechanical breakdowns in concentrators, smelters and refineries, production interruptions while pollution abatement equipment was being installed, and a shortage of railroad cars. As noted previously, a U.S. federal stockpile of 251,600 tons of copper is to be released in 1974.

Table 10 attempts to break the world copper industry into segments to show the relative importance of the various trading areas. The United States is a small net importer of copper; the U.S.S.R. is an exporter, but the communist bloc as a whole is in balance, mainly because China is a large net importer. Japan and Europe are large importing areas that are supplied by exports from the four CIPEC nations (Intergovernmental Council of Copper Exporting Countries, which are Chile, Peru, Zaire, and Zambia), Canada and the increasingly important group listed as other noncommunist countries. This last group had mine production of 1,238,100 tons of contained copper in 1972 versus 842,300 tons in 1971.

Within the group of other noncommunist countries, a subgroup is emerging. This subgroup is made up of nonaligned developing countries scattered around the globe that have substantial mine production of copper or a large potential production. Some of these countries are the Philippine Republic, Papua New Guinea, Indonesia, Iran, Panama, Argentina, and Brazil. These countries will become increasingly important sources of copper over the medium to long term as European and Japanese consumers search for further diversification of supply, an assured quantity of concentrates, and outlets for investment capital.

Table 9. World mine production of copper, 1972-73

	1972	1973
	(000 short tons)	
United States	1,664.8	1,727.0
U.S.S.R.	1,157.4^e	1,190.5^e
Canada	793.3	899.5
Chile	790.1	810.7
Zambia	791.1	778.9
Zaire	482.0	540.1
Philippines	235.6	242.8
Peru	239.2	242.5
Australia	199.0	237.4
Papua New Guinea	136.7	198.4
Republic of South Africa	178.5	193.8
Poland	165.4	185.2
Yugoslavia	136.6	162.8
People's Republic of China	148.8^e	152.1^e
Japan	123.6	100.6
Mexico	86.7	88.0
Other communist countries	89.3^e	98.1^e
Other noncommunist countries	364.3	452.3
Total	7,782.4	8,300.7

Source: World Metal Statistics, June 1974 and Statistics Canada.
^{e}Estimated.

Table 10. World copper production and consumption, 1973

	Mine Production	Refined Production	Refined Consumption
	(000 short tons)		
United States	1,727.0	2,277.0	2,398.0
U.S.S.R.	1,190.5^e	1,388.9^e	1,230.2^e
Japan	100.6	1,048.1	1,286.3
CIPEC	2,372.2	1,450.9	44.3
Europe	337.4	1,523.6	2,921.8
Canada	899.5	548.5	273.6
Other communist countries	435.4^e	539.1^e	687.8^e
Other noncommunist countries	1,238.1	469.3	571.0
Total	8,300.7	9,245.4	9,413.0

Sources: World Metal Statistics, June 1974 and Statistics Canada.
^{e}Estimated.

Smelters and refineries. The world production of refined copper for 1972 and 1973 is shown in Table 11.

Major expansions in smelter capacity are being undertaken in Chile, Mexico, Philippine Republic, Poland, South Korea, United States and Zambia. Japan has essentially completed its expansion and modernization program, and these facilities are now in operation. Major refinery expansions are under way in Chile, Mexico, Peru, Poland, South Africa, United States and Zambia. It is interesting to note that most of the new facilities are being installed in producer countries whereas previously new smelters and especially refineries were being built in consumer countries.

Table 11. World production of refined copper, 1972-73

	1972	1973
	(000 short tons)	
United States	2,258.5	2,277.0
U.S.S.R.	1,350.3^e	1,388.9^e
Japan	892.9	1,048.1
Zambia	678.1	703.8
Canada	546.6	548.5
Chile	508.6	457.2
West Germany	439.3	448.2
Belgium	346.4	369.3
Zaire	238.3	246.9
People's Republic of China	192.9^e	205.0^e
Britain	199.2	203.2
Australia	191.6	189.2
Poland	170.9	178.6
Yugoslavia	143.3	151.6
Spain	98.0	135.5
Republic of South Africa	87.4	99.2
Mexico	70.5	68.2
Sweden	56.9	65.6
Other communist countries	144.2^e	155.4^e
Other noncommunist countries	291.7	306.0
Total	8,905.6	9,245.4

Source: World Metal Statistics, June 1974.
^{e}Estimated.

Research into better methods of reducing copper sulphide ores and concentrates to metal is continuing on two fronts – hydrometallurgy and continuous smelting. Most hydrometallurgical research programs are still at the laboratory or pilot plant stage and large-scale commercial adaptation of any design is a few years away. The Anaconda Company plans to have a small commercial-size hydrometallurgical plant, using its "Arbiter Process", in operation during 1974. Continuous smelting, however, is farther along. Noranda Mines has placed its continuous smelting reactor into operation at Noranda, Quebec and has entered an agreement with South Korea to install a reactor in that country. In addition, Mitsubishi Metal Corporation interests are operating a pilot plant of their own design at the Onahama smelter in Japan; and the Conzinc-Rio Tinto Group has completed pilot plant testing of the Worcra process in Australia. Continuous smelting, which tends to be amenable to better pollution control and apparently has low construction and operating costs, is favoured as the medium term solution to conventional smelting problems.

Consumption. The consumption of refined copper in the world for 1972 and 1973 is shown in Table 12.

In reflection of the rapid economic expansion that was prevalent during 1972 and 1973, copper consumption expanded sharply and showed an 8 per cent increase in 1973 over the previous year. All countries showed substantial gains in consumption and some of the major consuming nations had remarkable gains over the previous year. Japan, Canada, West Germany, and the United States had increases of 22.3, 10.9, 8.3, and 7.2 per cent respectively. Several European countries, particularly Britain, experienced declines in copper consumption towards the end of 1973 as fuel conservation measures made their impact on industrial activity.

Table 12. World consumption of refined copper, 1972-73

	1972	1973
	(000 short tons)	
United States	2,236.1	2,398.0
Japan	1,051.7	1,286.3
U.S.S.R.	1,190.5[e]	1,230.2[e]
West Germany	741.0	802.2
Britain	578.4	601.4
France	430.1	449.5
Italy	311.9	325.4
People's Republic of China	281.1[e]	284.4[e]
Canada	246.7	273.6
Belgium	168.7	181.2
Spain	133.6	149.6
Brazil	121.9	138.1
Australia	112.6	127.8
Sweden	106.8	125.7
East Germany	99.2[e]	99.2[e]
Yugoslavia	69.8	86.1
Other communist countries	286.6[e]	304.2[e]
Other noncommunist countries	550.0	550.1
Total	8,716.7	9,413.0

Source: World Metal Statistics, June 1974.
[e]Estimated.

Uses

Copper's properties of malleability, ductility, conductivity, corrosion resistance, alloying qualities and pleasing appearance make its use universal in the electrical, construction, plumbing and automotive industries. Approximately half of all copper consumed is for electrical applications, including power transmission, electronics and electrical equipment, and transportation. Generation and utilization of electrical energy requires very large quantities of copper for heat exchangers, bus bars, magnet wire, and windings in motors, generators and transformers.

The noncorrosive qualities of copper and its alloys account for many uses in construction, for plumbing goods, builders' hardware, and roofing products. Copper alloys are used in bearings, fastenings and fittings for marine hardware. In the automotive industry, copper is used in radiators, wires, bearings, bushings, switches and oil lines.

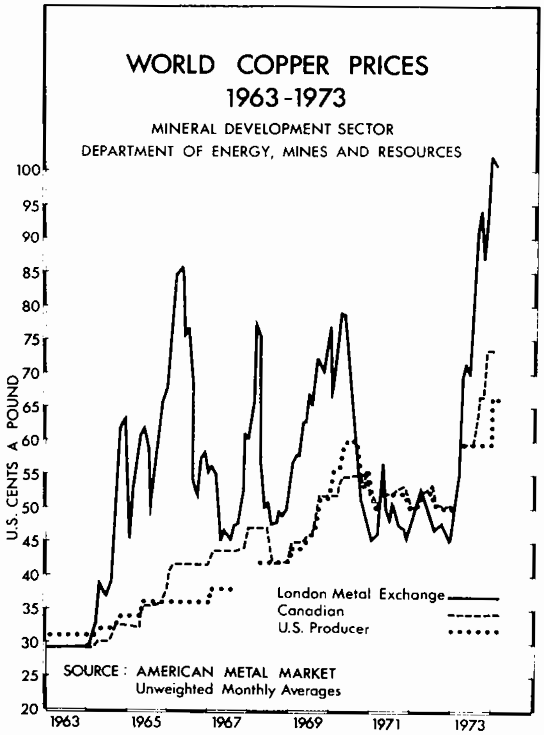
The principal copper and brass fabricators in Canada are: in British Columbia – Norco Industries Ltd. (formerly Noranda Metal Industries Ltd.), Vancouver; in Ontario – Anaconda Canada Limited, Toronto; Phillips Cables Limited, Brockville; Ratcliffs (Canada) Limited, Richmond Hill; Wolverine Tube Division of UOP Company Limited (formerly Calumet & Hecla (Canadian) Limited), London; in Quebec – The Noranda Copper Mills Limited, Montreal East; Pirelli Cables Limited, St-Jean; Northern Electric Company, Limited, Montreal; and Canada Wire and Cable Company, Limited, Montreal East.

Prices

The price of cash (spot) copper wirebar on the LME reached record levels in 1973. At the beginning of the year, the price per pound was quoted, in equivalent U.S. currency, at 47.59 cents and steadily rose to the 70 cent level where it remained until June. From June until the close of 1973, the price moved upwards and after hitting a high of $1.20 on December 5, ended the year at 91.55 cents.

The Canadian producer price for copper wirebar, which applied to North American markets, was quoted at Canadian 50.50 cents at the beginning of January and increased to 53.00 cents on January 10. The price was raised to 56.00 cents on February 16, 60.00 cents on March 1, 67.00 cents on July 26 and 74.00 cents on October 2. Canadian producers sell copper in markets outside of North America on the basis of LME cash price.

The U.S. producer price was U.S. 50.50-50.75 cents until January 10, when it was increased to 53.00-53.25 cents. On February 15, U.S. producers raised the price to 56.00-56.25 cents, on March 1 to 56.25-60.00 cents and on March 6, to 60.00-60.25 cents. Under United States Phase IV price controls, producer copper cathode was frozen at 60.00 cents until December 7 when the Cost of Living Council recommended a price rise to 68 cents. Producer prices for copper wirebar were immediately adjusted upward and remained at 68.15-69.25 cents to the end of the year.



Outlook

Copper consumption should attain a close balance with production during the first half of 1974. A substantial downward adjustment in economic growth rates has been forecast for most industrial nations in response to the energy shortage, and monetary and fiscal restraints which are being considered to control inflation and balance of payments problems. The energy situation coupled with the above policy measures will certainly affect copper consumption more than production. Accordingly, prices are expected to adjust downward.

Canadian 1974 mine production is forecast at 925,000 tons of recoverable copper and refinery output should increase to 610,000 tons. World mine production is expected to rise to 8.6 million tons and refined output to 9.3 million tons in 1974. This forecast does not take into account a prolonged work stoppage in the United States where labour contracts for the copper industry expire at the end of June. A lengthy strike in the U.S. industry could create copper shortages towards the end of 1974.

Exploration activity during 1974 should intensify, in response to the current high prices for metals. A renewed surge of announcements concerning mineral discoveries and mine developments is expected during the year.

Table 13 is a forecast of Canadian and world copper production, and world consumption of primary refined copper to 1980. This forecast reflects the belief that copper consumption will decline in 1974 and 1975, with little evidence of recovery until the second half of 1976. As a result of depressed consumption, several producers can be expected to reduce or cease operating until consumption (and hence prices) recover.

Table 13. Forecast of Canadian and world copper production and world primary refined copper consumption

	1974	1975	1976	1977	1978	1979	1980
				(000 short tons)			
Mine production							
Canada	925	870	850	925	1,180	1,250	1,400
World	8,600	8,200	8,100	8,250	9,350	10,500	11,000
Primary smelter production							
Canada	595	540	530	600	770	815	840
World	8,800	8,500	8,400	8,600	9,800	11,000	11,400
Primary refinery production							
Canada	610	555	540	630	700	770	775
World	9,300	9,000	9,200	9,500	10,700	11,700	12,100
World consumption of primary refined copper	9,000	8,700	9,100	9,900	10,800	11,700	12,200

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(%)	
32900-1	Copper in ores and concentrates	free	free	free
34800-1	Copper in pigs, blocks, or ingots, cathodes, plates, copper matte, and blister and copper scrap, per lb	free	free	1½¢
				(%)
33503-1	Copper oxides	free	15	25
34820-1	Copper in bars or in rods, for manufacture of trolley, telegraph, telephone wires, electric wires and cables	free	5	10
34835-1	Electrolytic copper powder (expires Feb. 28, 1975)	free	free	10
34845-1	Electrolytic copper wirebars, per lb (expires Feb. 28, 1974)	free	free	1½¢
35800-1	Anodes of copper	free	free	10%

United States

Item No.		On and After January 1 1970	1971	1972
			(¢ per lb)	
602.30	Copper ores and concentrates, on Cu content	1.1	1	0.8
612.06	Unwrought copper, on Cu content	1.1	1	0.8
612.10	Copper waste and scrap, on 99.6% of Cu content	1.1	1	0.8

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), T.C. Publication 452.

Fluorspar

G. H. K. PEARSE

Fluorspar, or fluorite in mineralogical nomenclature, is calcium fluoride (CaF_2), an industrial mineral with a broad spectrum of uses. The most important uses are: for the manufacture of hydrofluoric acid and other fluorine chemicals; as a fluxing agent in various metallurgical processes, the most important being steel manufacture; for the manufacture of artificial cryolite, an essential cell ingredient in the electrolytic reduction of alumina to aluminum; in the refining of uranium ores; and in the glass and ceramic industries.

In the past decade world fluorspar consumption has grown rapidly because of increasing demands in the steel, aluminum and chemical industries. In 1973, world consumption reached an estimated 5.5 million short tons* and, based on forecast demands by the major consuming industries, consumption is expected to reach 9 million tons by 1980. Contributing to this increase will be a greater use of the basic oxygen process in steelmaking, which requires about three times as much fluorspar as a slag thinner than the more traditional basic open-hearth process. Ever-widening usage of fluorocarbons and other fluorine chemicals will continue to stimulate world demand for acid-grade material.

Production in Canada

Fluorspar is the principal source of the element fluorine. It occurs in many geological environments from low-temperature fracture fillings to high-temperature emplacements and, as a result, it is not restricted to any particular geological province in Canada. In fact, fluorspar is known to occur in all physiographic provinces with the exception of the interior plains. However, all fluorspar produced in Canada is currently mined from the Burin Peninsula in Newfoundland by one company.

Newfoundland Fluorspar Works of Aluminum Company of Canada, Limited (Alcan), produces fluorspar from three mines, the Director, the Tarefare, and the Blue Beach located near the village of St. Lawrence in Newfoundland. The Director mine has been in operation for 31 years. In August 1968 the Tarefare commenced production at about 25,000 tons a year of fluorspar concentrate. Production from the Blue Beach began in 1972 and the mill capacity was increased to 1,200 tons of ore a day. Concentrates from these operations are shipped to Alcan's aluminum smelter at Arvida, Quebec, where they are upgraded by flotation and converted to aluminum fluoride for the reduction of alumina to aluminum. Small tonnages are sold to Newfoundland Steel (1968) Company Limited for steel slagging. Shaft sinking operations have started on extensive new reserves recently outlined, about one mile northwest of St. Lawrence. In 1973, shipments totalled an estimated 150,000 tons, valued at $5.5 million, down 6 per cent from the previous year as a result of a month-long strike in the spring.

Allied Chemical Canada, Ltd. imports acid-grade fluorspar for the production of hydrofluoric acid at the company's plant located at Valleyfield, Quebec. Some of the acid is utilized in the manufacture of various fluorine chemicals. Allied Chemical operates mines in Mexico and the United States to ensure an uninterrupted supply of fluorspar. The company established a new hydrofluoric acid plant at Amherstburg, Ontario in mid-1971.

Huntingdon Fluorspar Mines Limited with a plant near North Brook, Ontario, imports metallurgical-grade fluorspar to make five-pound briquettes for foundry use.

International Mogul Mines Limited has done considerable geological and mineralogical assessment work on its barite-fluorite deposits east of Lake Ainslie, Cape Breton Island, Nova Scotia. Indicated ore reserves are 2.97 million tons grading 28 per cent barite and 19 per cent fluorite. Pilot plant testing, with the objective of producing an acid-grade concentrate at an acceptable rate of recovery, has yet to prove successful. From 1940 to 1949, approximately 1,400 tons of fluorspar, along with some barite, was recovered from this deposit.

*The short ton of 2,000 pounds is used throughout, unless otherwise indicated.

Table 1. Canada, fluorspar production, trade and consumption

	1972		1973p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
Newfoundland	. .	5,432,151	. .	5,505,000
Imports				
Mexico	51,075	2,777,000	100,908	5,365,000
Britain	10,566	639,000	39,099	1,766,000
United States	2,871	233,000	10,951	700,000
Spain	7,398	498,000	18,595	516,000
Total	71,910	4,147,000	169,553	8,347,000

	1971	1972
	(short tons)	
Consumption[1] (available data)		
Metallurgical flux[2]	34,710	43,985
Glass and glass wool	654	499
Enamels and frits	235	385
Other[3]	161,850	187,259
Total	197,449	232,128

Source: Statistics Canada.
[1]As reported by consumers; breakdown by Mineral Development Sector. [2]Consumption as flux in the production of steel and magnesium, and use in foundries. [3]Includes consumption in the production of aluminum and chemicals and other miscellaneous uses.
pPreliminary; . . Not available for publication.

Prior to The First World War, small tonnages of fluorspar were mined from vein-type deposits in the Madoc district of Ontario. As a strategic material of great importance, it showed a marked increase in production during the war. After the war production decreased substantially, but was stimulated once again during The Second World War by government assistance for exploratory drilling programs and by loans on capital equipment. From 1943 to 1947 some 25,000 tons were mined. Fluorspar was mined continuously in the Madoc area up to 1961 when severe underground flooding, lack of export markets, and increased mining costs made mining uneconomic. Altogether, some 150,000 tons of fluorspar were mined in the Madoc area, production being derived from 24 separate properties. Most significant producing properties were along a prominent linear vein structure, the southern extension of which could still contain economically attractive reserves.

The Rock Candy mine, near Grand Forks, British Columbia was mined intermittently from 1918 to 1942 and is still controlled by Cominco Ltd. Substantial reserves probably remain.

Some fluorine is being recovered as fluosilicic acid from the processing of phosphate rock by Erco Industries Limited (formerly Electric Reduction Company of Canada, Ltd.), at Port Maitland, Ontario, and by Cominco Ltd., at Trail, British Columbia.

Exploration

Strong demand growth during the 1960's, coupled with a somewhat stagnant world reserve growth picture and higher prices, reactivated vigorous exploration for fluorspar over the last few years both in Canada and abroad.

Fluorspar veins on Burin Peninsula are genetically related to two large stocks of alaskite. Most of this favourable area is obscured by shallow overburden, and inumerable showings and float blocks containing fluorspar are known. Combustion Engineering Inc., and Allied Chemical Canada Ltd. have undertaken intensive exploration programs on the Burin Peninsula immediately north of Aluminum Company of Canada, Limited's operations. The Madoc district of southern Ontario, where fluorspar was produced for many years, attracts interest from time to time. Jorex Limited, in a joint venture with Conwest Exploration Company Limited, staked fluorspar occurrences in the Liard River area in northern British Columbia in mid-1971. Diamond drilling indicated significant tonnage of fluorspar amenable to open-pit mining but because of prohibitive transportation costs from this remote area to available markets development has been suspended.

Consolidated Rexspar Minerals & Chemicals Limited has a large uranium bearing, medium-grade fluorspar deposit adjacent to Canadian National Railways' line at Birch Island, about 60 miles north of Kamloops. Although it is fine-grained and difficult to concentrate, higher prices have stimulated renewed interest in this deposit. A program of diamond drilling, geological mapping and metallurgical testing was initiated in 1970 to augment earlier work. Geological work indicates the possibility of multiple ore-bearing structures and an assessment of these is planned. Metallurgical testing carried out by a Japanese company continued during 1973. Denison Mines Limited, which has a 46.9 per cent interest in Rexspar, is conducting these investigations.

Although not located in Canada, a Canadian company, Lost River Mining Corporation Limited, a subsidiary of Pan Central Explorations Limited, is working on an extensive fluorspar-tin-tungsten deposit in Alaska. Some 32.3 million tons of ore grading 15 per cent CaF_2 have been indicated in one ore zone and an additional 6.3 million tons grading 31.0 per cent CaF_2 in another. Drilling on a third ore zone indicates the presence of a new, major high-grade deposit averaging approximately 30 per cent CaF_2 over widths of 30 to 75 feet. A feasibility study was completed during 1973, and a target date for beginning production at a rate of 4,000 tons a day has been set for 1976.

Uses, markets and trade

The most important uses of fluorspar are: as a fluxing material in metallurgical and related industries; in the chemical industry for the manufacture of hydrofluoric acid and other fluorine compounds; in the glass and ceramic industries; in the refining of uranium ores and concentrates; and in the manufacture of artificial cryolite utilized in aluminum refining. Minor quantities of clear, transparent, colourless fluorite are used in optical equipment.

Fluorspar is marketed in three grades according to end use, although in times of shortage, high-grade material may be substituted in applications normally requiring lower-grade materials. These three grades are acid grade containing a minimum of 97 per cent CaF_2, metallugical grade containing 60-80 per cent CaF_2, and ceramic grade containing 88-97 per cent CaF_2.

Acid grade. Over 50 per cent of the world's fluorspar requirements are as acid grade and, as the term implies, are used in the manufacture of hydrofluoric acid. Most of this material is beneficiated by flotation to achieve the high CaF_2 content required. In general, two to three tons of ore must be mined to produce one ton of acid-grade fluorspar concentrate and the production of one ton of hydrofluoric acid required two tons of acid-grade concentrate and almost three tons of sulphuric acid. Hydrofluoric acid is produced according to the reaction $CaF_2 + H_2SO_4 \rightarrow CaSO_4 + 2HF$ and has a variety of uses, but by far the most important, accounting for some 80 per cent, are the aluminum and fluorocarbon industries.

About one third of all hydrofluoric acid produced is used by the aluminum industry. Hydrofluoric acid is reacted with a sodium salt and aluminum fluoride to produce artificial cryolite, an essential cell ingredient for fluxing in the electrolytic reduction of alumina to aluminum. In general, about 45 pounds of cryolite and 40 pounds of aluminum fluoride are required for the production of one ton of primary aluminum. This is equivalent to 130 to 140 pounds of acid-grade fluorspar concentrate. Allowing for increased cell efficiencies and fluorite recoveries from potlines the above figure should be reduced to 120 pounds a ton of primary aluminum. Because fluorite is an essential raw material, many primary aluminum producers operate or participate in the operation of fluorspar mines to ensure uninterrupted and adequate supplies.

Over 40 per cent of hydrofluoric acid is consumed in the manufacture of fluorocarbons. Fluorocarbons, which are used in the manufacture of solvents, resins, plastics, films, refrigerants and aerosol propellants, are produced by reacting hydrofluoric acid with carbon tetrachloride or with chloroform.

Fluorspar is used in uranium refining. Uranium dioxide is reacted with anhydrous hydrofluoric acid to form a green salt (UF_4), which is then reacted with elemental fluorine in the form of fluorine gas to form UF_6. For each ton of uranium processed into uranium hexafluoride, one and two-third tons of fluorspar are required.

Metallurgical grade. About one half of the world's fluorspar output is consumed as a metallurgical fluxing agent, primarily in the manufacture of steel. Metallurgical-grade fluorspar is used in the steel industry to remove impurities during melting and also to improve separation of metal and slag in the furnace by increasing the fluidity of the slag. Consumption of fluorspar in the steel industry has, in recent years, increased substantially because of increased steel output and changing technology. Steelmakers have shifted increasingly from the basic open-hearth process to the basic oxygen process. The latter consumes from 10 to 15 pounds of metallurgical-grade fluorspar compared with three to five pounds in the open-hearth process. The electric furnace process consumes from eight to ten pounds of metallurgical-grade material for each ton of steel produced. The basic oxygen process substantially reduces production costs, doubles capacity per unit dollar of capital cost and reaches heat much faster than the open-hearth process. Within the next decade, older basic open-hearth furnaces should be replaced by more efficient new basic oxygen or electric furnaces. Faced with higher prices and uncertain supply conditions, the steel industry will attempt to find methods of reducing consumption of fluorspar. In addition, some major consumers have become involved in exploration for fluorspar reserves. No satisfactory total substitute for fluorspar as a fluxing agent in steelmaking has been found, although research in this area is considerable and indications are that the growth of metallurgical-grade reserves is not keeping pace with requirements. Consequently, steelmakers may have to switch to higher-grade, higher-cost material, produced as flotation concentrates and converted into pellet or briquette form. World consumption in the steel industry is forecast to increase from a current level of 3.4 million tons to 3.9 million tons in 1975. Metallurgical-grade fluorspar is also used as a flux in foundries and in the reduction of dolomite to magnesium.

Ceramic grade. Ceramic-grade fluorspar is used as an opacifier in enamels and opal glass. It is also used to a limited extent in the manufacture of clear glass as an active flux, a contributor to the gloss and a decolourizer. Much of this grade of fluorspar concentrates could be used for the manufacture of hydrofluoric acid or as pellets and briquettes for steelmaking.

Canadian consumption and trade

Most fluorspar consumed in Canada, and virtually all domestic production, is used in the manufacture of aluminum fluoride for the electrolytic reduction of alumina to aluminum.

Table 2. Canada, fluorspar production, trade and consumption, 1964-73

	Production[1]	Exports	Imports	Consumption
	(short tons)			
1964	96,000	. .	69,986	155,828
1965	112,000	. .	69,848	167,537
1966	79,000	12	75,324	166,275
1967	72,752	. .	94,244	155,349
1968	105,000	. .	115,465	178,901
1969	131,600	. .	104,382	200,827
1970	136,800	. .	94,682	212,949
1971	85,000[e]	. .	225,093	197,449
1972	180,000[e]	. .	71,910	232,128
1973[p]	180,000[e]	. .	169,553	. .

Source: Statistics Canada.
[1]Shipments reported in annual reports of Aluminum Ltd. for 1964-1970. Shipments 1970-1973 are estimates as reported by the U.S. Bureau of Mines.
[p]Preliminary; . . Not available; [e]Estimated.

In 1973, fluorspar imports were 169,553 tons, up sharply from the previous year's 71,910 tons. Imports tend to vary widely from year to year in an inverse relationship to swings in production caused primarily by strikes. However, growth in consuming industries is also an important factor and in 1973, steel output in Canada increased 10 per cent and aluminum ingot production 2.5 per cent. Mexico provided 60 per cent of total imports, the remainder coming from Britain, Spain and the United States.

Prior to 1957, much of Canadian production was exported to the United States and Europe. In 1958, exports declined abruptly owing to the development of alternative low-cost deposits in Mexico by large consumers in the United States.

World review

Rapid growth in fluorspar consumption by the steel, chemical and aluminum industries coupled with a stagnant ore-reserve situation during the 1960's raised fears of a shortage towards the end of the decade. Under the impetus of tightening supply and rising prices, intensive exploration efforts in various parts of the world were successful in substantially augmenting reserves. Expanded and new facilities were brought on stream to meet the expected strong demand. However, coincident with the surge in production came a slackening in demand due to an economic slowdown in the major consuming nations, notably the United States and Japan, and during the latter part of 1971 and the first half of 1972 an over-supply situation, especially of acid grade material, developed in many areas. World production at 5.2 million tons in 1973 was little changed from 1972, and the strong growth in consuming sectors was met by withdrawals from large inventories.

Mexico continued to rank as the world's largest supplier, production rising 4 per cent to 1.20 million short tons in 1973. Fluorspar mining began in Mexico prior to The First World War. However, the industry received its greatest stimulus during The Second World War when the United States government, cut off from European sources, encouraged exploration and development in Mexico. Most production is mined in the State of San Luis Potosi in the Zaragoza area where two major producing mines are located within a mile. The largest, accounting for some 40 per cent of total Mexican metallurgical-grade output is the Las Cuevas mine. This underground operation is an affiliate of Noranda Mines Limited. The rapid growth of fluorspar production in Mexico from 474,000 tons in 1963 to an estimated 1.20 million tons in 1973 has paralleled consumption increases in the United States which relies upon Mexico for most of its import requirements.

In 1971, four companies announced plans for building hydrofluoric acid plants in Mexico totalling over 200,000 tons a year of acid capacity. Of these, two plants, those of Du Pont-Minera Frisco and

Continental Ore Corporation are under construction and slated for production by 1975.

The United States is the world's largest consumer and is heavily reliant on imports to meet demand. In 1973, production was unchanged at 248,000 tons, and imports from Mexico were 892,000 tons. Most output in the United States comes from the Illinois-Kentucky district and is produced by two companies, Ozark-Mahoning Company and Minerva Oil Company. The new mine and mill development of Cerro Corporation near Salem, Kentucky was under construction during the year and is scheduled to be in production in 1974. Other states producing fluorspar are: Montana, Colorado, Idaho, Arizona, New Mexico and Utah. Lost River Mining Corporation Limited continued feasibility studies and exploration of its extensive deposits near Teller, Alaska.

In France, expansion of the industry continues with several new mining and milling developments under way. New deposits are being worked in central France and in the Massif Central and Alpine regions. Estimated production in 1973 was 400,000 short tons.

In 1972, Spain produced an estimated 500,000 short tons. Significant new reserves have been found in the Caravia district in Oviedo Province. Much of Spanish production is exported, mostly to the United States and West Germany.

Production in Britain is estimated to have exceeded 300,000 tons in 1973.

Italy, also a major producer, shipped an estimated 300,000 tons in 1973.

The U.S.S.R. is the world's second largest producer of fluorspar and, with other states in the Soviet bloc, produced about 450,000 tons in 1973. Domestic supply has fallen short of requirements for some years, and imports in 1973 exceeded 200,000 tons. The People's Republic of China and North Korea together produce approximately 300,000 tons a year.

Thailand, one of the fastest developing sources of fluorspar in the world, was the second largest producer in 1971 with an output of 471,015 tons. As a result of cutbacks in orders principally from Japan, production of the last two years has slipped back to 460,000 tons. However, reserves are reportedly 12 million tons of 60 per cent CaF_2 and large deposits indicated in the upper reaches of the River Kwai are currently being explored. Limiting factors on production and market development include primitive mining and beneficiating techniques, and costly and difficult transportation from producing areas to points of export. Loading facilities at Bangkok also present a bottleneck to efficient ocean transport. The Thai government has taken an active interest in the industry and is moving to eliminate these drawbacks.

South Africa's output more than doubled between 1968 and 1971 to 263,000 tons. However, production in 1972 and 1973 dipped to 230,000 tons. South America until recently produced limited quantities of hand-sorted metallurgical grade. Exploration and development is moving along rapidly in both Brazil and Argentina and large increases in output are anticipated within the next few years.

Table 3. World fluorspar production, 1971-73

	1971	1972	1973^e
	(short tons)		
Mexico	1,301,779	1,149,000	1,200,000
Thailand	471,015	435,000	460,000
U.S.S.R.	460,000	470,000	450,000
Spain	440,785	537,000	500,000
France	330,000	410,000	400,000
Italy	320,810	306,000	300,000
People's Republic of China	280,000	280,000	280,000
United States	272,071	251,000	241,000
Britain	269,920	. .	. .
Republic of South Africa	263,497	. .	. .
Canada	85,000	180,000	180,000
Other countries	622,488	1,132,000	1,189,000
Total	5,117,365	5,150,000	5,200,000

Source: U.S. Bureau of Mines.
. . Not available; ^{e}Estimated.

Outlook

The performance of the fluorspar industry necessarily parallels developments in the steel, chemical and aluminum industries, which together account for 95 per cent of fluorspar consumption.

Conversion from the open-hearth process to the basic oxygen process for steelmaking, and vigorous growth in the chemical and aluminum industries during the 1960's accelerated fluorspar consumption. A hiatus in this growth during 1971 and much of 1972 obviated a tight supply situation; and both consumer and producer stocks, particularly of acid grade, grew substantially. Although output was little changed in 1973, inventories were drawn down markedly as a result primarily of a boom in the steel industry.

Exploration efforts resulted in a welcome expansion of world fluorspar reserves to about 320 million tons averaging 30 per cent CaF_2, more than double the known reserves of 1970. Although economic problems in the world, which began to manifest themselves in early 1974, create some uncertainty for growth in the near-term, these reserves are little more than 15 years requirements.

Steel production increased 10 per cent in 1973 and available statistics for 1974 indicate a growth of 2 or 3 per cent. Expected steel output for 1980 is over one billion metric tons. Performance of the fluorine chemical and the aluminum industries in the near-term is predicated on world economic developments. In any case, consumption of fluorspar in the aluminum industry is expected to level off over the medium-term as fluorine emissions from potlines are reduced and greater efficiency in recycling is achieved. Also, recovery of fluorine from phosphate rock processing has begun and is currently being utilized in a small way in synthetic cryolite making.

In January 1973, Aluminum Company of America (Alcoa) announced a new aluminum-making technique which does not use fluorspar. Should this prove viable, this process, which has considerably reduced energy requirements, could begin to replace conventional plants and fluorspar requirements for aluminum making could be reduced to nil within 10 to 15 years.

Prices

United States fluorspar prices, quoted in Engineering and Mining Journal of December 1973

(net ton fob Illinois and Kentucky, CaF_2 content, bulk)

	($)
Ceramic, calcite and silica variable, CaF_2	
88-90%	77
95-96%	76.50-82
97%	87
In 100-lb paper bags, extra	6
Metallurgical, pellets, 70%, effective CaF_2	65.50
Acid, dry basis, 97% CaF_2	
Carloads	78.50-87
Less than carloads	78.50-87
Bags, extra	6
Pellets, 88% effective	76.50
Wet filter cake, 8-10% moisture, sold dry content – subtract approx.	2.50
Dry acid concentrates fob Wilmington, 97% CaF_2 st	97.50
European wet filter cake, 8-10% moisture, sold dry content, duty pd. st cif Wilmington/Philadelphia, term contracts (spot material $5-10 higher)	95-97
Mexican	
Metallurgical 70% fob cars Mexican border	48.50
Tampico, fob vessel	50.00
Acid, 97% + Eagle Pass, bulk	60-62

Tariffs

Item No.		
Canada		
29600-1	Fluorspar	free
United States		($/lt)
522.21	Fluorspar, containing over 97% calcium fluoride	2.10
522.24	Fluorspar, containing not over 97% calcium fluoride	8.40

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Tariff Schedules of the United States, Annotated (1972), T.C. Publication 452.

Gold

J.J. HOGAN

Gold production in Canada in 1973 was estimated at 1,931,000 ounces*, valued at $186,110,000, based on an average gold price of $96.38** compared with 2,078,567 ounces in 1972, valued at $119,742,087, based on an average gold price of $57.61**, a decline of 7.1 per cent in volume. The decrease in output resulted, mainly, from the mining of lower grade gold ore. The sharp rise in the free-market gold price made it economically possible to treat lower grade ore. Gold production in Canada has declined continuously since 1960 when 4,628,911 ounces were produced. The largest gold production for any year was recorded in 1941 when 5,345,179 ounces, valued at $205,789,302, were produced.

Canada has been one of the world's leading producers of gold and, since production was first officially recorded in 1858, has produced 197 million ounces to the end of 1973, valued at $6,622 million. Although most of the provinces and territories have contributed to total output, the largest producers, in decreasing order of output, were Ontario, Quebec, British Columbia, Yukon Territory and the Northwest Territories.

In 1973, the Republic of South Africa was by far the leading world gold producing country followed by the U.S.S.R., Canada and the United States. Other important gold producing countries were Australia, Ghana, the Philippines and Rhodesia. Smaller producers were Japan, Colombia, Mexico, Zaire, North Korea, Brazil, Yugoslavia and Peru.

In its 44th annual report for the fiscal year ending March 31, 1974, the Bank for International Settlements (B.I.S.) reports gold production in the noncommunist world for 1973 at 1,094.0 metric tons (mt), equivalent to 35.17 million ounces, compared with 1,172.9 mt (37.71 million ounces) in 1972, a decline of about 6.7 per cent. In 1973, the Republic of South Africa accounted for 852.3 mt (27.4 million ounces), 77.9 per cent of the noncommunist world total, and Canada accounted for 5.5 per cent. Table 2 shows the U.S. Bureau of Mines world gold production estimates for the years 1971 and 1972, at 46,508,844 and 44,711,074 ounces, respectively. U.S.S.R. production for 1972 was estimated at 6,900,000 ounces. In 1972, the Republic of South Africa accounted for 65.4 per cent of the world total followed by U.S.S.R. with 15.4 per cent and Canada with 4.6 per cent.

In 1973, the Republic of South Africa sold most of its production on the world market to meet balance of payments obligations, adding only an estimated 1.125 million ounces to its gold reserve holdings. The U.S.S.R. marketed gold to pay for wheat and other goods and its total sales were estimated by B.I.S. at 330 mt (10.61 million ounces).

On April 1, 1973, Japan removed restrictions on ownership of gold by private citizens. The initial effect of the lifting of the ban was an increase in the purchase of nonmonetary gold by the Japanese but, when this demand was met, gold purchases levelled off. In 1973 the United States government passed legislation which would allow U.S. citizens to buy, hold and sell gold. The President was given the authority to determine the appropriate time for the legislation to become effective. Also, in December 1973, legislation was passed allowing United States citizens to purchase any gold coins minted prior to 1960, including restrikes of these coins in subsequent years.

Gold produced by Canadian lode gold mines in 1973 was sold on the open market, and the companies, therefore, were not eligible for assistance payments under the provisions of the Emergency Gold Mining Assistance Act. The Act was to expire on June 30, 1973 but, by all-party agreement, it was extended, with no change in conditions, to June 30, 1976 and received royal assent on April 18, 1973. It provided a floor price guarantee of about $52.50 an ounce to those mines eligible for maximum assistance payments should the free-market price of gold fall below this level.

In 1973, the twenty-two operating lode gold mines in Canada produced 1,395,000 ounces compared with 1,598,460 in 1972, a decrease of 12.7 per cent. The sharp rise in the free-market price of gold made it possible for marginal mines to operate during the year. There were no mine closures, and one gold mine came into production. Gold produced from base-metal mining amounted to 531,000 ounces in 1973 compared with 475,653 ounces in 1972, an increase of 11.6 per cent. The porphyry copper mines, which began operations in British Columbia in 1972, reached capacity output in 1973 and were mainly responsible for the increase in byproduct production. Gold from this source accounted for 27.5 per cent of the

* When used in this review, the term "ounce" refers to troy ounce.

**See footnote 3, Table 1.

Table 1. Canada, production of gold, 1972-73

	1972	1973[p]
	(ounces)	
Newfoundland		
Base-metal mines	14,069	12,000
Nova Scotia		
Auriferous quartz-mine	42	–
New Brunswick		
Base-metal mines	3,205	5,000
Quebec		
Auriferous quartz-mines		
Bourlamaque-Louvicourt	160,390	138,000
Malartic	195,756	178,000
Total	356,146	316,000
Base-metal mines	183,523	166,000
Total, Quebec	539,669	482,000
Ontario		
Auriferous quartz-mines		
Larder Lake[1]	229,711	195,000
Porcupine	383,877	356,000
Red Lake and Patricia	321,065	277,000
Thunder Bay	140	–
Total	934,793	828,000
Base-metal mines	84,510	74,000
Total, Ontario	1,019,303	902,000
Manitoba-Saskatchewan		
Base-metal mines	68,559	74,000
Alberta		
Placer operations	3	–
British Columbia		
Auriferous quartz-mines	–	–
Base-metal mines	121,624	199,000
Placer operations	535	1,000
Total, British Columbia	122,159	200,000
Yukon		
Base-metal mines	163	–[2]
Placer operations	3,916	4,000
Total, Yukon	4,079	4,000
Northwest Territories		
Auriferous quartz-mines	307,479	251,000
Base-metal mines	–	1,000
Total, Northwest Territories	307,479	252,000
Canada		
Auriferous quartz-mines	1,598,460	1,395,000
Base-metal mines	475,653	531,000
Placer operations	4,454	5,000
Total	2,078,567	1,931,000
Total value	$119,742,087	$186,111,000
Average value per oz.[3]	$57.61	$96.38

Sources: 1972, Statistics Canada; 1973, Statistics Canada and company reports. Breakdown, for both years, by type of operation by Statistics Section, Mineral Development Sector.
[1]Includes Larder Lake and Kirkland Lake mines and the Ross mine of Hollinger Mines Limited. [2]Approximately 15,000 ounces not included. [3]Average weekly gold price – London Gold Market P.M. fixing reported in *Metals Week*.
[p]Preliminary; – Nil.

Canadian total compared with 22.9 per cent in 1972. A minor amount of gold was recovered from the placer deposits of the Yukon Territory and British Columbia.

Ontario continued as the leading gold producing province in 1973 accounting for 46.7 per cent of the national total followed by Quebec with 25.0 per cent, Northwest Territories with 13.1 per cent and British Columbia with 10.3 per cent.

Canadian developments

Atlantic provinces. All gold produced in the Atlantic provinces was derived as a byproduct of base-metal ores. Investigations were carried out on some of the lode gold deposits of Nova Scotia.

Quebec. The gold property of Agnico-Eagle Mines Limited, in Joutel township, northwestern Quebec, was brought into production in December 1973, at an estimated cost of $15 million. Rated mill capacity is 1,000 tons of ore a day. To handle ore more efficiently from the lower levels, Camflo Mines Limited installed a new headframe and a larger hoist. East Malartic Mines, Limited began driving a decline to recover ore below the bottom or 31 level. Diesel powered, load-haul-dump units were used for this work. Sigma Mines (Quebec) Limited deepened its No. 3 internal shaft and three new levels were established.

Chibex Limited began construction of a 750-ton-a-day mill and carried out underground development work to bring its property, the former producing mine of Key Anacon Mines Limited in the

Chibougamau district, into production in the latter part of 1974. After completing a surface diamond drill program at its property in the Bachelor Lake area, Quebec Sturgeon River Mines Limited awarded a contract to carry out an underground exploration program. Various companies initiated exploratory programs in the Val d'Or, Malartic, Cadillac and Noranda districts.

Ontario. The program which started in 1972 to increase the daily capacity of the mill at Pamour Porcupine Mines, Limited from 1,900 to 2,500 tons, to treat ore from the Aunor mine, was completed in May 1973. The Aunor mill was closed and the ore trucked to Pamour for treatment. Noranda Exploration Company, Limited optioned the property of New Joburke Explorations Limited about 50 miles southwest of Timmins. Ore obtained from an underground exploration program and from the old surface dump was trucked to the Pamour mill. In November, Pamour purchased the mine, plant and dwellings of McIntyre Porcupine Mines Limited at Schumacher, Ontario. Hollinger Mines Limited optioned the property of New Kelore Mines Limited which adjoins its Ross mine to the north at Holtyre. A surface and underground program was under way. Any ore developed at the property would be treated at the Ross mill. The roasting facilities at the plant of Campbell Red Lake Mines Limited were improved to reduce gaseous and particulate emissions.

Exploratory work was carried out in many of the mining districts and consisted largely of geological mapping, geophysical surveys, surface diamond drilling and re-evaluation of the results of underground work done by past operators. The uncertainty existing as to the level at which the price of gold will show some stability has been a deterring factor in exploration activity.

Prairie Provinces. Virtually all gold produced in the Prairie provinces in 1973 was recovered as a byproduct from mining base-metal ores. Exploratory work was done in some of the former gold producing districts.

British Columbia. With the exception of a minor amount of gold recovered from placer deposits, all gold produced in British Columbia in 1973 was recovered as a byproduct of base-metal mines, mainly from the treatment of copper ores. Over the years the province had produced a substantial amount of gold from lode mines, but exhaustion of ore reserves, increasing costs and, until recently, a fixed price of gold were all responsible for the phasing out of lode gold mines in the province.

The high gold price was responsible for Bralorne Resources Limited initiating a major underground exploration program at its Bralorne mine, a former major producer. In the Cariboo district, a substantial gold-producing district in the past, some of the old

Table 2. World gold production, 1971-72

	1971	1972^{p}
	(ounces)	
North America		
Canada	2,260,730	2,078,567
United States	1,495,108	1,449,943
Other countries	282,555	274,443
Total	4,038,393	3,802,953
South America		
Columbia	188,847	186,816
Brazil	157,378	165,531
Peru	65,000	82,885
Chile	64,417	75,946
Bolivia	21,541	19,640
Other countries	33,953	36,760
Total	531,136	567,578
Europe		
USSR	6,700,000	6,900,000
Yugoslavia	123,780	135,033
France	65,620	66,000
Other countries	147,413	142,920
Total	7,036,813	7,243,953
Asia		
Philippines	637,048	606,730
Japan	255,255	243,027
Korea, North	160,000	160,000
India	118,569	105,773
Other countries	118,574	105,688
Total	1,289,446	1,221,218
Africa		
Republic of South Africa	31,388,631	29,245,273
Ghana	697,517	724,051
Rhodesia, Southern	501,551	502,000
Zaire	171,685	81,566
Other countries	58,504	54,514
Total	32,817,888	30,607,404
Oceania		
Australia	672,106	754,932
Fiji	89,129	90,000
New Guinea	24,071	409,125
Other countries	9,862	13,911
Total	795,168	1,267,968
World total	46,508,844	44,711,074

Sources: U.S. Bureau of Mines *Minerals Yearbook* Preprint 1972 and Statistics Canada.
^{p}Preliminary; ^{e}Estimated.

properties were reassessed. Northair Mines Ltd. carried out an extensive underground exploration program on its gold-silver property at Brandywine Falls, north of Vancouver. Other gold prospects in the province were being re-evaluated.

Yukon. The favourable gold price resulted in an increased interest in placer mining in 1973. Byproduct gold was recovered from the copper mine of Whitehorse Copper Mines Ltd. near Whitehorse.

Northwest Territories. Following encouraging results obtained from deep diamond drilling on the lower levels, in 1973 Cominco Ltd. announced a major expansion program at its Con mine, at Yellowknife, costing an estimated $12 million. A new surface shaft was collared and will be sunk to a depth of 5,800 feet; and a new hoist, designed for an ultimate depth of 7,100 feet, will be installed. The company reports that reserves are now higher than at any time in the history of the mine. Many of the known gold prospects in the territory were re-examined.

Table 3. Canada, gold production, 1964-73

	Auriferous Quartz Mines		Placer Operations		Base-metal Ores		Total	
	(ounces)	(%)	(ounces)	(%)	(ounces)	(%)	(ounces)	(%)
1964	3,151,593	82.2	58,512	1.5	625,349	16.3	3,835,454	100
1965	2,958,874	82.1	44,598	1.2	602,559	16.7	3,606,031	100
1966	2,676,381	80.6	43,369	1.3	599,724	18.1	3,319,474	100
1967	2,426,137	81.2	9,411	0.3	550,720	18.5	2,986,268	100
1968	2,208,184	80.5	9,564	0.4	525,273	19.1	2,743,021	100
1969	2,030,680	79.8	8,725	0.3	505,704	19.9	2,545,109	100
1970	1,883,764	78.2	7,359	0.3	517,451	21.5	2,408,574	100
1971	1,766,634	78.2	4,988	0.2	489,108	21.6	2,260,730	100
1972	1,598,460	76.9	4,454	0.2	475,653	22.9	2,078,567	100
1973^p	1,395,000	72.2	5,000	0.3	531,000	27.5	1,931,000	100

Sources: Statistics Canada. Breakdown classification by Statistics Section, Mineral Development Sector.
^{p}Preliminary.

Table 4. Canada, gold production, average value per ounce and relationship to total value of all mineral production, 1964-1973

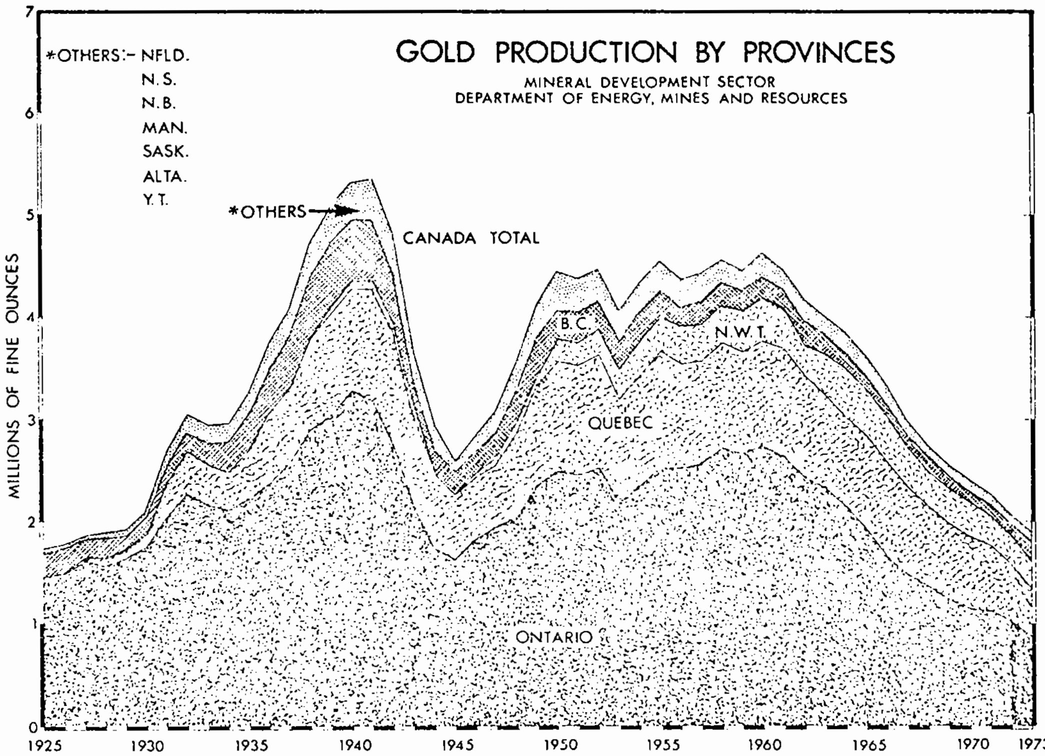
	Total Production	Total Value	Average Value per Ounce	Gold as Percentage of Total Value of Mineral Production
	(ounces)	($ Cdn.)	($ Cdn.)	(%)
1964	3,835,454	144,788,388	37.75	4.3
1965	3,606,031	136,051,943	37.73	3.7
1966	3,319,474	125,177,364	37.71	3.1
1967	2,986,268	112,731,618	37.75	2.6
1968	2,743,021	103,439,321	37.71	2.2
1969	2,545,109	95,925,158	37.69	2.0
1970	2,408,574	88,057,464	36.56	1.5
1971	2,260,730	79,903,241	35.34	1.3
1972	2,078,567	119,742,087	57.61[1]	1.9
1973^p	1,931,000	186,111,000	96.38[1]	2.3

Source: Statistics Canada.
[1]See footnote 3, Table 1.
^{p}Preliminary.

Foreign developments

Republic of South Africa. In 1973 the favourable gold price enabled South African gold mine operators to treat lower grade ore resulting in a decline in gold production to an estimated 27.4 million ounces. Peak production of 32 million ounces was recorded in 1970. Cost of mining increased because of the general rise in the price of supplies and services and substantial increases in wages granted to the European and African miners. Announcements have been made about bringing new properties into production and increasing output at some of the established producers, but production will continue to decline in the short-term as it will take a few years for expansion programs to be completed. The companies will continue to take advantage of the high free-market gold price and mine lower grade ore, thereby increasing the life of the mines.

U.S.S.R. Accurate statistical data on the U.S.S.R. gold production are not available. For 1972, the U.S. Bureau of Mines estimated the U.S.S.R. production at 6.9 million ounces. Forecasts indicate that production will increase over the next few years. A large part of U.S.S.R. gold production comes from placer deposits, but byproduct gold from base-metal ores is also an important source.



United States. Lode gold mines were the largest source of gold production in the United States and in 1972 accounted for 58 per cent of the total according to estimates by the U.S. Bureau of Mines. The major lode gold producers were Homestake Mining Company in South Dakota, and Carlin Gold Mining Company and Cortez Gold Mines in Nevada. Copper ores accounted for most of the byproduct gold production, Kennecott Copper Corporation being the main contributor. Considerable exploration was carried out on possible open-pit operations in Nevada. Carlin intends to bring two new open-pit properties into production in 1974. The Cortez mine has limited reserves. Both Carlin and Cortez recover gold from marginal ore by heap-leaching.

Australia. Renewed interest in gold was shown in Australia in 1973, especially in the Kalgoorlie district in Western Australia.

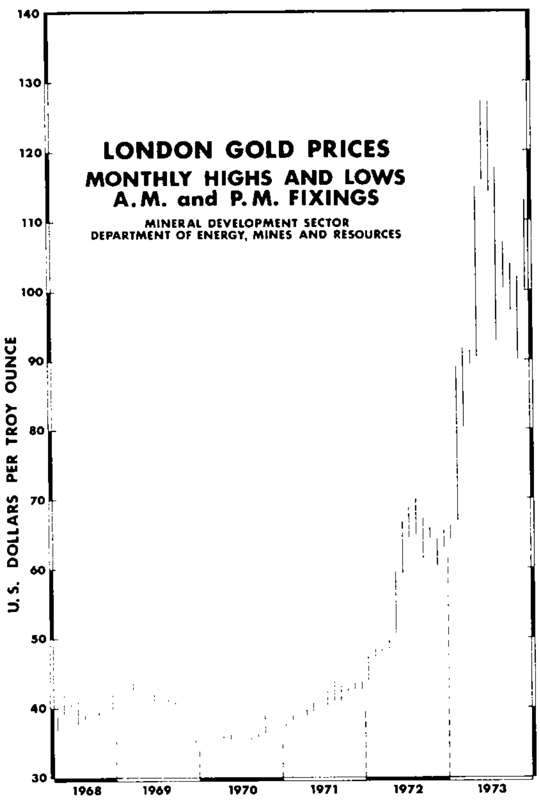
Costa Rica. In 1973 Esperanza Mines Corporation, a wholly-owned subsidiary of Bulora Corporation Limited, a Canadian company, began construction of a 100-ton-a-day mill which it expected to have in operation in 1974.

Dominican Republic. In 1973 Rosario Dominicana, S.A., owned by Rosario Resources Corporation and J.R. Simplet Co., U.S.A., continued the construction of an 8,000-ton-a-day plant to treat ore from its Pueblo Viezo open-pit gold-silver property. Production is scheduled for late 1974. Output is expected to be about 350,000 ounces of gold a year which will make it the second largest producer in the Western Hemisphere.

Territory of Papua, New Guinea. In 1973 Bougainville Copper Limited recorded the first full year of production at its open-pit copper mine on Bougainville Island. Byproduct gold output was 634,558 ounces.

Prices

The most significant event for the gold mining industry in 1973 was the sharp rise in the price of gold on the open market. The metal opened the year on the London Gold Market at $64.99 U.S. an ounce and recorded the low for the year of $63.90 on January 18. Prices increased steadily from this low until a high of $127 U.S. was reached on June 5, and again on July 6. The price was comparatively stable from August to the end of the year, with the monthly average varying from \$94.78 to \$106.53. Towards the end of December the gold price again began to show an upward trend and closed at \$112.25 at year-end.



The gold price was largely influenced by monetary considerations and did not follow the supply/demand pattern that affects most industrial metals. Many factors are considered to be responsible for the sharp increase in the gold price in 1973, the main ones being currency uncertainties, especially in relation to the United States dollar, economic problems confronting the different countries, lack of any concrete solutions to monetary reform, political tensions, a strong demand for gold as a hedge against inflationary pressures caused by higher world oil prices, and a strong demand for the metal by commodity speculators.

Because of problems related to world trade, on February 14, 1973 the United States announced its intention to devalue the dollar by 10 per cent by increasing the price of gold from \$38 to \$42.2222 U.S. an ounce. President Nixon signed into law the enabling legislation on September 21, 1973. The government of the United States proposed, and the International Monetary Fund (IMF) concurred, that the change in the par value of the U.S. dollar be effective at 12.01 a.m., Washington time, on October 18, 1973. Canada raised its official gold price to the Canadian equivalent of \$U.S. 42.2222, in order that there would be no change in the position of the Canadian dollar in relation to its United States counterpart.

An announcement was made on November 13, 1973 by the Chairman of the United States Federal Reserve Bank, that the seven signatories (Belgium, Britain, Italy, the Netherlands, Switzerland, the United States and West Germany) to the two-tier gold pricing system, established in 1968, agreed to terminate this agreement. France was not involved because it was not a party to the original agreement. The decision allows the central banks to make their official gold reserves available to the open market. In the United States view, any gold purchase made by central banks to add to their official reserves was bound by Article IV of the IMF agreement which prohibits members from buying gold at a price higher than the official monetary value.

In December 1973, South Africa and the IMF agreed to terminate an agreement reached on December 30, 1969, which allowed South Africa to sell gold on the free market under certain specific conditions. The terms of the agreement were no longer applicable.

At the annual meeting of the International Monetary Fund held at Nairobi, Kenya, in September 1973, the finance ministers of the participating countries agreed to delay their decision on monetary reform arrangements until July 31, 1974. The extra time was required to reach some consensus on points in dispute.

The unsettled situation in the world's economy and monetary arrangements makes it difficult to forecast gold prices, even on a short-term basis. A factor of major importance in the pricing of gold will be the eventual role gold will play in any new monetary arrangements. Gold held by individual countries in their official reserves at the end of 1973, excluding the U.S.S.R., other Eastern European countries, and Mainland China, totalled 1.1808 billion ounces. Table 7 shows gold held by each country.

Uses

Gold has been used traditionally as a monetary reserve by governments and central banks in the settlement of international balances but, since August 1971, when President Nixon temporarily suspended the convertibility of U.S. dollars to gold, it has not been used for this purpose. Gold's use as a monetary unit will depend on the role assigned to it, if any, by the

(text continued on page 194)

Table 5. Principal gold (mine) producers in Canada, 1973 and (1972)

Company and Location	Mill or Mine Capacity	Grade of Ore Produced: Gold	Grade of Ore Produced: Silver	Grade of Ore Produced: Copper	Combined Lead and Zinc	Ore Produced	Gold Produced	Remarks
	tons of ore/day	oz/ton	oz/ton	%	%	tons	oz	
Newfoundland								
Consolidated Rambler Mines Limited, Baie Verte	1,200 (1,200)	0.043 (0.038)	0.331 (0.346)	2.45 (1.84)	– –	292,011 (386,205)	9,158 (10,850)	Sinking new shaft to depth of 2,000 feet to mine deeper ore.
Quebec								
Agnico-Eagle Mines Limited, Joutel	1,000 (–)	– (–)	– (–)	– (–)	– (–)	– (–)	– (–)	Mill tune-up started in December 1973.
Camflo Mines Limited, Malartic	1,000 (1,000)	0.251 (0.263)	. . (. .)	– (–)	– (–)	389,622 (380,682)	98,228 (100,101)	Mill capacity to be increased to 1,250 tons; deepening of shaft 600 feet.
Campbell Chibougamau Mines Ltd., Main, Cedar Bay and Henderson mines, Chibougamau	4,000 (4,000)	0.029 (0.039)	0.244 (0.245)	1.49 (1.47)	– (–)	1,186,842 (987,266)	28,780 (31,608)	Ore reserves at June 30, 1973 were 9,578,000 tons averaging 1.93% copper and 0.048 ounce of gold a ton.
East Malartic Mines, Limited, Malartic	1,800 (1,800)	0.118 (0.131)	. . (. .)	– (–)	– (–)	560,942 (549,811)	63,417 (69,288)	Driving decline below 31 level to mine lower ore blocks.
Falconbridge Copper Limited, Lake Dufault Division, Millenbach and Norbec mines, Noranda-Rouyn	1,500 (1,500)	. . (. .)	1.41 (1.40)	3.65 (3.16)	4.41 (4.39)	555,292 (561,625)	. . (. .)	Continued exploration program.
Falconbridge Copper Limited, Opemiska Division, Perry, Springer and Robitaille mines, Chapais	3,000 (3,000)	. . (. .)	0.34 (0.33)	2.14 (2.20)	– (–)	1,062,818 (1,156,864)	. . (. .)	Bringing Cooke mine into production at a rate of 300 tons a day, reserves average 0.30 ounce gold a ton.

Table 5 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Produced: Gold	Silver	Copper	Combined Lead and Zinc	Ore Produced	Gold Produced	Remarks
	tons of ore/day	oz/ton	oz/ton	%	%	tons	oz	
Quebec (cont'd)								
Lamaque Mining Company Limited, Val d'Or	2,100 (2,100)	0.113 (0.114)	. . (. .)	– (–)	– (–)	598,120 (768,820)	63,117 (81,815)	Fiscal year ending Sept. 30, 1973. Mill output lowered to 1,500 tons a day. Underground exploration and development increased.
Marban Gold Mines Limited, Malartic	459[1] (536)[1]	(0.112) (0.141)	. . (. .)	– –	– –	167,700 (196,001)	18,510 (27,265)	Ore custom treated at mill of Malartic Gold Fields (Quebec) Limited. Limited ore reserves.
Noranda Mines Limited, Horne Division, Noranda	3,200 (3,200)	0.145 (0.160)	0.56 (0.49)	2.42 (2.30)	– (–)	485,783 (686,566)	53,790 (82,013)	Mine has limited reserves; because of increased gold price are re-evaluating Chadbourne deposit which contains about 1,100,000 tons averaging 0.11 ounce of gold a ton.
Patino Mines (Québec) Limited, Chibougamau	2,800 (2,800)	0.035 (0.036)	0.186 (0.194)	1.61 (1.77)	– (–)	973,395 (1,018,633)	27,901 (26,746)	
Sigma Mines (Québec) Limited, Val d'Or	1,400 (1,400)	0.158 (0.172)	. . (. .)	– (–)	– (–)	521,006 (519,553)	78,203 (85,614)	40 level established.
Ontario								
Campbell Red Lake Mines Limited, Red Lake	800 (800)	0.708 (0.715)	. . (. .)	– (–)	– (–)	303,796 (302,666)	196,190 (196,855)	One million dollar alteration to roasting plant to reduce gaseous and particulate emissions.
Dickenson Mines Limited, Red Lake	470 (470)	0.409 (0.472)	. . (. .)	– (–)	– (–)	105,805 (119,910)	39,947 (52,728)	

Dome Mines Limited, South Porcupine	1,900 (1.900)	0.224 (0.240)	. . (. .)	– (–)	– (–)	682,200 (629,800)	148,512 (146,242)	
Falconbridge Nickel Mines Limited, Ontario Mines, Sudbury district	12,600 (13,600)	. . (. .)	. . (. .)	. . (. .)	– (–)	4,292,900 (4,152,185)	. . (. .)	
Hollinger Mines Limited, Ross mine, Holtyre	450 (450)	0.133 (0.194)	. . (. .)	. . (. .)	– (–)	144,600 (136,019)	19,264 (24,227)	Exploration program under way on optioned adjoining property of Kelore Mines Limited
International Nickel Company of Canada, Limited (The), Sudbury, Ontario and Thompson, Manitoba	83,400 (97,500)	. . (. .)	. . (. .)	. . (. .)	– (–)	19,410,303 (18,938,225)	. . (. .)	
Kerr Addison Mines Limited, Virginiatown	811[1] (822)	0.44 (0.46)	. . (. .)	– (–)	– (–)	296,000 (300,000)	127,650 (135,900)	Mill operating on a decreasing scale.
Madsen Red Lake Gold Mines Limited, Red Lake	800 (800)	0.244 (0.288)	. . (. .)	– (–)	– (–)	126,070 (138,250)	29,163 (37,696)	Operating mill at one half capacity.
Pamour Porcupine Mines, Limited Nos. 1, 2 and 3 mines, Pamour	2,500 (1,900)	0.151 (0.172)	. . (. .)	– (–)	– (–)	877,331 (957,125)	126,654 (148,174)	No. 3 mine former Aunor mine – Aunor was purchased by Pamour in November 1972.
Pamour Porcupine Mines, Limited, Schumacher Division, Schumacher	1,500 (1,500)	0.277 (0.302)	. . (. .)	(– (–)	– (–)	237,800 (302,840)	61,542 (86,638)	Schumacher Division former McIntyre mine. Pamour purchased property in November 1973. Figures for gold sector only.
Pamour Porcupine Mines, Limited, Schumacher Division, Schumacher	2,000 (2,000)	0.027 (0.029)	. . (. .)	0.63 (0.66)	– –	777,670 (758,380)	15,838 (17,441)	Copper sector of the mine.
Robin Red Lake Mines Limited, Red Lake	119[1] 99[1]	0.795 (0.998)	. . (. .)	– (–)	– (–)	43,481 (36,216)	32,004 (33,669)	Mined and milled by Dickenson.

Table 5 (concl'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Produced Gold	Silver	Copper	Combined Lead and Zinc	Ore Produced	Gold Produced	Remarks
	tons of ore/day	oz/ton	oz/ton	%	%	tons	oz	
Ontario (cont'd)								
Willroy Mines Limited, Macassa Division, Kirkland Lake	500 (500)	0.537 (0.732)	. . (. .)	– (–)	– (–)	98,976 (98,425)	50,529 (68,213)	Operating mill at one half capacity.
Manitoba-Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon and Snow Lake districts	8,500 (6,800)	0.042 (0.031)	0.747 (0.59)	2.45 (2.67)	3.61 (3.28)	1,815,027 (1,847,903)	50,470 (44,163)	Commenced development at Centennial mine.
British Columbia								
Cominco Ltd., Sullivan mine, Kimberley	10,000 (10,000)	. . (. .)	. . (. .)	– (–)	9.96 (. .)	2,214,415 (1,925,099)	. . (. .)	
Granby Mining Company Limited, The, Granisle mine, Babine Lake	13,000 (13,000)	. . (. .)	. . (. .)	0.484 (0.455)	– (–)	2,537,138 (4,565,105)	17,083 (12,864)	
Granby Mining Company Limited, The, Phoenix	2,750 (2,600)	0.024 (0.03)	0.177 (0.258)	0.500 (0.677)	– (–)	1,003,815 (873,982)	15,047 (17,027)	
Granduc Operating Company, Stewart	8,000 (7,500)	. . (. .)	. . (. .)	1.25 (1.35)	– (–)	2,797,949 (2,089,865)	9,811 (9,811)	
Noranda Mines Limited, Bell Copper Division, Babine Lake	10,000 (10,000)	. . (. .)	. . (. .)	0.58 (0.66)	– (–)	4,114,000 (767,000)	25,200 (4,150)	

Similkameen Mining Company Limited, Ingerbelle Pit, Princeton	15,000 (15,000)	. . (. .)	. . (. .)	0.45 (0.44)	– (–)	5,356,829 (2,988,000)	28,100 (16,300)	Concentrator capacity to be increased to 22,000 tons a day.
Utah Mines Ltd., Island Copper mine, Coal Harbour, Vancouver Is.	33,000 (33,000)	. . (. .)	. . (. .)	0.50 (0.53)	– (–)	12,071,000 (7,980,429)	50,200 (40,000)	
Western Mines Limited, Buttle Lake, Vancouver Is.	1,100 (1,100)	. . (. .)	4.60 (. .)	1.39 (1.85)	9.57 (6.70)	354,240 (379,405)	26,122 (12,757)	
Yukon Territory								
Whitehorse Copper Mines Ltd., Little Chief mine, Whitehorse	2,400 (2,000)	. . (. .)	. . (0.40)	1.83 (1.92)	– (–)	700,054 (10,707)	14,300 (230)	Middle Chief orebody to be developed.
Northwest Territories								
Cominco Ltd., Con and Rycon mine, Yellowknife	500 (500)	0.54 (0.67)	. . (. .)	– (–)	– (–)	168,696 (164,776)	91,400 (106,300)	Collared new surface shaft in 1973 – to be sunk to a depth of 5,800 ft.
Giant Yellowknife Mines Limited, Yellowknife	1,000 (1,000)	0.426 (0.544)	. . (. .)	– (–)	– (–)	271,350 (264,114)	102,321 (128,272)	To open-pit block of ore.
Lolor Mines Limited, Yellowknife	158 [1] (195)[1]	0.458 (0.525)	. . (. .)	– (–)	– (–)	57,737 (71,422)	23,469 (33,471)	Ore mined and milled by Giant.
Supercrest Mines Limited, Yellowknife	165 [1] (180)[1]	0.608 (0.672)	. . (. .)	– (–)	– (–)	60,373 (65,736)	32,503 (39,443)	Ore mined and milled by Giant.

Source: Company reports.
[1] Average daily tonnage milled.
– Nil; . . Not available.

authorities responsible for the reform of the world monetary arrangements.

A study made by Consolidated Gold Fields Limited, *Gold 1974,* by Peter D. Fells shows that gold purchased by the private sector in the noncommunist world in 1973 was 45.2 million ounces (1,407 mt). Gold purchased by industrial and commercial users in 1973 amounted to 27.4 million ounces (853 mt) and hoarders, speculators and investors bought 17.8 million ounces (554 mt).

The major industrial and commercial uses of gold are in jewellery and the arts, the electronic industry and dentistry. From the study conducted by Consolidated Gold Fields Ltd., the use of gold in jewellery in 1973 in the noncommunist world was estimated at 16.2 million ounces (505.2 mt) compared with 31.9 million ounces (992.7 mt) in 1972, a decline of 15.7 million ounces. The decline was offset by increased purchases in the speculative field. The use of gold in dentistry in 1973 was estimated at 2.3 million ounces, about the same as in the previous year. Gold consumed in the electronic industry was 4.2 million ounces, about 0.6 million above 1972 consumption. Some 4 million ounces were consumed for other industrial and decorative uses and in medals and medallions.

Gold is used in a number of applications in the electronic field because of its superior physical and chemical characteristics and substitution by other metals at this time does not appear to pose any threat. However, should the price increase too sharply, industry may design away from gold. New techniques have been developed to reduce gold consumption, some being a thinner film in gold plating, selective and spot gold plating and duplex plating with low-carat base and a high-carat surface.

Outlook

Gold production in Canada will decline in the short-term. The mine operators will continue to take advantage of the high gold price and mine lower grade ore in order to extend the life of the mines. There are no new major developments on the horizon that will offset the lower output from producing mines. Should the gold price decline significantly from present levels mine closures would take place and exploration programs would be curtailed. Byproduct gold production should remain near its present level, perhaps showing a small decline.

Because it will take time for expansion programs in South Africa to augment gold production, the short-term outlook is for a continuing lower mine output in the noncommunist world. With the exception of the gold property of Rosario Dominicana, there are no major developments taking place in other parts of the noncommunist world.

Table 6. Average annual price of gold, 1969-73

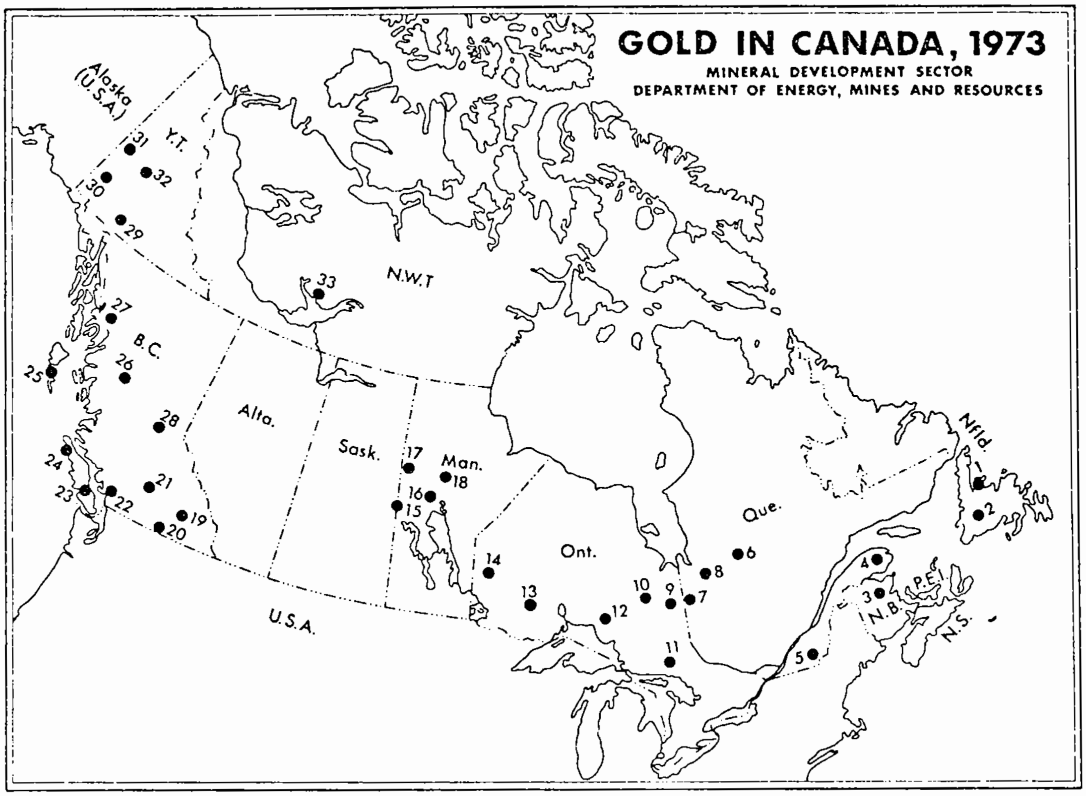
	London Free Market[1]		Royal Canadian Mint[2]
	($U.S.)	(equiv. $Cdn.)	($Cdn.)
1969	41.09	44.25	37.69
1970	35.97	37.55	36.56
1971	40.80	41.20	35.34
1972	58.13	57.61[3]	36.60
1973	97.22	96.38[3]	38.86

[1]Annual averages of London Free Market price, calculated from a.m. and p.m. fixings, as reported by Sharps Pixley Ltd. [2]Annual averages of the Royal Canadian Mint weekly published buying prices. [3]See footnote 3, Table 1.

Table 7. Gold reserves of central banks and governments, December 31, 1973

Country	Value in millions of dollars; gold valued at $42.22 U.S. per fine ounce	ounces (fine) in millions of ounces
United States	11,652	276.0
Germany (Fed. Rep. of)	4,966	117.6
France	4,261	100.9
Switzerland	3,513	83.2
Italy	3,483	82.5
Netherlands	2,294	54.3
Belgium	1,781	42.2
Portugal	1,163	27.5
Canada	927	22.0
Japan	891	21.1
United Kingdom	886	21.0
Austria	881	20.9
South Africa	802	19.0
Spain	602	14.3
Others	5,035	119.3
International monetary fund	6,478	153.4
Bank for international settlements	235	5.5
Estimated total, world[1]	49,850	1,180.7

Sources: Value from Federal Reserve Bulletin, April 1974 issue; number of ounces calculated by Mineral Development Sector, Department of Energy, Mines and Resources.
[1]Excludes holdings of the U.S.S.R., other Eastern European countries, Mainland China and North Korea.



GOLD PRODUCERS 1973
(numbers refer to numbers on the map)

Newfoundland
(1) Consolidated Rambler Mines Limited (*a*)
(2) American Smelting and Refining Company (Buchans Unit) (*a*)

New Brunswick
(3) Heath Steele Mines Limited (*a*)

Quebec
(4) Gaspé Copper Mines, Limited (*a*)
(5) Sullivan Mining Group Ltd. (*a*)
(6) Chibougamau District
Campbell Chibougamau Mines Ltd. (*a*)
Falconbridge Copper Limited (Opemiska Division) (*a*)
Patino Mines (Quebec) Limited (Copper Rand Division) (*a*)

(7) Noranda Rouyn district
Falconbridge Copper Limited (Lake Dufault Division) (*a*)
Noranda Mines Limited (*a*)
Malartic district
Camflo Mines Limited (*b*)
East Malartic Mines, Limited (*b*)
Marban Gold Mines Limited (*b*)
Bourlamaque – Louvicourt district
Lamaque Mining Company Limited (*b*)
Manitou-Barvue Mines Limited (*a*)
Sigma Mines (Quebec) Limited (*b*)
Duparquet district
Kerr Addison Mines Limited (Normetal) (*a*)

(8) Matagami District
Agnico-Eagle Mines Limited (*b*)
Mattagami Lake Mines Limited (*a*)
Orchan Mines Limited (*a*)

Ontario
(9) Larder Lake Mining Division
Hollinger Mines Limited (Ross) (*b*)
Kerr Addison Mines Limited (*b*)
Willroy Mines Limited (Macassa Division) (*b*)

(10) Porcupine Mining Division
Dome Mines Limited (*b*)
Pamour Porcupine Mines, Limited (Nos. 1,2, and 3 mines) (*b*)
Pamour Porcupine Mines, Limited – Schumacher Division (McIntyre mine) (*a and b*)

(11) Sudbury Mining Division
Falconbridge Nickel Mines Limited (*a*)
The International Nickel Company of Canada, Limited (*a*)

(12) Thunder Bay Mining Division
Noranda Mines Limited (Geco Mine) (*a*)

(13) Patricia Mining Division
Mattabi Mines Limited (*a*)

(14) Red Lake Mining Division
Campbell Red Lake Mines Limited (*b*)
Dickenson Mines Limited (*b*)
Madsen Red Lake Gold Mines Limited (*b*)
Robin Red Lake Mines Limited (*b*)

Manitoba
(15) Hudson Bay Mining and Smelting Co., Limited (*a*)
(16) Hudson Bay Mining and Smelting Co., Limited (Snow Lake) (*a*)
(17) Sherritt Gordon Mines, Limited (Fox Lake) (*a*)
(18) The International Nickel Company of Canada, Limited (Thompson) (*a*)

Saskatchewan
(15) Hudson Bay Mining and Smelting Co., Limited (*a*)

British Columbia
(19) Cominco Ltd. (*a*)
(20) The Granby Mining Company Limited (Phoenix Copper Division) (*a*)
(21) Brenda Mines Ltd. (*a*)
Similkameen Mining Company Limited (*a*)
(22) Texada Mines Ltd. (*a*)
(23) Western Mines Limited (*a*)
(24) Utah Mines Ltd. (Island Copper Mine) (*a*)
(25) Wesfrob Mines Limited (*a*)
(26) Granisle Copper Limited (*a*)
Nadina Explorations Limited (Bradina Joint Venture) (*a*)
Noranda Mines Limited (Bell Copper) (*a*)
(27) Granduc Operating Company (*a*)
(28) Small placer operations (*c*)

Yukon Territory
(29) Whitehorse Copper Mines Ltd. (*a*)
(30) Small placer operations (*c*)
(31) Small placer operations (*c*)
(32) Small placer operations (*c*)

Northwest Territories
(33) Cominco Ltd. (Con Mine) (*b*)
Giant Yellowknife Mines Limited (*b*)
Lolor Mines Limited (*b*)
Rycon Mines Limited (*b*)
Supercrest Mines Limited (*b*)

(*a*) Base metals; (*b*) Auriferous quartz; (*c*) Placer.

Gypsum and Anhydrite

D. H. STONEHOUSE

Gypsum is a hydrous calcium sulphate ($CaSO_4.2H_2O$) which, when calcined at temperatures ranging from 250° to 400°F, releases three quarters of its chemically combined water. The resulting hemihydrate of calcium sulphate, commonly referred to as plaster of paris, when mixed with water, can be moulded, shaped or spread and subsequently dried, or set to form a hard plaster product. Gypsum is the main mineral constituent in gypsum wallboard, lath and tile. Anhydrite, the anhydrous calcium sulphate ($CaSO_4$), is commonly associated geologically with gypsum.

Crude gypsum is crushed, pulverized and calcined to form stucco, which is mixed with water and aggregate (sand, vermiculite or expanded perlite) and applied over wood, metal or gypsum lath to form interior wall finishes. Gypsum board, lath and sheathing are formed by introducing a slurry of stucco, water, foam, pulp and starch between two sheets of absorbent paper, which results in a continuous "sandwich" of wet board. As the stucco hardens, the board is cut to predetermined lengths, dried, bundled and stacked for shipment.

Crude gypsum is also used in the manufacture of portland cement where it acts as a retarder, to control set. It is used as a filler in paint and paper manufacture, as a substitute for saltcake in glass manufacture and as a soil conditioner.

Production of gypsum in Canada is closely related to activity in the building construction industry, particularly to activity in the residential building sector, in both Canada and the eastern United States. About 75 per cent of Canadian gypsum production is exported to the United States. In 1973, Canadian production increased to 8.4 million tons, exports rose to 6.3 million tons and imports, mainly from Mexico to the west coast, reached 92,291 tons. Most of the gypsum for export is quarried in Nova Scotia by Canadian subsidiaries of United States gypsum products manufacturers. While most of the output from other provinces is used regionally, nearly all of the Nova Scotian production is exported in large "in company" shipments to the eastern United States.

The value of total construction in Canada during 1973 was estimated at $18.5 billion, about 30 per cent of which was recognized as residential construction. Housing starts reached 268,529 in 1973, up 7 per cent from the previous year, with a continued trend towards single-family dwellings. Production of gypsum wallboard, lath and sheathing increased by only 80,815,315 square feet in 1973, and plaster production decreased by 10,569 tons, reflecting the effects of work stoppages at a number of wallboard plants. This situation added one more construction item to a growing list of shortages with which the construction industry had to cope during the year and which caused many building construction projects to be slowed down, if not halted, for varied and indefinite periods.

Canadian industry and developments

Atlantic provinces. During 1973, five companies produced crude gypsum in Nova Scotia, two in New Brunswick and one in Newfoundland. Regional consumption of raw gypsum was small compared to the quantity exported to the United States from the Atlantic provinces. Three cement manufacturing plants, two gypsum wallboard manufacturing plants and one plant producing plaster of paris, together used only about 100,000 tons. Crude gypsum from Nova Scotia is used by Quebec wallboard plants and by Quebec and Ontario cement producers, each supplying regional construction industries.

Fundy Gypsum Company Limited, a subsidiary of United States Gypsum Company, Chicago, mines gypsum by open-pit methods at Wentworth and at Miller Creek near Windsor, Nova Scotia, for export to the United States. Crushed and beneficiated crude gypsum is shipped to company-owned processing plants through the port of Hantsport, Nova Scotia.

National Gypsum (Canada) Ltd. produces gypsum from a quarry near Milford, Nova Scotia, and exports most of it through the port of Halifax to east coast United States plants operated by the parent company, National Gypsum Company of Buffalo, New York.

Unit-trains of 40 cars each are used to haul gypsum from the quarry site 30 miles to Dartmouth. Company-owned, self-unloading ore carriers of up to 30,000 tons capacity are loaded at rates of up to 5,000 tons an hour through facilities on Bedford Basin. Shipments are made also to Quebec for use in the manufacture of gypsum products and cement, and by truck to Brookfield, Nova Scotia for use in cement manufacture.

Georgia-Pacific Corporation, Bestwall Gypsum

Table 1. Canada, gypsum production and trade 1972-73

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
Crude gypsum				
Nova Scotia	5,999,301	13,228,556	6,119,000	15,674,000
Newfoundland	735,252	2,145,985	787,000	2,409,000
Ontario	726,491	2,158,231	746,000	1,950,000
British Columbia	388,229	1,087,197	365,000	1,060,000
Manitoba	175,625	495,674	206,000	650,000
New Brunswick	74,582	220,248	93,000	255,000
Total	8,099,480	19,335,891	8,316,000	21,998,000
Imports				
Crude gypsum				
Mexico	55,000	179,000	84,084	327,000
United States	7,264	84,000	7,289	64,000
Britain	118	4,000	41	5,000
Argentina	–	–	877	1,000
West Germany	1	1,000	–	–
Total	62,383	267,000	92,291	397,000
Plaster of paris and wall plaster				
United States	15,863	939,000	20,830	1,270,000
Britain	363	17,000	340	18,000
Japan	–	–	44	1,000
Other countries	16	2,000	14	1,000
Total	16,242	958,000	21,228	1,290,000
Gypsum lath wallboard and basic products	sq. ft		sq. ft	
United States	48,779,016	1,691,000	82,520,137	3,445,000
Other countries	366,513	23,000	3,200	–
Total	49,145,529	1,714,000	82,523,337	3,445,000
Total imports gypsum and gypsum products		2,939,000		5,132,000
Exports				
Crude gypsum				
United States	5,914,998	12,221,000	6,259,025	13,987,000
Bahamas	47,975	72,000	83,644	125,000
West Germany	–	–	139	3,000
Total	5,962,973	12,293,000	6,342,808	14,115,000

Source: Statistics Canada.
^{p}Preliminary; – Nil.

Division, mines gypsum from a quarry near River Denys, Inverness County, Nova Scotia. Crushed rock is transferred by rail to open storage at Point Tupper, 20 miles from the quarry, and loaded on chartered vessels through a conveyor and reclaim tunnel system. Shipments are exported mainly to the Georgia-Pacific plant at Wilmington, Delaware.

Little Narrows Gypsum Company Limited, another subsidiary of United States Gypsum Company, produces gypsum from a quarry at Little Narrows, Victoria County, Nova Scotia, for shipments to the United States, Quebec and Ontario, through company ship-loading facilities near the plant site. This is the source of raw gypsum for a new wallboard plant made operative in February 1971 by Canadian Gypsum Company, Limited at St-Jérôme, 27 miles northwest of Montreal, Quebec.

At Walton, Hants County, Nova Scotia, gypsum and anhydrite are produced for National Gypsum (Canada) Ltd. by B. A. Parsons under contract. Shipments are made through the port of Walton to United States destinations.

Domtar Construction Materials Ltd. operates a calcining plant at Windsor, Nova Scotia, for the production of plaster of paris. Gypsum for the plant is supplied from a quarry at MacKay Settlement, under contract with D. MacDonald.

Many other gypsum occurrences are known in the central and northern mainland of Nova Scotia and on Cape Breton Island.

Gypsum is mined at Flat Bay Station, Newfoundland, 60 miles southwest of Corner Brook, by The Flintkote Company of Canada Limited, mostly for export to company plants in the United States. Raw gypsum is supplied to the Corner Brook plant of Atlantic Gypsum Limited for the manufacture of gypsum wallboard products and plaster of paris, and to the cement plant operated by North Star Cement Limited, also at Corner Brook. Exports are made through the port of St. George's from an open stockpile supplied by an aerial cable tramway carrying rock from Flat Bay, 6 miles from the shipping site. Other gypsum occurrences are known in the southwestern lowlands, west of the Long Range Mountains.

In New Brunswick, two companies quarry gypsum. Canadian Gypsum Company, Limited, a subsidiary of United States Gypsum Company, produces gypsum for use in the manufacture of plaster and wallboard in the company-owned plant at Hillsborough. Canada Cement Lafarge Ltd. obtains gypsum from the Havelock area, west of Moncton, for use in the manufacture of portland cement at Havelock.

Other gypsum occurrences in the southeastern counties of New Brunswick have been recorded. On the Magdalen Islands in Quebec many gypsum outcrops occur.

Ontario. Two underground gypsum mines are operated in southwestern Ontario to produce raw material for three gypsum products plants and a number of cement manufacturing plants. Domtar Construction Materials Ltd. mines gypsum at Caledonia, near Hamilton, from an 8-foot seam 75 feet below the surface. Crude gypsum is shipped to other consumers as well as being supplied to the company's wallboard plant at the mine site, where a full range of gypsum building products is manufactured.

At Hagersville, southwest of Caledonia, Canadian Gypsum Company, Limited, a subsidiary of United States Gypsum Company, Chicago, produces crude gypsum by room-and-pillar mining methods from a 4-foot seam, reached through a 95-foot vertical shaft. Gypsum rock is shipped in crude form. It is used also by the company in the production of wallboard and plaster in a plant adjacent to the mine shaft. The production capacity of the gypsum products plant was increased in 1969 by doubling the output potential of one wallboard line.

Gypsum has been proven at depths down to 200 feet in other parts of southwestern Ontario and under 10 to 30 feet of overburden in the Moose River area south of James Bay.

Western provinces. Crude gypsum is produced from one underground mine and one surface operation in Manitoba and from one surface operation in British Columbia. Gypsum products plants, situated in areas exhibiting major development trends, are supplied from Canadian producers of gypsum rock. Imports, mostly from Mexico, supply a number of cement producers.

Domtar Construction Materials Ltd. obtains crude gypsum from its quarry at Gypsumville, 150 miles northwest of Winnipeg, Manitoba. The company's gypsum products plant at Winnipeg uses crude from this source as well as gypsum from Silver Plains mined by Westroc Industries Limited.

Westroc Industries Limited mines gypsum from a deposit 140 feet beneath the surface near Silver Plains, 30 miles south of Winnipeg. Crushed and screened product is used by the company's gypsum products plant in Winnipeg and quantities are shipped to BACM Industries Limited's gypsum products plant at Saskatoon as well as to cement manufacturers in Winnipeg, Regina and Saskatoon.

Western Gypsum Ltd., a subsidiary of Westroc Industries Limited, operates an open-pit mine near Windermere in the southeastern part of British Columbia, supplying raw gypsum to its products plants at Calgary and Vancouver, to the Calgary and Vancouver plants of Domtar Construction Materials Ltd., to the Edmonton plant of BACM Industries Limited and to cement manufacturers in the Vancouver area, Kamloops, Exshaw and Edmonton. Crude gypsum from Windermere is exported to cement manufacturers in northeastern United States.

Gypsum occurs in Wood Buffalo National Park, in Jasper National Park, along the Peace River between

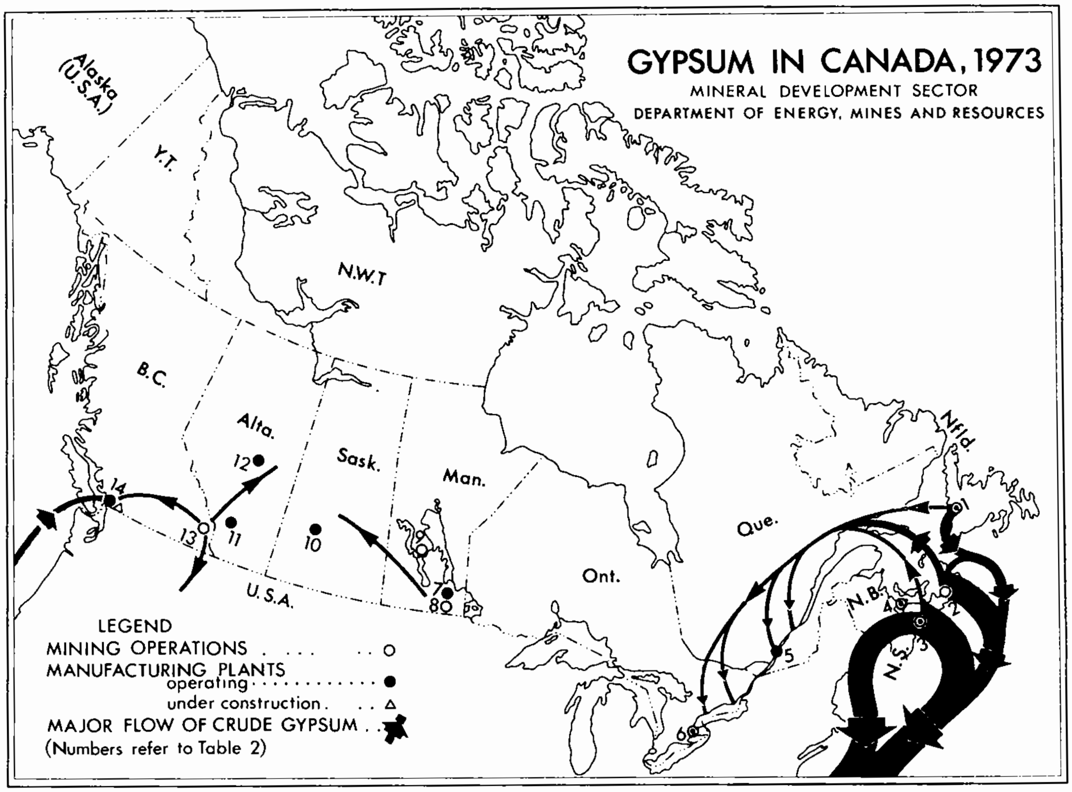


Table 2. Canada, summary of gypsum and gypsum products operation, 1973 (numbers refer to map)

Company	Location	Remarks
Newfoundland		
1. The Flintkote Company of Canada Limited	Flat Bay	Open-pit mining of gypsum
Atlantic Gypsum Limited	Corner Brook	Gypsum products manufacture
Nova Scotia		
2. Little Narrows Gypsum Company Limited	Little Narrows	Open-pit mining of gypsum and anhydrite
Georgia-Pacific Corporation Bestwall Gypsum Division	River Denys	Open-pit mining of gypsum
3. Fundy Gypsum Company Limited	Wentworth and Miller Creek	Open-pit mining of gypsum and anhydrite
National Gypsum (Canada) Ltd.	Milford	Open-pit mining of gypsum
	Walton	Open-pit mining of gypsum and anhydrite
Domtar Construction Materials Ltd.	Mackay Settlement	Open-pit mining of gypsum
	Windsor	Gypsum plaster manufacture

Table 2 (cont'd)

Company	Location	Remarks
New Brunswick		
4. Canadian Gyspum Company, Limited	Hillsborough	Open-pit mining of gypsum and gypsum products manufacture
Canada Cement Lafarge Ltd.	Havelock	Open-pit mining of gypsum used in cement manufacture
Quebec		
5. Canadian Gypsum Company, Limited	Montreal	Gypsum products manufacture
Canadian Gypsum Company, Limited	St-Jérôme	Gypsum products manufacture
Domtar Construction Materials Ltd.	Montreal	Gypsum products manufacture
Westroc Industries Limited	Ste-Cathérine d'Alexandrie	Gypsum products manufacture (Operative mid-1973)
Ontario		
6. Canadian Gypsum Company, Limited	Hagersville	Underground mining of gypsum and gypsum products manufacture
Domtar Construction Materials Ltd.	Caledonia	Underground mining of gypsum and gypsum products manufacture
Westroc Industries Limited	Clarkson	Gypsum products manufacture
Manitoba		
7. Domtar Construction Materials Ltd.	Winnipeg	Gypsum products manufacture
Westroc Industries Limited	Winnipeg	Gypsum products manufacture
8. Westroc Industries Limited	Silver Plains	Underground mining of gypsum
9. Domtar Construction Materials Ltd.	Gypsumville	Open-pit mining of gypsum
Saskatchewan		
10. BACM Industries Limited	Saskatoon	Gypsum products manufacture
Alberta		
11. Domtar Construction Materials Ltd.	Calgary	Gypsum products manufacture
Westroc Industries Limited	Calgary	Gypsum products manufacture
12. BACM Industries Limited	Edmonton	Gypsum products manufacture
British Columbia		
13. Western Gypsum Mines Ltd.	Windermere	Open-pit mining of gypsum
14. Westroc Industries Limited	Vancouver	Gypsum products manufacture
Domtar Construction Materials Ltd.	Vancouver	Gypsum products manufacture
15. BACM Industries Limited	Vancouver	Gypsum products manufacture (operative late 1974)

Table 3. World production of gypsum, 1972-73

	1972	1973^e
	(thousand short tons)	
United States	12,328	13,700
Canada	8,099	8,316
France	6,451	7,000
Italy	3,860	4,000
United Kingdom	4,590	5,000
Other Free World	20,071	20,684
Communist Countries (except Yugoslavia)	8,146	9,000
World total	63,545	67,700

Source: United States Bureau of Mines Commodity Data Summaries, January 1974, and for Canada, Statistics Canada.
^{e}Estimated.

Peace Point and Little Rapids, and north of Fort Fitzgerald in Alberta; on Featherstonhaugh Creek, near Mayook, Canal Flats, Loos, and Falkland in British Columbia; on the shores of Great Slave Lake, the Mackenzie, Great Bear and Slave rivers in the Northwest Territories and on several Arctic islands.

Markets, trade and outlook

The long-established gypsum industry in Nova Scotia exists because efficient, large-volume transportation facilities and favourable mining conditions and costs enable successful competition with inland United States operations. Canadian exports of crude gypsum are mainly to the eastern United States and are dependent on the building construction industry there. New housing starts in the United States are estimated at 2,150,000 for 1973, down about 9 per cent from 1972. However, non-residential construction increased, in support of which portland cement production was up by 10 per cent with subsequent greater usage of gypsum as a retarder. United States gypsum industry authorities predict a decline in the consumption of gypsum in excess of 10 per cent in 1974. Long-range forecasts indicate an annual rate of increase in demand of about 4 per cent. Cumulative United States domestic demand for crude gypsum to the year 2000 has been estimated at 680 million tons.

Some raw gypsum is moved from the Atlantic provinces to Montreal and Toronto regions for use in gypsum products manufacture and in cement production. Raw gypsum is rail-hauled from near Winnipeg, Manitoba to Calgary, Alberta and to Saskatoon, Saskatchewan, and from Windermere, British Columbia to Calgary, Edmonton and Vancouver for gypsum products manufacture. Raw gypsum is imported on the west coast from Mexico, mainly for

Table 4. Canada, gypsum production, trade and consumption, 1964-73

	Production[1]	Imports[2]	Exports[2]	Apparent Consumption[3]
	(short tons)			
1964	6,360,685	80,940	5,057,253	1,384,372
1965	6,305,629	75,433	4,746,628	1,634,424
1966	5,976,164	85,913	4,672,518	1,389,559
1967	5,175,384	69,112	3,896,134	1,348,362
1968	5,926,940	69,062	4,463,605	1,532,397
1969	6,373,648	81,799	4,871,184	1,584,263
1970	6,318,523	38,880	4,853,304	1,504,099
1971	6,702,100	105,783	5,034,974	1,772,909
1972	8,099,480	62,383	5,962,973	2,198,890
1973^p	8,316,000	92,291	6,342,808	2,065,483

Source: Statistics Canada.
[1] Producers' shipments, crude gypsum.
[2] Includes crude and ground, but not calcined.
[3] Production plus imports minus exports.
^{p}Preliminary.

Table 5. Canada, production of gypsum products, 1972-73

Item	1972	1973
	(square feet)	
Wallboard	1,198,962,046	1,278,042,523
Lath	109,453,464	109,311,140
Sheating	39,489,214	41,367,376
	(short tons)	
Plaster	132,395	121,826

Source: Statistics Canada.

cement manufacture. Minor amounts of crude gypsum are shipped to the mid-United States for agricultural use, and quantities are exported to the northwestern United States from British Columbia, mainly for use by cement manufacturers.

Gypsum products are not shipped great distances because freight and handling costs represent a major part of the price to the consumer for items that are relatively low-priced and readily available at many locations. Although gypsum products are usually manufactured close to the consumer, with modern containerized shipments becoming more popular and with the trend to trade off economic and environmental factors, the establishment of wallboard plants at the raw material source could become attractive.

Construction expenditures in both Canada and the United States are expected to increase. Construction of homes, apartments, schools and offices will continue and the need for gypsum-based building products will rise steadily. Although new construction materials are being introduced, gypsum wallboard will remain popular because of price and ease of installation. The present structure of the gypsum industry in Canada is unlikely to change greatly in the near future. Building materials plants have sufficient capacities to meet the short-term, regional demand for products and the ability to adapt to new building techniques.

One new gypsum products plant went on stream in Canada during 1973 – that of Westroc Industries Limited, south of Montreal. It should be operating at near its capacity of 125 million square feet of wallboard a year by mid-1974. Increased production capability was introduced at two other plants.

BACM Industries Limited announced plans for a 100-million-square-feet-a-year wallboard plant in Vancouver at a cost of $5-million. Production will likely begin late in 1974.

Canadian Standards Association standards A 82.20 and A 82.35 relate to gypsum and gypsum products.

World review

Gypsum occurs in abundance throughout the world but, because its use is dependent on the building construction industry, developments are generally limited to the industrialized countries. Reserves are generally considered "adequate."

The United States is the world's largest single producer and, together with Canada, brings North American production to near 30 per cent of world output. Asian producers account for about 12 per cent of the world total; the three major producers being Iran, India and Japan. Central America, South America, Africa and Oceania each produce significant amounts, with Mexico contributing by far the greatest tonnage of any country in this group.

Interest in byproduct gypsum continued at a

Tariffs

Canada

Item No.		British Preferential Tariff	Most Favoured Nation	General
29200-1	Gypsum, crude	free	free	free
29300-1	Plaster of paris, or gypsum calcined, and prepared wall plaster, the weight of the package to be included in the weight for duty per 100 pounds	free	6¢	12 1/2¢
29400-1	Gypsum, ground not calcined	free	free	15%
28410-1	Gypsum tile	15%	15%	25%

United States

Item No.		
512.21	Gypsum, crude	free
		On and after Jan. 1, 1972
512.24	Gypsum, ground calcined	59¢ per long ton
245.70	Gypsum or plastic building boards and lath	6%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States annotated (1972) TC Publication 452.

slower pace although the production of wallboard, plaster and plaster-based blocks or panels from the waste gypsum that results during the manufacture of phosphoric acid from phosphate rock can still be attractive under the proper set of conditions. A new plant to use byproduct gypsum for wallboard manufacture was announced for Pernis, The Netherlands. The phosphoric acid plant from which the gypsum byproduct is to come, is to use the Nissan process which yields "a gypsum byproduct of good quality which is especially suitable for the production of plaster board."

Production of sulphuric acid and coproduct cement from gypsum and anhydrite has been practiced in European countries for a number of years. If current projections of sulphur supply and demand imbalance by the 1980's are accurate, use of both natural and byproduct gypsum for sulphuric acid production could become significant.

Anhydrite

Production and trade statistics for anhydrite are included with gypsum statistics. Anhydrite is produced by Fundy Gypsum Company Limited at Wentworth, Nova Scotia, by Little Narrows Gypsum Company Limited at Little Narrows, Nova Scotia and for National Gypsum (Canada) Ltd. by B. A. Parsons at Walton, Nova Scotia. According to the Nova Scotia Annual Report on Mines, production of anhydrite in 1973 was 243,621 tons. Most of this was shipped to the United States for use in portland cement manufacture and as a peanut crop fertilizer. Cement plants in Quebec and Ontario also used some Nova Scotia anhydrite.

Indium

G.S. BARRY

Indium occurs as a minor constituent of certain ores of zinc, lead, tin, tungsten and iron. It is commonly associated with sphalerite, the most abundant zinc mineral. Indium becomes concentrated in zinc residues and smelter slags derived from zinc and lead smelting operations. It is recovered at only a few of the world's zinc and lead smelters.

Cominco Ltd. is the only Canadian producer of indium and is one of the world's largest producers. Its output in 1973 was 681,000 troy ounces; in 1972, the production was 462,000 ounces.

Indium is produced in the United States, Japan, Belgium, Peru, U.S.S.R. and West Germany, as well as in Canada. Statistics on output and consumption are not generally available.

Production

Indium was first recovered at Trail in 1941, though the presence of indium in the lead-zinc-silver ores of Cominco's Sullivan mine at Kimberley, British Columbia, had been known for many years. In 1942, 437 ounces were produced by laboratory methods. After a decade of intensive research and development, production began in 1952 on a commercial scale. At present, the potential annual production at Trail is 1 million troy ounces (about 35 tons).

Indium enters the Trail metallurgical plants with the zinc concentrates. In the electrolytic zinc process, indium remains in the zinc calcine during roasting and in the insoluble residue during leaching. The residue is then delivered to the lead smelter for recovery of contained lead and residual zinc. In the lead blast furnaces, the indium enters lead bullion and blast furnace slag in about equal proportions. From the slag, it is recovered along with zinc and lead during slag-fuming. The fume is leached for recovery of zinc, and indium again remains in the residue, which is retreated in the lead smelter. From the lead bullion, indium is removed in bullion dross. The dross is retreated for recovery of copper matte and lead, and in this process a slag is recovered which contains lead and tin together with 2.5 to 3.0 per cent indium.

The dross retreatment slag is reduced electrothermally to produce a bullion containing lead, tin, indium and antimony, which is treated electrolytically to yield a high (20 to 25 per cent) indium anode slime. The anode slime is then treated chemically to give a crude (99 per cent) indium metal, which is refined electrolytically to produce a standard grade (99.97 per cent) or high-purity grade (approximately 99.999 and 99.9999 per cent) indium. The metal is cast in ingots varying in size from 10 ounces to 10 kilograms. Also produced are various alloys and chemical compounds of indium, such as indium antimonide and a variety of fabricated forms such as discs, wire, ribbon, foil and sheet, powder, and spherical pellets.

Properties and uses

Indium is a silvery-white metal that resembles tin in its physical and chemical properties. Its chief characteristics are extreme softness, low melting point, and high boiling point. It is easily scratched with the fingernail and can be made to adhere to other metals by hand-rubbing. It has a melting point of 156°C. Like tin, a rod of indium will emit a high-pitched sound if bent quickly. The metal has an atomic weight of 114.8; its specific gravity at room temperature is 7.31, which is about the same as that for iron.

Indium forms alloys with silver, gold, platinum and many of the base metals, improving their performance in certain special applications. Its first major use, still an important outlet, was in high-speed silver-lead bearings in which the addition of indium increases the strength, wettability, and corrosion resistance of the bearing surface. Such bearings are used in aircraft piston engines, diesel engines and several types of automobile engines; the standard grade (99.97 per cent) is satisfactory for this purpose.

A zinc-indium alloy was used in applying a noncorrosive plating to hollow-steel aircraft propellers. Indium is used also in low-melting-point alloys containing bismuth, lead, tin and cadmium; for example, a bismuth-tin-cadmium-lead-indium alloy containing 19.1 per cent indium used as a heat fuse melts at 47°C. Indium is also used in glass-sealing alloys containing about equal amounts of tin and indium, in certain solder alloys in which resistance to alkaline corrosion is required, and in gold dental alloys.

Indium is one of several metals that find application in various semiconductor devices. In these, high-purity indium, alloyed in the form of discs or spheres into each side of a germanium wafer, modifies the properties of the germanium. Indium is especially suitable for this purpose because it alloys readily with germanium at low temperatures and, being a soft metal, does not cause strains on contracting after alloying.

Discovered in 1863, but in commercial use only since 1927 when it was first used as a nontarnish coating on silverware, indium and its compounds are relatively new materials whose potential applications are still being explored. Uses have been found in electrical contacts, resistors, thermistors, photoconductors, small lightweight batteries, and infra-red detectors. Indium can be used as an indicator in atomic reactors since artificial radioactivity is easily induced in indium by neutrons of low energy (about 1.5 electron-volt). Indium foil was used as a neutron indicator in the uranium-graphite piles of the first atomic bomb project. Silver-cadmium-indium alloys are now used for reactor control rods. Indium compounds added to lubricants have a beneficial anticorrosive effect. Indium also has possible applications in decorative plating of jewelry and tableware.

Foreign trade

Statistics on foreign trade are not generally available for indium. United States imports in 1973 totalled 890,000 troy ounces, obtained from: Canada, 44%; U.S.S.R., 14%; Peru, 11%; Japan, 9%; and other, 22%.

Prices

Prices are quoted on a weekly basis by *Metals Week*. At the beginning of the year the price quoted was U.S. Ingot $1.75 a troy ounce. In the last week of December the price was $2.00 a troy ounce. The price change occurred in the week ending December 14, 1973.

Iron Ore

D.D. BROWN

Canadian iron ore production (shipments) in 1973 increased by 11.1 million tons* (29 per cent) from the previous year. With strong domestic and foreign demand for iron ore through the year, Canadian mines and benefication plants operated at, or near, rated production capacity. Record production in 1973 followed a significant production decline in the previous year.

While export shipments of iron in 1973 increased 28.6 per cent over export shipments in 1972, domestic shipments of iron ore increased 6 per cent over domestic shipments in 1972. Imports of iron ore, principally from the United States, increased 53 per cent over imports in 1972. The sharp rise in imports reversed the trend of declining imports that extended from 1964 to 1971.

Early in 1973, the firm upward trend of general economic activity in most of the industrialized countries resulted in a world-wide boom in steel production. World crude steel output increased by 9 per cent to reach a new record of 696 million metric tons. World iron ore production (shipments) at 828 million metric tons in 1973 increased by 9.5 per cent from the previous year to provide for increased steel production. Strong iron ore demand in 1973 did not immediately affect export prices as contracts had been negotiated during general oversupply and weak demand in 1972. Upward price revisions were negotiated during the year to compensate for escalating production cost increases and currency losses resulting from U.S. dollar devaluations. At year-end, the energy crisis, precipitated by OPEC[1] petroleum price increases and supply reductions, affected iron-ore pellet production costs and ocean freights. In addition, inflationary forces resulted in higher operating costs and significantly increased capital costs for new projects. Although a number of producers had record production and shipments, unit profit levels declined because of price restraints, and other economic phenomena.

Developments

With the completion of construction of new iron ore production facilities, Canadian iron ore production capacity at the end of 1973 was about 63 million tons including 31 million tons of pellet capacity compared with 47.4 million tons including 25 million tons of pellet capacity at the end of 1972. Only a portion of new capacity was operational at year-end.

In mid-1973, Iron Ore Company of Canada (IOC) completed a major three-year expansion program in iron ore mining and processing operations. The company's Carol Lake concentrator was expanded from 10.3 million tons of concentrate a year to 22.8 million tons a year and the Carol Lake pellet plant was reconstructed. A new 6-million-ton-a-year concentrator and pelletizing-plant complex was constructed at Sept-Îles. The construction completion date for the expansion program was delayed because of a three-month strike in 1972 during which construction was suspended; total cost of the expansion program was in excess of $390 million. The expansion program brought IOC's total design capacity to about 32.5 million tons of iron ore a year. In 1973 and early 1974, on-stream production from the new facilities had been hampered by mechanical difficulties, shortages of key replacement components and shortage of skilled maintenance employees. The new production facilities did not reach full or efficient production in 1973 as was originally planned. A significant operating loss was evident for the first half of 1974.

During 1973, construction continued on the huge Mt. Wright project of the Quebec Cartier Mining Company (QCM), with some elements being completed. The scope of the Mt. Wright project, 70 miles northeast of Gagnon, Quebec, includes construction of a concentrator and related facilities capable of producing in excess of 16 million tons of concentrate a year. The construction of an 88-mile railway extension of the Cartier Railway and construction of the new town of Fermont, to accommodate a population of 5,000 are other elements of the project. The Mt. Wright specular hematite ore deposit is roughly 4 miles long, 4,000 feet wide and 1,000 feet deep. Mine production is scheduled over a period of at least 75 years. The Mt. Wright development was delayed in 1973 by a construction slowdown and strike action. Initial production is expected sometime in 1975, with most shipments allocated for export demand.

At year-end, Quebec Cartier Mining Company was planning to bring its Fire Lake iron ore property into production by 1976. The property is close to the Mt. Wright Railway spur line, roughly halfway between QCM's Lac Jeannine mine and QCM's Mt. Wright mine. Crude ore from the Fire Lake mine will be railed to the Lac Jeannine concentrator following the depletion of Lac Jeannine mine reserves in 1976.

*The long or gross ton (2,240 pounds) is used throughout unless otherwise stated.

[1]OPEC is the acronym for Organization of Petroleum Exporting Countries.

Output from the Lac Jeannine concentrator will be reduced from the rate of 8.8 million tons of concentrate a year achieved in 1973 to 5 million tons of concentrate a year when only Fire Lake crude ore will be processed. Early in 1974, Sidbec-Dosco Limited, with steelworks at Contrecoeur, Quebec, announced that it will acquire at least 25 per cent of annual production. Under an agreement, Sidbec-Dosco will provide about $160 million for the construction of a 6-million-ton-a-year pelletizing plant to process Fire Lake concentrates at Port Cartier on the Gulf of St. Lawrence.

Outlook

The outlook for the Canadian iron ore industry, notwithstanding regional manpower shortages and escalating production cost factors, appears to be excellent

Table 1. Canada, iron ore production and trade, 1972-73

	1972		1973^p	
	(long tons)[1]	$	(long tons)[1]	$
Production (mine shipments)				
Newfoundland	16,135,480	235,249,411	23,545,000	325,837,000
Ontario	10,495,835	139,514,537	11,014,000	145,025,000
Quebec	10,370,607	101,655,102	13,226,000	128,338,000
British Columbia	1,121,704	12,604,409	1,418,000	13,912,000
Total	38,123,626	489,023,459	49,203,000	613,112,000
Byproduct iron ore[2]	746,000^e			
Imports				
United States	1,472,960	20,161,000	2,137,603	32,121,000
Brazil	35,700	352,000	476,285	6,952,000
Sweden	56,235	977,000	33,025	575,000
Liberia	159,907	801,000	–	–
West Germany	29	. . .	–	–
Total	1,724,831	22,291,000	2,646,913	39,648,000
Exports				
Iron ore, direct shipping				
United States	3,084,699	29,106,000	4,821,961	49,281,000
Britain	1,074,363	7,604,000	1,165,144	11,711,000
Italy	911,561	6,236,000	806,879	7,929,000
Japan	–	–	370,703	2,854,000
Belgium-Luxembourg	–	–	123,015	933,000
France	–	–	32,641	333,000
Total	5,070,623	42,946,000	7,320,343	73,041,000
Iron ore, concentrates				
United States	3,934,647	40,052,000	3,544,302	40,948,000
Japan	1,706,254	15,030,000	3,251,228	27,208,000
Britain	1,293,545	10,171,000	2,449,302	19,868,000
Netherlands	1,536,556	11,811,000	1,815,799	14,252,000
West Germany	763,813	5,952,000	1,736,019	14,223,000
France	300,187	2,359,000	457,082	3,793,000
Finland	27,797	218,000	179,059	1,477,000
Italy	–	–	188,930	1,455,000
Spain	–	–	85,687	712,000
Portugal	–	–	35,638	329,000
Belgium-Luxembourg	48,531	541,000	20,810	172,000
Bahamas	16,290	169,000	11,300	93,000
Australia	16,170	191,000	3,815	47,000
Sweden	1	. . .	–	–
Total	9,643,791	86,494,000	13,778,971	124,577,000

for 1974 and the remainder of this decade, given apparent demand. At year-end, strong demand to supply capacity domestic and world steel production continued unabated. Canadian producers can be expected to supply about 52 million tons in 1974 for an increase of about 7.5 per cent. Canadian iron ore production is projected to 80 million metric tons a year in 1980 to give a linear growth rate of 6.5 per cent a year over 1973-1980. This projected growth rate compares to an annual growth rate of 7.2 per cent achieved over 1960-1973.

Production and shipments

Canada's iron ore shipments in 1973 including byproduct iron ore amounted to 49.2 million tons valued at $613 million compared with 38.1 million tons valued at $489 million in 1972. Export shipments of 37.1 million tons in 1973 were 8.3 million tons more than 1972 shipments, but did not reach the record export shipments of 38.7 million tons set in 1970. Domestic shipments of iron ore amounted to 10.5 million tons, some 600,000 tons more than in 1972 when the previous record was set.

Table 1 (concl'd)

	1972		1973[p]	
	(long tons)[1]	$	(long tons)[1]	$
Exports (cont'd)				
Iron ore, agglomerated				
United States	10,609,601	166,614,000	12,590,522	207,721,000
Britain	1,123,932	17,649,000	1,188,842	19,880,000
Italy	446,322	7,129,000	860,558	14,199,000
Spain	785,205	12,496,000	396,040	6,465,000
Netherlands	357,670	5,601,000	376,921	6,305,000
West Germany	–	–	125,490	2,068,000
Belgium and Luxembourg	52,060	815,000	82,550	1,360,000
Japan	180,790	2,900,000	–	–
Total	13,555,580	213,204,000	15,620,923	257,998,000
Iron ore, not elsewhere specified				
United States	516,822	8,947,000	352,461	6,380,000
Netherlands	20,461	941,000	–	–
Britain	5,000	148,000	–	–
Total	542,283	10,036,000	352,461	6,380,000
Total exports, all classes				
United States	18,145,767	244,719,000	21,309,246	304,330,000
Britain	3,496,840	35,572,000	4,803,288	51,459,000
Japan	1,887,045	17,930,000	3,621,931	30,062,000
Italy	1,357,883	13,365,000	1,856,367	23,583,000
Netherlands	1,914,687	18,353,000	2,192,720	20,557,000
West Germany	763,814	5,952,000	1,861,509	16,291,000
Spain	785,206	12,496,000	481,727	7,177,000
France	300,187	2,359,000	489,723	4,126,000
Belgium and Luxembourg	100,591	1,356,000	226,375	2,465,000
Finland	27,797	218,000	179,059	1,477,000
Portugal	–	–	35,638	329,000
Bahamas	16,290	169,000	11,300	93,000
Australia	16,170	191,000	3,815	47,000
Total	28,812,277	352,680,000	37,072,698	461,996,000

Source: Statistics Canada.
[1] Dry long tons for production (shipments) by province; wet long tons for imports and exports. [2] Total shipments of byproduct iron ore compiled by Mineral Development Sector from data supplied by companies. Total iron ore shipments include shipments of byproduct iron ore.
[p] Preliminary; – Nil; [e] Estimated; . . . less than $1,000.

Iron ore was produced by 15 companies and joint-venture consortia at 16 locations, with 9 operations in Ontario, two each in Quebec and Newfoundland (Labrador) and British Columbia and one in Quebec-Labrador. Following the closure of Falconbridge Nickel Mines Limited's iron-nickel refinery early in 1973, the iron recovery plant of The International Nickel Company of Canada, Limited at Copper Cliff, Ontario, was the only byproduct iron ore plant operating.

All of the iron ore producing provinces increased shipments, with Newfoundland and Quebec and British Columbia having significant increases and Ontario having a marginal increase. Newfoundland was the leading producer with 23.5 million tons, followed by Quebec with 13.2 million tons, Ontario with 11.0 million tons and British Columbia with 1.4 million tons.

In Quebec-Labrador, shipments from the three largest iron ore producers in Canada, increased by 8.3 million tons from the previous year. Shipments by Iron Ore Company of Canada (IOC), the largest Canadian producer, amounted to 20.4 million tons. The principal portion of iron ore shipped by IOC consisted of 9.7 million tons of pellets produced at the Carol division at Labrador City, Newfoundland. The second largest portion consisted of 7.2 million tons of direct shipping ore originating at mines at the Knob Lake division, at Schefferville, Quebec. The third largest portion was composed of 3.1 million tons of concentrate recovered at the Carol division. The remaining 372,490 tons of pellets and 22,083 tons of concentrate were produced at the new beneficiating and agglomerating complex started up by IOC in 1973 at Sept-Îsles, Quebec, to treat natural ores from mines at Schefferville.

In addition to the new 6-million-ton-a-year processing complex at Sept-Îsles, the program completed by IOC in 1973 included doubling the annual production capacity at the Carol Lake concentrator to 22.8 million tons of concentrate. Although, the new production facilities did not reach production targets in 1973 as was planned, IOC's shipments of iron ore in 1973 exceeded the previous record of 20.1 million tons set in 1970. In 1972, because of an extended strike that interrupted operations, the tonnage shipped was reduced to 13.6 million tons.

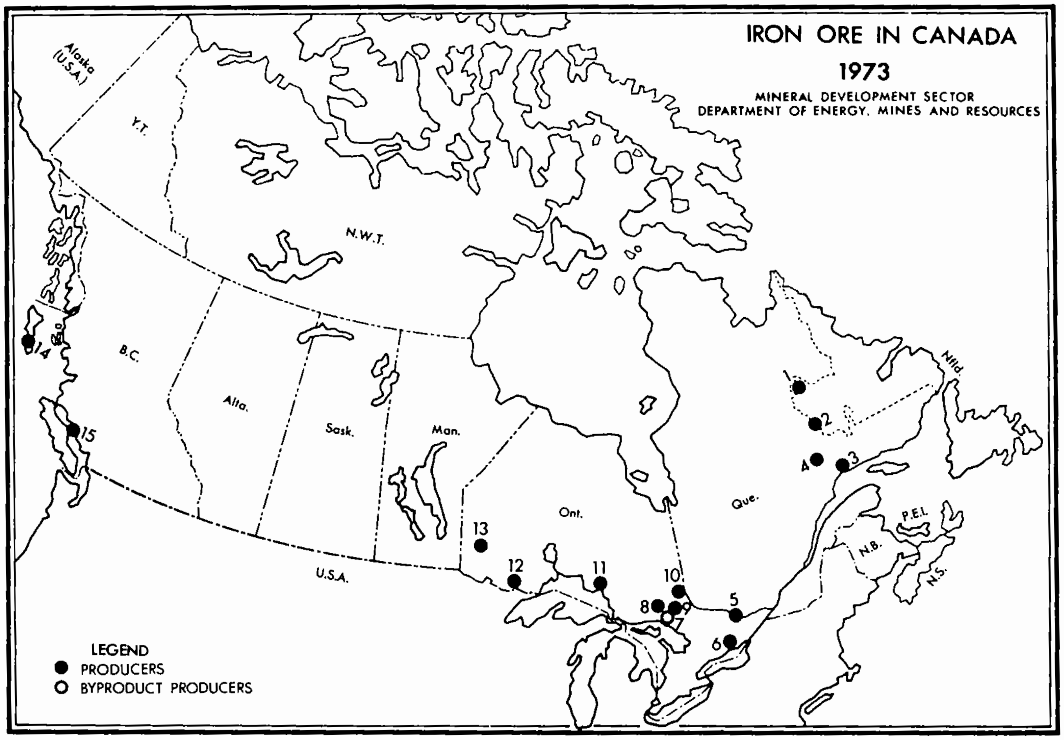
Quebec Cartier Mining Company (QCM) and Wabush Mines shipped 8.8 million tons and 5.4 million tons, respectively, compared with 7.4 and 5.3 million tons the year before. Iron ore shipments from Wabush Mines were lower than scheduled because of transportation problems on one of the connecting railroads between Labrador City, Newfoundland and Pointe Noire, Quebec and shutdown of the pelletizing furnaces at Pointe Noire, Quebec for major repairs.

The Hilton Mines, in Quebec, about 40 miles from Ottawa and the only Quebec iron mine not in the Labrador Trough, operated at capacity during the year. The company's shipments, all by rail to U.S. and Canadian consumers, amounted to 870,240 tons. Depletion of open-pit reserves at the Hilton Mine will necessitate closing of operations during 1975.

With high domestic and U.S. demand, most Ontario mines shipped iron ore at, or near, their rated production capacity. In the Atikokan area, the largest Ontario producer, Caland Ore Company Limited, loaded 2.2 million tons compared with 1.9 million tons in 1972. Shipments comprised 1.18 million tons of pellets, 0.93 million ton of concentrate and 86,000 tons of direct-shipping ore. The concentrate and pellets were shipped to Caland's parent company, the Inland Steel Company, in the United States. The direct-shipping ore was sold to nearby Steep Rock Iron Mines Limited. A further 200,000 tons of direct-shipping is expected to be delivered to Steep Rock in 1974. Because of imminent depletion of ore reserves and reduced demand for natural ore, Caland Ore Company Limited announced its intention to close its mining operation late in 1976 and to continue operation of its pelletizing plant on stockpiled ore until January 1978, at which time pellet production will terminate. At the close of Caland's mining operation, the lease to the Caland property will be surrendered to nearby Steep Rock Iron Mines Limited under the terms of the lease agreement. Steep Rock may elect to obtain its ore by further development of the Caland pits in preference to continuing mining at its own open-pit mine.

The other producer in the Atikokan area, Steep Rock Iron Mines Limited, operated at capacity. The company shipped 1.4 million tons of pellets and 9,200 tons of concentrate. The shipments comprised 1.18 million tons of pellets delivered to the steelworks of The Algoma Steel Corporation, Limited, Sault Ste. Marie, Ontario and 235,000 tons of pellets delivered to Detroit Steel Corporation at Portsmouth, Ohio. The bulk of raw ore came from the Hogarth open-pit mine. Underground mining from the Errington Mine, which was resumed in 1970 to recover reserves beneath the open pits, was discontinued in November 1973 because the underground operation was not economic. Steep Rock's raw ore production was supplemented by purchased run-of-pit ore from the nearby Caland mining operation. During 1973, the company continued its engineering feasibility study for the proposed development of a major iron deposit at Lake St. Joseph located northeast of Sioux Lookout, northwestern Ontario.

The Griffith Mine on Bruce Lake near Red Lake, Ontario, operated at capacity and recorded its best year since 1960. Griffith shipped 1.5 million tons of pellets to its parent company, The Steel Company of Canada, Limited, (Stelco), Hamilton, Ontario. During 1973, the company opened the south pit and began a two-year dredging and dyking operation to further extend the north pit. Stelco began construction in 1973 of a 400,000-ton-a-year direct reduction plant at the Griffith Mine that will use the SL-RN process to reduce Griffith Mine pellets to about 92 per cent iron. The sponge iron product will be used at Stelco's electric-furnace steelmaking plants at Edmonton, Alberta, and Contrecoeur, Quebec. Each plant will take half of the projected output following initial production scheduled to come on stream in 1975.



PRODUCERS
(numbers refer to numbers on map)

1. Iron Ore Company of Canada, Knob Lake division (Schefferville)
2. Iron Ore Company of Canada, Carol division, (Labrador City)
2. Scully Mine of Wabush Mines (Wabush)
3. Iron Ore Company of Canada, Sept-Îles division (Sept-Îles)
3. Pointe Noire Division of Wabush Mines (Pointe Noire)
4. Quebec Cartier Mining Company (Gagnon)
5. The Hilton Mine (Shawville)
6. Marmoraton Mining Company, Division of Bethlehem Chile Iron Mines Company (Marmora)
8. National Steel Corporation of Canada, Limited (Capreol)
9. Sherman Mine of Dominion Foundries and Steel, Limited (Temagami)
10. Adams Mine of Dominion Foundries and Steel, Limited (Kirkland Lake)
11. Algoma Ore Division of The Algoma Steel Corporation, Limited (Wawa)
12. Caland Ore Company Limited (Atikokan), Steep Rock Iron Mines Limited (Atikokan)
13. The Griffith Mine (Bruce Lake)
14. Texada Mines Ltd. (Texada Is.)
15. Wesfrob Mines Limited (Moresby Is.)

BYPRODUCT PRODUCERS

7. The International Nickel Company of Canada, Limited (Copper Cliff)

Table 2. Canada, iron ore producers, 1972 and 1973

Company and Property Location	Participating Companies	Material Mined and/or Treated	Product Shipped	Shipments 1972	Shipments 1973
		(% Fe natural)	(% Fe dry/wet)	('000 wet long tons)	
Adams Mine; Boston Twp., near Kirkland Lake, Ont.	Dominion Foundries and Steel, Ltd.; managed by Cliffs of Canada Limited, a wholly-owned subsidiary of The Cleveland-Cliffs Iron Company	Magnetite from open-pit mine (19)	Pellets (66/65)	1,093	1,174
Algoma Ore Division of The Algoma Steel Corp., Ltd.; mines and sinter plant near Wawa, Ont.	Wholly owned	Siderite from open-pit and underground mine (34)	Siderite sinter (48/48)	1,797	2,046[1]
Caland Ore Co. Ltd.; East arm of Steep Rock Lake, near Atikokan, Ont.	Inland Steel Co.	Hematite and goethite from open-pit mine (55)	Pellets (63/64)	1,115	1,178
			Concentrate (59/56)	783	928
			Direct Shipping (60/55)	–	86
Griffith Mine, The; Bruce Lake, 35 miles south of Red Lake, Ont.	The Steel Co. of Canada, Ltd.; managed by Pickands Mather & Co.	Magnetite from open-pit mine (24)	Pellets (67/67)	1,380	1,506
Hilton Mine, The; near Shawville, Quebec, 40 miles NW of Ottawa	The Steel Co. of Canada, Ltd., 50%; Jones & Laughlin Steel Corp., 25%; Pickands Mather & Co. (managing agent), 25%	Magnetite from open-pit mine (20)	Pellets (67/67)	878	870
Iron Ore Company of Canada 1. Schefferville, Quebec-Labrador operation	Labrador Mining and Exploration Co. Ltd., 4.73%; Hollinger Mines Ltd., 10.17%; The Hanna Mining Co. (managing agent), 26.37%	Hematite-goethite-limonite from open-pit mines (54)	Direct-shipping ore (59/54)	5,046	7,211

Table 2. (cont'd)

Company and Property Location	Participating Companies	Material Mined and/or Treated	Product Shipped	Shipments 1972	Shipments 1973
		(% Fe natural)	(% Fe dry/wet)	('000 wet long tons)	
2. Carol Lake, Labrador operation	Bethlehem Steel Corp. 18.80%; Armco Steel Corp., 5.87%; Lykes-Youngstown Corp. 5.87%;	Specular hematite and magnetite from open-pit mines (39)	Pellets (65/64) Concentrate (65/63)	7,985 578	9,721 3,060
3. Sept-Îsles, Que.,[2] Pellet operation	National Steel Corp., 17.62%; Republic Steel Corp., 5.87%; Wheeling-Pittsburgh Steel Corp., 4.70%	Hematite-goethite-limonite from open-pit mines, Schefferville area	Pellets (63/61) Concentrate (61/65)	– –	372 22
Marmoraton Mining Co., Division of Bethlehem Chile Iron Mines, Company, near Marmora, Ont.	Bethlehem Steel Corp.	Magnetite from open-pit mine (36)	Pellets (65/65)	490	481
National Steel Corporation of Canada, Ltd., Moose Mountain Mine; Sudbury area, 20 miles north of Capreol, Ont.	National Steel Corp. (The Hanna Mining Co. is the managing agent)	Magnetite from open-pit mine (33)	Pellets (64/63)	641	725
Quebec Cartier Mining Company; Gagnon, Quebec	United States Steel Corp.	Specular hematite from open-pit mine (34)	Specular hematite concentrate (66/64)	7,432	8,805
Sherman Mine; near Temagami, Ont.	Dominion Foundries and Steel, Limited, 90%; Tetapaga Mining Company (wholly-owned subsidiary of The Cleveland-Cliffs Iron Company), 10%. The operation and management of the mine is by Cliffs of Canada Limited, also a wholly-owned subsidiary of The Cleveland-Cliffs Iron Company	Magnetite from open-pit mines (21)[e]	Pellets (66/65)	1,052	1,305

Table 2. (cont'd)

Company and Property Location	Participating Companies	Material Mined and/or Treated	Product Shipped	Shipments 1972	1973
		(% Fe natural)	(% Fe dry/wet)	('000 wet long tons)	
Steep Rock Iron Mines Ltd.; Steep Rock Lake, N. of Atikokan, Ont.	Publicly-owned company	Hematite-goethite from open-pit mine (51)	Concentrate (58/54)	7	9
			Pellets (63/63)	1,467	1,417
Texada Mines Ltd.; Texada Island, B.C.	Kaiser Aluminum and Chemical Corp.	Magnetite and chalcopyrite from underground mine (35)	Magnetite concentrate (64/61)	614	486
Wabush Mines, Scully Mine includes mine and concentrator at Wabush, Labrador; Pointe Noire Division includes pelletizing plant at Pointe Noire, Que.	The Steel Co. of Canada Ltd., 25.6%; Dominion Foundries and Steel, Ltd., 16.4%; Youngstown Sheet and Tube Company, 15.6%; Inland Steel Co., 10.2%; Interlake, Inc., 10.2%; Wheeling-Pittsburgh Steel Corp., 10.2%; Finsider of Italy, 6.6%; and Pickands Mather & Co. (managing agent), 5.2%.	Specular hematite and some magnetite from open-pit mine (35)	Pellets (66/64)	5,310	5,371
			Concentrate (66/64)	3	66
Wesfrob Mines Limited; Tasu Harbour, Moresby Is., Queen Charlotte Is., B.C.	Falconbridge Nickel Mines Limited	Magnetite and chalcopyrite from open-pit mines (37)	Pellet-feed concentrate (70/63)	330	496
			Sinter-feed concentrate (61/58)	284	461
Byproduct Producers					
Cominco Ltd.; Kimberley[3], B.C.	Publicly-owned company	Pyrrhotite flotation concentrates roasted for acid production; calcine sintered	Iron oxide sinter (63/63) is processed into pig iron at plant	28[4]	–

Table 2. (concl'd)

Company and Property Location	Participating Companies	Material Mined and/or Treated	Product Shipped	Shipments 1972	1973
		(% Fe natural)	(% Fe dry/wet)	('000 wet long tons)	
Falconbridge Nickel Mines[3] Ltd.; Falconbridge, Ont.	Publicly-owned company	Pyrrhotite flotation concentrates (57) treated	Iron oxide calcine (67/67)	19	–
The International Nickel Co. of Canada, Ltd.; Copper Cliff, Ont.	Publicly-owned company	Pyrrhotite flotation concentrates (57)[e] treated	Pellets (68/68)[e]	700	624
Quebec Iron and Titanium Corp.; mine at Lac Tio, Que.; electric smelter at Sorel, Quebec	Kennecott Copper Corp.; Gulf & Western Industries, Inc. (The New Jersey Zinc Co.)	Ilmenite-hematite ore (40% Fe, 35% TiO_2) from open-pit mine at Lac Tio, beneficiated and calcined at Sorel	Ilmenite calcine electric smelted to TiO_2 slag and various grades of desulphurized pig iron or remelt iron	1,600[5]	1,900[5]

Sources: Company reports, personal communication.
[1]Includes 170,408 tons of regular sinter; 1,873,844 tons of superfluxed sinter; 1,409 tons of crude ore shipped as food supplement to livestock industry.
[2]Commenced operations in 1973. [3]Ceased operations in 1972. [4]Sinter consumed in pig iron production. [5]Ilmenite calcine smelted.
[e]Estimated; – Nil.

Production (shipments) at the Algoma Ore Division of The Algoma Steel Corporation, Limited (Algoma), near Wawa, Ontario, was 2.04 million tons of sinter compared with shipments of 1.77 million tons in 1972. The principal portion of shipments consisted of 1.98 million tons of super-fluxed sinter to the company's main steelworks at Sault Ste. Marie, Ontario. The remaining 59,000 tons of regular sinter were delivered to the Canadian Furnace division of the company, Port Colborne, Ontario. In 1973, production of sinter was 2.03 million tons, all of which was produced from 2.91 million tons of siderite ore originating at the George W. MacLeod underground mine.

The Sherman Mine, near Temagami, Ontario, operated at capacity with production and shipments of slightly more than one million tons of pellets. The entire output was shipped by rail to the steelworks of Dominion Foundries and Steel, Limited (Dofasco), Hamilton, Ontario.

The Adams Mine, near Kirkland Lake, Ontario shipped a record 1.17 million tons of pellets in 1973. Some 769,241 tons were shipped by rail to Dofasco's Hamilton steelworks and 404,470 tons were shipped by rail to Jones & Laughlin Steel Corporation in Pittsburgh. Following July 1974, all production shipments are scheduled for delivery to Dofasco.

Production was normal at the Moose Mountain Mine of the National Steel Corporation of Canada, Limited, and Marmoraton Mining Company, Division of Bethlehem Chile Iron Mines Company; pellet shipments were 724,906 tons and 480,697 tons respectively.

The International Nickel Company of Canada, Limited, was the only byproduct iron ore producer in 1973. The company shipped 624,000 tons of iron ore comprised of 165,000 tons to domestic consumers and 459,000 tons to U.S. consumers.

Cominco Ltd. closed its iron ore recovery plant in British Columbia in 1972 and Falconbridge Nickel Mines Limited closed its pyrrhotite plant during the same year. Furthermore, Falconbridge closed its new iron-nickel refinery in 1973 after two years of discontinuous operation, because of technical difficulties in processing.

British Columbia's two iron ore producers had a comparatively good year in 1973 as shipments totalled 1.4 million tons, up from 1.1 million tons shipped in 1972, but down from 1.77 million tons shipped in 1971. Wesfrob Mines Limited, the larger producer, shipped 956,674 tons of concentrate. The shipments comprised 736,661 tons to Japan for sintering and pelletizing purposes, 206,692 tons to the direct reduction plant at Midland-Ross Corp. in Oregon, and 13,321 tons to Australian coal preparation plants for heavy media usage. Wesfrob was planning a new underground program to develop ore reserves under one of the open pits and to provide access for further exploration drilling. Texada Mines Ltd., produced a total of 455,867 tons of iron ore concentrate at its underground mining property on Texada Island. The company loaded 485,505 tons of iron ore concentrates into ore carriers, all for export to Japan.

Table 3. Production and capacity of pig iron and crude steel at Canadian iron and steel plants, 1972-73

	1972	1973^p
	(short tons)	
Pig iron		
Production	9,363,893	10,510,994
Capacity at December 31	11,115,000	11,145,000
Steel ingots		
Production	13,072,873	14,755,379
Capacity at December 31	15,537,800	17,940,800

Source: Statistics Canada.
^p Preliminary.

Trade

Canadian export shipments during the year totalled 37.1 million tons compared with 28.8 million tons in 1972 and a record 38.7 million tons in 1970.

The largest market, the United States, took 21.3 million tons, followed by the EEC with 11.4 million tons and Japan with 3.6 million tons. Of the member nations of the EEC, Britain was the largest importer of Canadian ore, 4.8 million tons, followed by Netherlands, 2.2 million tons; West Germany, 1.9 million tons; and Italy, 1.9 million tons.

Canadian iron ore imports in 1973 were 2.7 million tons, compared with 1.7 million tons in 1972. The sharp increase of iron ore imports over the previous year strongly reversed the downward trend that extended from 1964 to 1971. Canadian imports are expected to continue to increase after the Tilden Mine, Michigan, commences shipments to Ontario steel producers in the second half of 1974. Capacity production shipments will amount to 1.7 million tons a year. Also in 1974, Ontario steel producers arranged for iron ore deliveries at a rate of 2.0 million tons a year after the Eveleth Taconite Co. and Hibbing Taconite Co. start up their new pellet production facilities in Minnesota in 1976. Imports from the U.S.A. in 1973 accounted for 81 per cent of total imports. Other imports from Brazil and Sweden were utilized at the new direct reduction plant and steelmaking complex of Sidbec-Dosco Limited, Contrecoeur, Quebec, where the ores were mixed with IOC, Carol division pellets and Hilton pellets before feeding to the reduction reactor. Brazilian ore was imported by Sydney Steel Corporation, Sydney, Nova Scotia, to supplement iron ore supplied by IOC.

Table 4. Receipts, consumption and stocks of iron ore at Canadian iron and steel plants, 1972-73

	1972	1973
	(long tons)	
Receipts imported	1,523,839	2,731,772[1]
Receipts from domestic sources	9,741,839	10,388,613[2]
Total receipts at iron and steel plants	11,265,678	13,120,385
Consumption of iron ore	11,711,134	13,285,745[3]
Stocks of ore at iron and steel plants, December 31	4,031,719	3,882,225
Change from previous year	-495,595	-149,494

Source: American Iron Ore Association, compiled from company submissions.
[1]Compared with 2,646,913 tons in Table 1.
[2]Compared with domestic shipments of 10,465,182 tons compiled by Statistics Canada.
[3]Compared with 13,299,461 tons compiled by Statistics Canada for blast furnace consumption.

Consumption

Iron ore consumption at Canadian iron and steel plants was 13.1 million tons, some 1.85 million tons more than iron ore consumption in 1972. Domestic iron ore requirements were met by receipts from domestic producers amounting to 10.47 million tons and imports amounting to 2.65 million tons.

World supply and demand

All the major world steel producers increased production in 1973 as total output rose from the previous year by about 10.7 per cent to a record 696 million metric tons.* World iron ore production (shipments) increased 13.6 per cent from the previous year to achieve a record of 828 million metric tons. World production in 1971 and 1972 was 770 and 759 million metric tons respectively.

The U.S.S.R., with production (shipments) of 216 million metric tons, was the leading producer, followed by United States, Australia, France, China, Canada and Brazil. Australia again led major exporters in 1973 with export shipments of 75 million metric tons while Brazil placed second with export shipments of 42 million metric tons. The U.S.S.R. and Canada held third and fourth positions with exports of 39 and 37.7 million metric tons respectively.

Australia made the greatest gain in iron ore production over the previous year with an increase of 19.5 million metric tons. Other significant production increases were made in Brazil, 12 million metric tons; United States, 11.9 million metric tons; and Canada 11.3 million metric tons.

*A metric ton is 2,204.6 pounds.

Table 5. World production[1] of iron ore, 1972-73

	1972	1973^p
	('000 metric tons)	
Canada	38,734	49,990
United States	75,493	88,397
France	54,856	60,625
Sweden	33,124	34,811
Eastern Europe	14,722	15,155
U.S.S.R.	207,600	216,000
Australia	62,849	82,319
India	35,196	33,895
Brazil	30,516	42,525
Chile	8,640	9,432
Peru	12,000	13,000
Venezuela	17,328	21,030
Angola	4,846	6,205
Liberia	24,594	26,192
Mauritania	9,252	10,286
South Africa	11,172	10,700
Others	113,851	107,597
Total	755,773	828,159

Sources: Mineral Development Sector, various statistics including *Metal Bulletin*, June 4, 1974.
[1]Shipments.
^{e}Estimated; ^{p}Preliminary.

Markets and prices — general

Excluding eastern Europe, which imports iron ore mainly from the U.S.S.R., there are three major market regions for iron ore – United States, Western Europe and Japan. In 1973, Canada exported iron ore to all these market regions. Shipments to the United States represented 57 per cent of total exports; shipments to western Europe represented 33 per cent and shipments to Japan represented 8 per cent.

International iron ore fob prices generally increased in 1973 to reflect negotiated price adjustments for massive increases in operating costs and the currency losses due to U.S. dollar devaluations. International iron ore delivered costs (cif) in U.S. dollars increased substantially from 1972 to reflect marked increases in world shipping rates as well as fob price increases. Some producers were compensated only for successive devaluations of the U.S. dollar and other producers delivered ore at low 1972 price levels. The average European and Japanese import cost of iron ore was reduced in 1972 from the previous year.

During 1973, sea freights on iron ore increased markedly. By the fourth quarter of the year freights touched unprecedented levels because of the world petroleum crisis, increased bunker fuel costs and an increased demand for spot charters.

United States market

Prices for United States domestic shipments and the bulk of its imports are established at the beginning of each year according to a published price schedule called the Lake Erie base price. This price schedule applies to Canadian and Venezuelan imported into the U.S.A. as well as most Canadian ores delivered to Canadian steel producers. The Lake Erie base prices increased at the beginning of 1973 by 4.7 per cent for natural ore and 3.8 per cent for iron ore pellets. The Hanna Mining Company, a major U.S. iron ore firm, departed from traditional procedure when it raised prices in March 1973 amounting to U.S. 20 cents a ton for natural ore and 3/10 of a cent a long-ton unit of iron* contained in pellets to cover increases in rail and Great Lakes vessel rates. A further increase of 2.2 per cent was obtained for pellets in October 1973. During the year, iron ore prices increases were constrained by the U.S. government's price controls. Because the price increases essentially reflected increased costs of labour, fuel, supplies and transportation, these price increases were adopted by other producers who operated under rapidly-moving inflationary cost pressures. Hanna posted a major across-the-board increase in the Lake Erie base price on May 1, 1974, following the lifting of U.S. price controls. The price increases amounted to U.S. 5.5 cents a long-ton unit contained in pellets and U.S. $1.44 a long ton for iron ores.

The United States' iron ore demand brought capacity domestic production of 87.2 million tons; U.S. imports of iron ore for consumption increased 20 per cent in 1973 from the previous year to reach 43.3 million tons. Canada was the largest supplier of imported ore (21.6 million tons) providing about 50 per cent of total U.S. imports.

Venezuela was the second largest supplier of iron ore to the United States providing 13.1 million tons. The price of Venezuelan direct-shipping ore from two U.S.-owned mines (58 per cent - iron base), fob, Puerto Ordaz, has been tied to the Lake Erie base price for Mesabi non-Bessemer ore. The fob Venezuelan prices increased from U.S. $9.10 a long ton in October 1972; U.S. $9.38 on January 1, 1973; U.S. $9.60 in April 1973; U.S. $9.69 in August 1973; U.S. $9.76 in October 1973 and U.S. $10.05 in January 1974. In March 1973, the Venezuelan government initiated a new policy to set and monitor fob export prices through its Ministry of Mines and Hydrocarbons. Price changes will be adjusted according to Lake Erie base price changes.

European market

Europe's steelmakers, unlike those in the United States and Japan, obtain about half of their iron ore through annual contracts, usually negotiated in December of the preceding year. Notwithstanding a steep rise in European steel production in 1973, fob prices obtained by world producers in this market were mixed. The principal factor accounting for this situation was that demand for iron ore by European steelmakers came after most ore sellers settled their contracts in late 1972. The earlier state of oversupply in late 1972 gave way to a measure of shortage in 1973. In the bargaining for 1973, Swedish sellers, who are price leaders in the European market were, in general, obliged to accept reductions on the prices that were established by the two-year agreement of 1971. These reductions varied, but for high-phosphorous ores, they amounted to 12 per cent. The statistical figure, in practice, worked out to 5-6 per cent. In late 1973, all 1974 production from Swedish mines was sold forward, with

*A long-ton unit of iron is 22.4 lb. of iron contained in ore.

Table 6. Lake Erie base prices of selected ores, 1964-74

	1964-69	1970	1971-72	1973[1]	1973[2]	1974[3]
	($U.S. a long ton[4])					
Mesabi Non-Bessemer	10.55	10.80	11.17	11.71	11.91	13.85
Mesabi Bessemer (+ phos. premium)	10.70	10.95	11.32	11.86	12.06	14.00
Old Range Non-Bessemer	10.80	11.05	11.42	11.96	12.16	14.10
Old Range Bessemer	10.95	11.20	11.57	12.11	12.31	14.25
High Phosphorous	10.55	10.80	10.80	–	–	–
Pellets (per long ton natural unit)[5]	0.252[6]	0.266	0.280	0.291	0.300[7]	0.355

[1]Increase effective January 1, 1973. [2]Increase effective March 1973. [3]Increase effective May 1, 1974. [4]51.5% of iron natural, at rail of vessel, lower lake port; coarse ore premium: 80¢ a ton and penalty for fines: 45¢ a ton. [5]Equals 1% of a ton, i.e., 22.4 pounds for a long-ton unit. An iron ore containing 60% Fe, therefore, has 60 units. [6]Price applicable for years 1962 to 1969. [7]Increases effective March 1973 and October 1973.

European agreements calling for increases of 20-25 per cent above 1973 prices. However, the 1974 contract price increases were 10–12 per cent higher than 1971 prices, or equivalent to an overall price rate increase of 3 per cent a year. Some other European ore imports increased in price in 1973 and spot prices rose sharply in the year, reflecting the large European demand over and above contracted tonnages.

Canadian fob prices for European exports were, as a whole, about the same as the previous year for pellets, U.S. 24 cents to U.S. 25 cents a long-ton unit, while concentrate prices increased from about U.S. 12 cents to U.S. 14 cents an iron unit. European iron ore prices are expected to rise sharply in 1974.

Japanese market

Japan's steel production in 1973 increased about 23.1 per cent from the previous year, iron ore imports increased about 21 per cent to 135 million metric tons. Average 1973 cif prices of iron ore imported into Japan increased 7.3 per cent from the previous year to reach U.S. $12.26 per wet metric ton. Currency realignments had an important impact on prices of world ores entering the Japanese market, especially prices for Australian ores. Because Australia raised the exchange value of its dollar in December 1972 and February 1973, the Australian dollar increased in value more than 26 per cent in terms of the U.S. dollar. The currency realignments resulted in lowered values for Australian iron ore exports tied to long-term contracts between Australian producers and Japanese consumers because the contracts were written in terms of U.S. dollars. Australian producers were successful in renegotiating their contract prices to achieve an average 15 per cent increase in the fob price of iron ore exports over the previous contracted prices.

Table 7. Representative fob prices of Australian lump, fines and pellets[1] according to Japanese contracts, 1966-73

	Hamersley		Goldsworthy		Mt. Newman	
	Lump	Fines	Lump	Fines	Lump	Fines
	($ U.S./dry long ton, 64% Fe basis)					
1966-67	9.92	7.68	9.86	7.25	Nil	Nil
1968	9.37	7.68	9.37	7.68	9.37	7.13[3]
1969	9.37	7.63	9.37	7.68	–	–
1970	9.58	7.23[3]	9.86	7.95	9.58	7.23[3]
1971	9.58	7.95	9.58	7.25[3]	9.58	7.25[3]
1972[2]	–	–	–	–	–	–
1973[4]	10.96	8.68	10.96	8.68	10.96	7.89-8.45

Source: Japan Commerce Daily and others.
[1]Long-term contracts in force at beginning of 1973 with Hamersley and Robe River (18.5 U.S. ¢/lt unit), BHP Whyalla (18.3 U.S. ¢/lt unit), and Savage River (50% at 18.5 U.S. ¢/lt unit, and 50% at 22 U.S.¢/lt unit). Beginning April 1973 these prices were raised 17-20 per cent to 22.3 U.S. ¢/lt unit for Hamersley and Robe River pellets, 21.4 U.S. ¢/lt for Whyalla pellets, and 22.0 and 24.0 U.S. ¢/lt for Savage River pellets. [2]No spot or pertinent long-term contracts were concluded in 1972. In fact, Japanese steelmakers reduced 1972 intakes substantially from the basic contract volumes. [3]62 per cent Fe. [4]Typical values. Prices for lump and fines were increased by 17 and 13 per cent, respectively.

The Australian price increases amounted to 17 per cent for lump ores and pellets and 13 per cent for fines (in terms of Australian dollars). The average delivered (cif) price a wet metric ton of Australian iron ore imported into Japan increased from U.S. $11.11 in 1972 to U.S. $11.65 in 1973. Australia supplied 65 million metric tons of iron ore to Japan or 48 per cent of Japan's total imports in 1973.

Brazilian ores, shipped by Companhia Vale Do Rio Doce (CVRD) to Japan were raised by an average of 13 per cent in April 1973. The average cif price per wet metric ton of Brazilian iron ore imported into Japan increased from U.S. $10.72 in 1972 to U.S. $11.65 in 1973. CVRD's shipments to Japan amounted to 13.8 million metric tons. Marcona pellets from Peru were raised by one U.S. cent a metric-ton unit[1] to bring the price up to U.S. 26.25 cents a metric-ton unit.

Japanese integrated steelmakers hold a joint contract with Hanna Mining, managing agent for Iron Ore Company of Canada to purchase Carol division concentrates at a rate of 5 million tons a year over 15 years starting April 1, 1973. The price at U.S. 16.4 cents a metric-ton unit will be raised by 85 cents a ton, beginning January 1, 1974 (for concentrates containing 64% Fe, this amounts to about 1.3¢ a metric-ton unit).

In British Columbia, Texada Mines Ltd.'s contract was revised from U.S. $11.62 a dry metric-ton c and f to U.S. $9.12 a dry metric-ton fob price, commencing October 1973. Wesfrob Mines Limited, was contracted to receive U.S. $9.12 a dry metric ton fob for its sinter feed and U.S. $9.07 fob a dry metric ton for its pellet feed.

The average cif price of a wet metric ton of Canadian iron ore imported into Japan increased from U.S. $12.16 in 1972 to U.S. $13.69 in 1973.

Forecast and outlook

The outlook for the Canadian iron ore industry in 1974 appears excellent in the aspect of both domestic demand and export demand. Iron ore shipments should increase to 52.5 million tons with increased production resulting from correction of technical

[1]A metric-ton unit is 22.046 lb. of iron contained in ore.

difficulties of start up at Iron Ore Company of Canada's (IOC) new plant facilities. Exports should increase to about 41 million tons, and domestic shipments are expected to at least equal the 10.3 million tons consigned in 1973. The increase in export shipments will depend on the rate at which new capacity of IOC is made fully operational. A further increase in the prices of Canadian iron ore is evident in 1974.

Growth of the Canadian iron ore industry will continue to be primarily dependent on growth of export demand. About 80 per cent of production is currently exported, and domestic demand will increase, in terms of total tonnage, only modestly.

World iron ore requirements in 1980 are expected to be slightly more than 1 billion metric tons. Canadian shipments in 1980 should reach 80 million metric tons with approximately 67 million metric tons of exports and 13 million metric tons of domestic shipments. Production (shipments) in 1975 should reach 61 million tons.

World iron ore trade, which represented 41 per cent of world iron ore production in 1972, is expected to rise to 54 per cent of world iron ore production by 1980. This projection takes into account the continuing depletion of iron ore reserves in some developed consumer countries and expansion of iron ore exports from established iron ore exporting countries. Of total estimated world iron ore trade of 580 million metric tons in 1980, Japan is expected to take about 207 million tons, western Europe (excluding Scandinavia) about 156 million tons and the United States about 75 million tons.

Taking into consideration new iron ore developments that will come on stream over the next few years, principally in the U.S.A., Canada, Brazil and Australia, world production capacity should be able to meet projected demand to 1976. Additional capacity will be needed from 1976 onwards to match projected steel growth. Australia, Brazil, Canada and West Africa (Liberia and Mauritania) appear to have the best potential for significant production expansion. In quantitative terms, global iron ore reserves and additional resources are adequate to satisfy world demand well beyond the year 2000.

Actions of multinational corporations coupled with unknown political-economic aspects in years ahead make any forecasting of future directions of world iron ore production and trade somewhat tenuous. The decision of a number of producers to expand production will depend on the response of ore consumers to demands to re-establish equitable and renumerative iron ore prices following the background of the continuous decline in fob iron ore prices during the 1960's. In addition to consumer uncertainties caused by producing countries seeking higher returns on their iron ore exports, the spectre of nationalization of foreign owned iron mines in some developing countries is viewed with some apprehension by steel companies who have come to rely more and more on imports from captive foreign sources.

Iron and Steel

P. LAFLEUR

The Canadian iron and steel industry had an excellent year in 1973 when production of crude steel* attained a record level and major new capacity was brought on stream. Notwithstanding higher than normal cost increases for materials, energy and labour, production increased some 13 per cent as a result of burgeoning demand. The growth in apparent consumption was slightly lower at 10 per cent because some of the increased production was allocated to exports which increased by some 4 per cent from 1972. Also, imports were down for a number of reasons from the previous year by about 6 per cent. Shipments were particularly strong to the automotive and construction industries which together took an estimated 47 per cent of total domestic shipments.

The new production record was achieved through the start up of new plants as well as the operation of most facilities at high-capacity levels throughout the year. Although major new BOF capacity and new electric steelmaking capacity was added during the year, the net gain was only 700,000 tons** because some less efficient open-hearth furnaces were taken out of production. The total capacity was 16.1 million tons at year-end. Some 2.1 million tons of new capacity is expected for 1974 but, with the phasing out of more open-hearth capacity, the net gain should amount to 1.7 million tons, bringing total capacity to 17.9 million tons by the end of the year.

The year 1973 was also characterized by rising steel prices on both the domestic and foreign markets to reflect mainly higher material, labour, and transportation costs. Because of domestic demand, exports increased only slightly and, as a result, domestic steel companies were unable to take advantage of the higher world prices. Similarly, imports decreased slightly because of shortfalls in supplies from countries that traditionally ship to Canada. Imports also decreased in the face of price competition from Canadian steel, the delivered cost for which was much lower because of the following factors: currency realignments favouring the dollar; comparatively lower production costs; and higher shipping rates for imports that tripled from the previous year.

The year 1973 was a period of buoyant economic activity in most countries and this had a beneficial effect on world steel use and output which increased over 1972 by 10 per cent to establish a new record for the second consecutive year. Although total trade in semifinished and finished steel continued its inexorable upward trend with an increase of about 6 per cent over 1972, exports fell for some countries as home steel was allocated for domestic use.

A total of 15.3 million tons of crude steel production is forecast for Canada for 1974. Because of buoyant demand factors, the increase of 4 per cent will be largely dependent on the timing of new production facilities to be brought on stream during the year. For 1975, 1980, 1985 and 2000, consumption is forecast at 16.3, 20.8, 25.6 and 35.5 million tons while production is expected to reach 15.3, 19.1, 23.2 and 33.0 million tons. These forecasts are based on forces already at work and do not make allowances for fundamental changes or actions by industry and/or government.

* Crude steel includes ingots, semis and castings.

**The net or short ton of 2,000 pounds is used throughout, unless otherwise indicated.

Canada, steel supply and demand

Steel is made at forty-four plants* in Canada of which five are integrated plants and thirty-nine are electric steel and castings facilities (see accompanying figure for location of major facilities). Of the six pig iron plants in Canada, two–Quebec Iron and Titanium Corporation and the Port Colborne facilities of The

*A complete listing of Canadian primary iron and steel plants including steel foundries is in the booklet *Operators List 2, Primary Iron and Steel* (75 cents). More detailed statistics are compiled in MR 133, *Canadian Primary Iron and Steel Statistics to 1972* (75 cents). Both are available from the Mineral Development Sector or Information Canada.

Algoma Steel Corporation, Limited–make iron either for use in foundries or for the production of iron powder. They are therefore not considered as integrated steel production facilities in that the pig iron is not converted to steel. The four other pig iron plants–two at Hamilton, Ontario, and one each at Sault Ste. Marie, Ontario, and Sydney, Nova Scotia–are part of integrated complexes which have backward linkages into iron ore and coal production and forward linkages into manufacturing and fabrication. A fifth, but unconventional type of integrated plant, was added in 1973 with the start up of Sidbec-Dosco Limited's new direct-reduction plant at Contrecoeur, Quebec which converts iron ore to reduced iron for use in electric furnaces.

Statistics Canada reported a total steelmaking capacity of 15.97 million tons at the beginning of 1973, comprised of 6.73, 5.83, and 3.41 million tons of BOF, open-hearth and electric steelmaking capacity. See Table 3. Although the actual capacity attained

Table 1. Canada, general statistics of the domestic primary iron and steel industry, 1971-73

		1971	1972	1973[p]
Production				
Volume indexes				
Total industrial production	1961=100	184.2	196.8	213.3
Iron and steel mills[1]	1961=100	172.6	185.4	204.2
		($ million)	($ million)	($ million)
Value of shipments, iron and steel mills[1]		1,745.3	1,975.6	2,358.6
Value of unfilled orders, year-end, iron and steel mills[1]		244.8	306.7	434.8
Value of inventory owned, year-end, iron and steel mills[1]		367.3	433.3	443.6
Employment, iron and steel mills[1]		(number)	(number)	(number)
Administrative		11,293	9,691	9,859
Hourly rated		38,308	38,242	40,133
Total		49,601	47,933	49,992
Employment index, all employees	1961=100	136.8	139.0	146.8
Average hours per week, hourly rated		39.9	40.2	39.9
		($)	($)	($)
Average earnings per week, hourly rated		169.55	182.91	198.19
Average salaries and wages per week, all employees		176.38	192.28	208.13
Expenditures, iron and steel mills[1]		($ million)	($ million)	($ million)
Capital: on construction		32.6	28.2	38.8
on machinery		169.0	165.0	180.2
Total		201.6	193.2	219.0
Repair: on construction		12.4	13.6	15.0
on machinery		184.6	194.2	215.4
Total		197.0	207.8	230.4
Total capital and repair		398.6	401.0	449.4
Trade, primary iron and steel[2]				
Exports		345.2	342.1	394.6
Imports[3]		423.5	457.9	579.5

Source: Statistics Canada.
[1]S.I.C. Class 291–Iron and Steel Mills: covers the production of pig iron, steel ingots, steel castings, and primary rolled products, sheet, strip, plate, etc.
[2]Includes pig iron, steel ingots, steel castings, semis, hot- and cold-rolled products, pipe and wire. Excluded sponge iron, iron castings and cast iron pipe-compilation by Mineral Development Sector.
[3]There were negligible imports of pig iron in 1970 and 1971.
[p]Preliminary.

did not differ much from that anticipated, there were major changes in the capacity mix with completion by Algoma of facilities earlier than expected. In September 1973, the company closed its open-hearth shop and brought into production a BOF facility of 2.8 million tons capacity. Therefore, at the end of 1973 total steelmaking capacity stood at 16.124 million tons comprised of 8.200 million tons of BOF capacity, 4.510 million tons of open-hearth capacity and, as predicted, 3.413 million tons of electric steelmaking capacity.

According to company reports, some 2.138 million tons of new capacity is expected in 1974–Algoma, The Steel Company of Canada, Limited (Stelco) and Dominion Foundries and Steel, Limited (Dofasco) will add 700,000; 500,000; and 200,000 tons, respectively, to BOF capacity and six new plants or expansions will add 763,000 tons to electric steelmaking capacity. However, with open-hearth capacity reduced by 360,000 tons to 4.15 million tons the net gain expected is only 1.78 million tons bringing total capacity to 17.9 million tons a year for an increase of 11.1 per cent over 1973.

Production and shipments

Both raw steel production at 14.8 million tons and mill shipments of rolled steel products (including steel semis and steel castings) at 11.5 million tons were at record levels in 1973. Increases in production and shipments over 1972 were 12.9 and 10.3 per cent, respectively. This compares with increases of 7.4 and 5.4 per cent in 1972 over 1971.

Oxygen steel production, which surpassed open-hearth production for the first time in 1972, amounted to 7.4 million tons and comprised 50 per

Table 2. Canada, pig iron production, shipments, trade and consumption, 1971-73

	1971	1972	1973^p
		(net tons)	
Furnace Capacity, December 31			
Blast	10,125,000	10,410,000	10,470,000
Electric	782,000	705,000	675,000
Total	10,907,000	11,115,000	11,145,000
Production			
Basic iron	7,835,632	8,510,470	9,627,429
Foundry iron	780,124	853,423	883,565
Malleable iron	*	*	*
Total	8,615,756	9,363,893	10,510,994
Shipments			
Basic iron	47,883	53,042	63,594
Foundry iron	709,545	895,502	952,433
Malleable iron	*	*	*
Total	757,428	948,544	1,016,027
Imports			
Net tons	670	4,125	2,052
Value ($000)	39	17[illegible]	183
Exports			
Net tons	549,454	688,982	641,987
Value ($000)	32,767	38,316	40,768
Consumption of pig iron			
Steel furnaces	7,676,289	8,362,780	9,515,584
Iron foundries	279,384	293,287	348,907
Consumption of iron and steel scrap			
Steel furnaces	6,226,859	6,616,320	7,493,341
Iron foundries	1,070,664	1,111,915	1,366,625

Source: Statistics Canada, Primary Iron and Steel (monthly); Iron and Steel Mills (annual) and Iron Castings and Cast Iron Pipe and Fittings (monthly).
*Included under "Foundry iron".
^{p}Preliminary.

cent of the total steel produced in 1973. Open-hearth production declined from 5.2 million tons to 4.6 million tons while electric steel production rose some 17.6 per cent to 2.7 million tons. The high-average capacity utilization of 92 per cent in 1973 compared with about 86 per cent in 1971 and 1972 indicates the buoyant demand for steel during the year which saw many plants operating at capacity.

In 1973 the value of mill shipments, including that for rolled steel products, pig iron, steel castings, coke oven products and ferroalloys amounted to $2.4 billion compared with $2.0 billion the year before. The difference between the increase in value of 19.4 per cent and the increase in mill shipments of 10.3 per cent reflects major increases in the cost of materials and in the cost of labour which rose some 12.9 per cent to $541 million as well as increases in company profits.

Stelco was the leading producer of steel in 1973 with 5.7 million tons, followed by Dofasco with 3.0 million tons, Algoma with 2.7 million tons and Sydney Steel Corporation (Sysco) with 0.8 million ton. Together, the four integrated producers not including Sidbec-Dosco, which began the production of steel using sponge iron during the year, accounted for 82 per cent of Canadian production. Of 39 companies producing steel in Canada, twelve at sixteen locations account for 98 per cent of all production. See Table 4. The others are mostly small-tonnage steel foundries.

The 12.3 per cent increase in pig iron production to 10.5 million tons nearly paralleled the increase in steel production. This is understandable in view of the fact that some 90 per cent of production is used to make steel directly. The remaining 10 per cent, or 1.0 million tons, was cast into shapes and sold to foundries–some 641,000 tons were shipped to the United States and 375,000 tons to domestic plants.

The principal product shipped in 1973 was hot-rolled sheet and strip at 2.6 million tons, followed by cold-rolled sheet and strip at 1.9 million tons, bars at 1.8 million tons and plate at 1.3 million tons. Increased shipments over 1972 were recorded for almost all the product lines; the largest growth in terms of tonnage was for flat-rolled products, accounting for 61 per cent of all shipment in 1973. Two industries, automotive and construction, absorbed some 75 per cent of the increase in shipments in 1973, while shipments to most other industry groups had little or no growth. The consumers were placed on allocation by the producers during the year because of the unavailability of steel to fill all the demand. Notwithstanding the higher prices that could be obtained in foreign markets, producers sought to fill domestic needs first and, as a result, exports increased only marginally.

Trade

Imports of rolled steel, semis and fabricated products such as wire and pipe were slightly down to 2.4 million tons from 1972, while exports were slightly up to 1.7 million tons. The net trade balance has been maintained at about the same level since 1971 when the present world steel cycle began, which saw increasing production in almost all countries. Exports have remained stable notwithstanding increased Canadian production and the possibility of obtaining higher steel prices for foreign sales. Imports have not increased in the last three years because of the competitiveness of Canadian steel prices, the maintenance of effective tariff rates, and the cost of transportation on the one hand and the buoyant demand for steel in countries that traditionally ship to Canada on the other hand.

Canada's principal trading partner is the United States and imports were up 200,000 tons to 1.1 million tons in 1973. Transportation costs are not a major factor in the delivered cost from the U.S. because most of the imports originate from plants situated along the Great Lakes. Also, Canadian tariffs do not apply to steel products consumed in auto manufacture, covered under the Automotive Agreement. The same factors apply to Canadian steel sold in the United States, Canada's largest market, which took some 1.2 million tons or 69 per cent of total exports in 1973. Imports from all other countries were down from 1972, particularly those from Japan, which ships large tonnages into British Columbia and to which the transportation charge from eastern Canada is high.

While the domestic deficiency has shrunk for most steel products, the Canadian market may still not be sufficiently large to justify the investment in mills to produce them. The deficiency gap is never static, and there is always a new demand for products that the Canadian steel industry cannot immediately produce.

Consumption

Apparent consumption of crude steel increased 9.9 per cent to 15.7 million tons in 1973. This was lower than the increase in production at 12.9 per cent because some of the production was allocated to increased exports, which increased by 3.6 per cent. More important, production was higher to replace imports which, for a number of reasons, were down from the previous year by 5.8 per cent.

Investments and corporate developments

Capital and repair expenditures in 1973 for iron and steel mills amounted to $449 million compared with $401 million in 1972. Of this total, about half was spent on new buildings and equipment and the other half on repairs to structures and machinery. The ratio of repair expenditures per ton of ingot steel produced was $15.61 a ton, down slightly from the 1972 figure of $15.90 a ton. Total expenditures for pipe and tube mills and for iron foundries at $33 million and $30 million, respectively, were also up from the previous year. With projects either under way or announced, capital expenditures should again increase in 1974.

Table 3. Canada, crude steel production, shipments, trade and consumption, 1971-73

	1971	1972	1973p
		(net tons)	
Furnace capacity, January 1			
Steel ingot			
Basic open-hearth	6,970,000	5,380,000	5,830,000
Basic oxygen convertor	4,400,000	6,690,000	6,730,000
Electric	2,294,450	2,961,600	2,977,800
Total	13,664,450	15,031,600	15,537,800
Steel castings	418,925	429,525	436,525
Total furnace capacity	14,083,375	15,461,125	15,974,325
Production			
Steel ingot			
Basic open-hearth	6,330,838	5,164,585	4,608,197
Basic oxygen	3,934,965	5,601,287	7,433,896
Electric	1,698,429	2,125,934	2,507,127
Total	11,964,232	12,891,806	14,549,220
Continuously cast in total	1,393,724	1,535,761	1,709,682
Steel castings[2]	205,320	181,067	206,159
Total steel production	12,169,552	13,072,873	14,755,379
Alloy steel in total	1,046,502	1,200,946	1,546,231
Shipments from plants			
Steel castings	200,037	174,027	191,617
Rolled steel products	9,220,748	9,829,866	10,935,708
of which steel ingots	503,817	323,935	388,853
Total	9,917,164	10,458,121	11,584,317
Exports[3] equivalent steel ingots	2,130,320	2,126,290	2,203,290
Imports[3] equivalent steel ingots	3,136,105	3,355,164	3,162,161
Indicated consumption, equivalent steel ingots	13,175,337	14,301,747	15,714,250

Source: Statistics Canada.
[1]The capacity figures as of January 1 for each year are in anticipation of either new capacity to be installed or old production facilities that may become obsolete during the year. [2]Includes basic open-hearth and electric. [3]Computed by Mineral Development Sector.
p Preliminary.

The Steel Company of Canada, Limited (Stelco) was the leader among Canadian steel companies in capital spending for 1973, with investment in plant and mining properties amounting to $117 million. Major expenditures were for improvements at the Hilton Works, Hamilton, Ontario, new steel-making facilities at Contrecoeur, Quebec, and at Edmonton, Alberta, and for a spiralweld pipe mill at Welland, Ontario.

Major modernization and expansion projects that were completed at the Hilton Works included the conversion of a rod mill to bar mill production; a new slab-cooling and handling system was added to the universal slabbing mill to expand output; the production capacity of the hot-strip mill was increased with the installation of a fifth slab-heating furnace and ancillary facilities; and the construction of four additional soaking pits that raised the capacity of the No. 3 bloom and billet mill.

Under construction during the year (and completed in June, 1974), was a $26 million steel furnace plant at Stelco's Edmonton plant. Two furnaces of 75-ton capacity and a new continuous casting machine will be capable of producing 300,000 tons of steel

Table 4. The major* producers of steel in Canada, 1973

		Crude steel (net tons)	rank
The Steel Company of Canada, Limited			
Hilton Works	5,589,000		
Edmonton	133,000		
Total		5,722,000	1
Dominion Foundries and Steel, Limited		3,036,000	2
The Algoma Steel Corporation, Limited		2,651,000	3
Sydney Steel Corporation		811,000	4
Sidbec-Dosco Limited			
Contrecoeur	350,000		
Montreal	226,000		
Total		576,000	5
Interprovincial Steel and Pipe Corporation Ltd.		381,000	6
Lake Ontario Steel Company Limited		323,000	7
Atlas Steels			
Welland	195,000		
Tracy	65,000		
Total		260,000	8
Burlington Steel Company		236,000	9
Manitoba Rolling Mills		186,000	10
Canadian Steel Wheel Limited		167,000	11
Western Canada Steel Limited			
Vancouver	70,000		
Calgary	60,000		
Total		130,000	12
Grand Total		14,479,000**	

* Production 100,000 tons or over.
**Represents 98% of total production of crude steel in 1973.

billets a year. However, the net gain in capacity will be about 172,000 tons because the old plant of 128,000-ton capacity will shut down. The installation of a $14.5 million, 80-ton electric arc furnace was begun in 1973 at Stelco's McMaster Works in Contrecoeur and was completed in early 1974. The furnace will feed directly to a new continuous casting operation that can produce 175,000 tons of steel billets a year. Both the Edmonton and Contrecoeur operations will supplement their iron and steel scrap charge with reduced pellets from the new SL/RN reduction plant being built at the company's Griffith Mine in northwestern Ontario.

In early 1974 Stelco completed the installation of a new $18 million spiralweld-tube mill at its Page-Hersey Works near Welland, Ontario. The plant, capable of producing pipe from 30 to 60 inches in diameter, has the capacity to produce 700,000 tons a year of 56-inch pipe. Stelco previously could only make pipe up to 42 inches in diameter and, therefore, the new pipe mill will allow Stelco to compete in the market for large-diameter pipe that is expected to develop within the next few years to bring oil and gas from the Arctic to southern markets in Canada and the United States.

Stelco began construction of reduction facilities at its Griffith Mine in northwestern Ontario in 1973. The SL/RN process, developed by a consortium including Stelco, will convert a portion of the high-quality oxide pellets produced at the mine to a reduced product grading as high as 92 per cent iron. This product will be used as a supplement to the scrap charge in Stelco's new steelmaking plant at Contrecoeur, Quebec, and at its expanded steelmaking operations at Edmonton, Alberta. The plant's rated capacity is 400,000 tons a year and the expected cost is $35 million.

The Algoma Steel Corporation, Limited (Algoma) recorded the second largest capital investment among steel companies in 1973. A $50 million basic oxygen steel plant was completed during the year, and construction began on a 5,000-ton-a-day blast furnace. With the start up of the new steel shop and the shutdown of its open-hearth furnaces, the effective steel capacity (all BOF) was raised from 2.6 million tons to 2.8 million tons. When the new blast furnace is completed in 1975, the effective steel capacity will be raised to 3.5 million. Construction of a 1,500-ton-a-day coke battery began in early 1974 and, when completed in 1975, will provide an adequate supply of coke so that the new blast furnace can then operate at its full-rate capacity. With the additional coke supply, hot metal throughput will again increase and steel capacity will be raised to 4.0 million tons.

Algoma had under construction at year-end a 2-strand continuous slab caster that will provide slabs up to 10 inches thick and from 40 to 85 inches wide. It will be on-line with the 166-inch plate mill which can either produce plate or acts as the roughing mill for the 106-inch hot-strip mill that will be relocated downstream of the plate mill. At year-end, the wide-flange beam mill facilities were being expanded and modified. When these improvements are completed in 1975, capacity to produce structural shapes will be increased by over 20 per cent.

Canadian Pacific Investments Limited acquired a majority interest in Algoma through the purchase of the 25 per cent interest held by Mannesmann A.G., of West Germany and by the purchase in mid-1974 of 2.5 million shares on the open market.

Dominion Foundries and Steel, Limited (Dofasco) made expenditures in 1973 amounting to $41 million. The company announced that it will start construction of a 5-strand, 72-inch tandem cold mill early in 1974, capable of rolling at 5,000 feet a minute. It is estimated that the new mill will cost upwards of $50 million and, when completed in 1975, will increase Dofasco's cold-rolling capacity by 60,000 tons a month to a total of 180,000 tons a month. The mill is the first step in a program designed to eventually double the company's capacity to 6 million tons of crude steel per annum over the next 7 to 10 years. The company's No. 1 blast furnace, which was shut down in 1971, will be rebuilt at an estimated cost of $15 million. When it comes on stream sometime in 1975 it will increase Dofasco's pig iron capacity by approximately 1,600 net tons a day.

Table 5. Canada, net shipments of rolled steel products by type, 1971-73

	1971	1972	1973^p
		(net tons)	
Hot-rolled products			
Semis	448,723	323,935	388,853
Rails	297,618	170,176	301,986
Wire rods	611,396	690,256	801,185
Structurals			
Heavy	557,592	636,597	636,369
Light	144,220	151,696	164,204
Bars, concrete reinforcing	755,645	707,126	757,391
Bars, other hot-rolled	799,877	894,165	1,048,969
Tie plate and truck material	83,765	67,664	55,673
Sheet and strip	1,871,037	2,279,105	2,574,965
Plates	1,174,222	1,285,260	1,345,722
Total	6,744,095	7,205,980	8,075,317
Cold-rolled products			
Bars	68,799	82,334	98,415
Sheet, tin mill black plate and tin plate	1,698,388	1,753,436	1,851,353
Galvanized sheet	709,466	788,116	910,623
Total	2,476,653	2,623,886	2,860,391
Total shipments	9,220,748	9,829,866	10,935,708
Alloy steel in total shipments	525,425	565,110	685,266

Source: Statistics Canada, Primary Iron and Steel (monthly).
^{p}Preliminary.

The Sydney Steel Corporation (Sysco), a company owned by the Nova Scotia government and Canada's fourth largest steel producer, completed several major projects during the year. These included a new $15 million rail-finishing mill; a 450-ton-a-day oxygen plant; a new hot blast stove and a major rebuilding of a blast furnace. This modernization is part of a $72 million program begun in 1971. Also as part of the program, a continuous slab-caster was under construction at year-end that will cost $16 million (original estimate) when finished in 1974. In May, 1973 in Sysco repurchased the coke ovens sold in 1968 to the Cape Breton Development Corporation (Devco), a federal agency which operates the Sydney coal mines.

Sidbec-Dosco Limited became Canada's fifth integrated steel producer* with the completion of its Midrex reduction plant in early 1973. The Contrecoeur, Quebec, plant produces a 93 per cent metallized product from oxide pellets and natural ores at daily production rates of from 1,000 to 1,100 tons for charging to electric furnace as a supplement to scrap. The start up of the reduction facilities marked the end of Phase I of the company's program, which started in 1969, to raise annual steelmaking capacity from 165,000 tons to 880,000 tons (including 380,000 tons a year at Sidbec's Montreal Works). However, Sidbec is still short of steelmaking capacity because its rolling mills have a combined capacity to process about 1.2 million tons of raw steel a year, and the purchase of steel ingots and semis continue to be made from outside sources to compensate for the shortfall.

Phase II, announced by Sidbec in 1973, calls for two electric furnaces that will raise steelmaking capacity by 700,000 tons to 1.58 million tons a year; a second reduction plant to increase total reduction capacity to one million tons a year; and additions to rolling milling capacity including a continuous galvanizing line. The program will cost an estimated $185 million and is expected to be completed by 1978.

Interprovincial Steel and Pipe Corporation Ltd. (IPSCO) had total capital expenditures in 1973 of $17 million of which, $12 million was for the purchase of two pipe mills from the West German owners of Canadian Phoenix Steel & Pipe Ltd. and $5 million was for expansion of facilities at its Regina, Saskatchewan, steel plant.

IPSCO obtained from Canadian Phoenix two pipe and tube plants at Edmonton, Alberta, and two pipe mills at Port Moody, British Columbia. In addition, the company entered into a five-year contract with Canadian Phoenix to manage its pipe mill situated at Calgary, Alberta. IPSCO's total capacity including the managed plant amounts to 853,000 tons. With pipe mills at three locations in western Canada, IPSCO's ability to fully service the oil and gas industry's tubular requirements is greatly improved. This forward integration into fabricated products will increase the demand for skelp from its recently expanded Regina steelmaking facilities.

With the installation of a new electric furnace at Regina early in 1973, ingot capacity was doubled to 600,000 tons a year. However, it was not possible to take full advantage of the increased melt capacity until mid-1973 when two additional soaking pits were completed. Consequently, steel ingot production increased only 26 per cent in 1973 to 381,000 tons.

A $68 million expansion program over the next two years is being planned by IPSCO that will include the construction of a $28 million sponge iron plant at Regina to produce about 400,000 tons of reduced iron to supplement the scrap charge, and the installation of a fifth steelmaking furnace to increase capacity from 600,000 to one million tons a year. IPSCO's annual report states that the company purchased a used cold-rolling mill of about 100,000-ton capacity. The mill is being stored until galvanizing facilities are acquired because the major portion of the cold-rolled product would most likely be galvanized. It was also reported that the company will be installing two more spiral-pipe mills at Edmonton. On December 20, 1973, Ipsco announced that it had agreed in principal to grant an option to the government of Alberta for the purchase of 938,400 shares; it also offered similar options to the government of Saskatchewan (135,200 shares) and to Slater Steel Industries Limited (52,400 shares). With the exercise of the option in April, 1974, Saskatchewan and Slater Steel will each control 20.1 per cent of IPSCO.

The Atlas Steels Division of Rio Algom Mines Limited, Canada's largest producer of stainless and special steels, announced early in 1974 a $20 million program for a new melt shop at its Welland, Ontario, plant. The program, to be completed in late 1976, will replace the six furnaces now in use by two 60-ton and one 25-ton furnaces. A $2.5 million "baghouse" filtering system to clean effluents from the air will also be installed as well as a $1.5 million forging press and a third Sendzimir cold-rolling mill which will increase the cold-rolling capacity by 50 per cent. To improve the quality of the stainless steel produced at its Tracy, Quebec, plant, a $1.3 million oxygen degassing unit is being installed.

The Burlington Steel Division of Slater Steel Industries Limited had a furnace rebuilding program underway at year-end to increase melting capacity from 254,000 tons a year to 320,000 tons a year. To be completed in 1974, the program will cost an estimated $2 million. Finishing capacity was expanded in 1974 from 175,000 to 250-275,000 tons a year through modification of its bar mill and other improvements.

*The four others located at Hamilton, Ontario (Stelco and Dofasco); Sault Ste. Marie (Algoma) and Sydney (Sysco) reduce iron ore by blast furnaces followed by refining in either BOF or open-hearth steel furnaces.

Table 6. Canada, net shipments of rolled steel products (carbon and alloy) to consuming industries, 1971-73

	1971	1972	1973^p
		(net tons)	
Automotive and aircraft	1,105,710	1,328,057	1,683,904
Agricultural equipment manufacturers	134,509	201,440	211,453
Construction	1,514,133	1,652,674	1,839,296
Containers	529,845	533,269	590,861
Machinery and tools	300,751	310,345	340,129
Wire, wire products and fasteners	584,263	692,189	795,593
Resources and extraction	194,638	197,515	238,100
Appliances, utensils, stamping, pressing	693,428	749,610	857,024
Railway operating	331,591	213,548	279,862
Railway cars and locomotives	108,336	131,987	130,924
Shipbuilding	52,906	55,285	50,913
Pipes and tubes	1,161,746	1,261,453	1,298,356
Wholesalers and warehouses	1,229,124	1,261,156	1,556,067
Miscellaneous	61,604	66,940	72,797
Total	8,002,584	8,655,468	9,945,279
Direct exports[1]	1,218,164	1,174,398	990,429
Total	9,220,748	9,829,866	10,935,708

Source: Statistics Canada, Primary Iron and Steel (monthly).
[1]Includes only producer exports and excludes exports of steel castings, pipe and wire. These categories are included in export statistics by Trade of Canada which recorded producer and nonproducer exports of 1.656, 1.636 and 1.697 million tons in 1971, 1972 and 1973, respectively (Table 7).
[p]Preliminary.

The Manitoba Rolling Mills Division of Dominion Bridge Company, Limited (owned 43½ per cent by Algoma) at Selkirk, Manitoba, commenced construction in 1973 of a new $28.5 million merchant bar-rolling mill. To be completed at the end of 1975, the mill will replace two obsolete smaller mills.

The Ivaco Rolling Mills Division of Industrial Fasteners Ltd. (Ivaco Industries Limited) at L'Orignal, Ontario, had under construction at year-end an electric furnace and continuous casting facilities to produce 275,000 tons of billets a year. Currently, the company purchases billets to supply its rod mill which has a capacity of 225,000 tons a year. The rods are distributed to the company's other manufacturing operations for use in the production of wire, fasteners, nails, fencing and barbed wire, welded wire fabrics, precision machined parts, and axles and suspension systems.

QSP Ltd. at Longueuil, Quebec, had a new steel plant under construction at year-end. Original plans called for the construction of a 145,000-ton-a-year steel plant with continuous casting and rolling facilities at a cost of $22.5 million. In mid-1974, the company announced that it will spend an additional $6 million to double the steelmaking capacity to 300,000 tons through the installation of a second electric arc furnace and a continuous casting machine. The company recently announced a $50 million contract to supply semifinished and finished steel products over a three-year period to Thyssen Steel of Canada Limited. Initial production is expected to start in mid-1974, with full capacity expected to be achieved sometime in 1975.

Lake Ontario Steel Company Limited (Lasco) at Whitby, Ontario, started a $6.5 million program which will increase efficiency and raise steelmaking capacity some 10 per cent to about 350,000 tons a year sometime in 1974. It was reported that the company is considering a $35 million expansion that will double steelmaking and rolling mill facilities, but the implementation of such a plan is dependent, according to the company, on obtaining sufficient iron units other than scrap, such as reduced pellets.

Western Canada Steel Limited, a wholly-owned subsidiary of Cominco Ltd., is expected to complete a $3.5 million furnace program to raise melting capacity from 110,000 to 200,000 tons by mid-1975 at its Vancouver facilities. More efficient roughing mills to prepare ingots for rolling will also be installed. Melting capacity at its Calgary, Alberta, plant will also be doubled to 100,000 tons by 1975 when the melting equipment that is being replaced at its Vancouver plant, is installed.

Table 7. Canada, trade in steel castings, ingots, and rolled products, 1971-73

	Imports			Exports		
	1971	1972	1973p	1971	1972	1973p
	(net tons 000)					
Steel castings	7.0	11.5	19.6	31.6	22.5	25.5
Steel forgings	12.0	13.0	11.3	16.9	19.8	38.7
Steel ingots	38.9	50.7	8.5	78.6	79.7	37.7
Hot-rolled products						
Semis	238.0	217.4	86.8	123.2	49.8	98.7
Rails	12.9	8.5	13.6	65.8	72.0	123.2
Wire rods	204.2	241.5	232.9	135.8	114.0	133.5
Structurals	306.2	322.9	428.5	148.6	168.2	121.4
Bars	166.1	217.1	239.1	72.4	85.8	76.5
Track material	2.7	1.8	3.4	4.7	8.6	13.7
Plates	278.9	332.7	311.6	164.0	194.2	212.1
Sheet and strip	401.9	433.4	349.4	196.1	263.2	188.5
Total hot-rolled	1,610.9	1,775.3	1,665.3	910.6	955.8	967.6
Cold-rolled and other products						
Bars	14.9	17.4	22.7	11.3	10.6	9.9
Sheet and strip cold-rolled	172.7	160.3	143.6	151.4	119.1	86.2
Galvanized	48.4	51.1	37.4	112.3	105.1	98.0
Other[1]	99.4	100.4	123.0	135.2	147.1	157.1
Pipe	274.4	257.6	270.9	180.1	136.7	216.5
Wire	76.3	86.4	97.4	28.1	39.3	60.1
Total cold-rolled and other	686.1	673.2	695.0	618.4	557.9	627.8
Total rolled products	2,297.0	2,448.5	2,360.3	1,529.0	1,513.7	1,595.4
Total steel	2,354.9	2,523.7	2,399.7	1,656.1	1,635.7	1,697.3

Source: Statistics Canada, Trade of Canada; compilation by Mineral Development Sector.
[1] Includes hot-rolled stainless sheet and strip.
p Preliminary.

Pipe and tube industry

Production in 1973 at 1,313,001 tons was up only slightly from the 1,295,064 million tons the year before. Shipments of large diameter pipe were down 22 per cent from 1972 to reflect decreased construction of big-inch pipelines during the year.

Pipe-making capacity increased sharply to 3.6 million tons with the completion of Stelco's 700,000-ton-a-year pipe plant at Welland, Ontario. Initially, the spiral mill will be able to produce pipe from 30 to 60 inches in diameter with wall thicknesses varying from 0.219 inch up to 1.125 inches. The Stelform process, developed by Stelco in conjunction with Hoesch Rohrenwerke AG of West Germany, will produce pipe some four times as fast as spiral mills currently installed in Canada. With a production rate of some 1.7 miles a day, the new mill will greatly enhance the ability of the company to participate more fully in the expanding pipeline market in Canada's north-south axis.

A major corporate development during the year was the sale of all the assets of Canadian Phoenix Steel & Pipe Ltd., a subsidiary of August Thyssen-Hutte AG of West Germany. Interprovincial Steel and Pipe Corporation Ltd. purchased two mills at Edmonton, Alberta, and one at Port Moody, British Columbia. In addition, they took over management of the Calgary, Alberta, plant. The Phoenix facilities at Toronto, Ontario, was also purchased by York Steel Construction Ltd. IPSCO with a total pipe-making capacity of 853,000 tons a year is second in size only to Stelco which has a production capacity of 1.9 million tons of pipe a year.

Dofasco purchased the Calgary, Alberta pipe facilities of Prudential Steel Ltd. early in 1973 and represents Dofasco's second entry within a year into the pipe and tube making industry. Prudential Steel's electric resistance weld mill has the capacity to produce 75,000 tons a year of small-diameter pipe. Stelco increased its interest to about 33 per cent in

Shaw Pipe Industries Ltd., which is the established leader in the pipe coating field with facilities located in five provinces as well as in Texas and Australia.

Raw materials – consumption and prices

Consumption of raw materials in the manufacture of steel was at an all-time high as suggested by the record steel production. Iron ore consumption amounted to 15.7 tons compared with 13.1 million tons the year before, while coke consumption totalled 5.1 million tons compared with 4.6 million tons in 1972. These materials and 951,000 tons of dolomite and limestone and 138,000 tons of scrap were charged to blast furnaces to produce about 9.9 million tons of pig iron for use in either steelmaking furnaces or foundries. An additional 0.6 million ton of pig iron was produced in electric furnaces from 1.9 million tons of ilmenite ore and from about 300,000 tons of coal at Quebec Iron and Titanium Corporation's Sorel plant.

Table 8. Canada, value of trade in steel castings, ingots and rolled products, 1971-73

	Imports			Exports		
	1971	1972	1973p	1971	1972	1973p
	($ 000)					
Steel castings	5,526	6,963	16,122	11,009	9,268	10,132
Steel forgings	12,042	13,204	16,496	9,660	11,364	23,248
Steel ingots	3,294	3,991	1,090	7,724	8,306	5,252
Rolled products						
Hot-rolled	214,007	237,182	302,609	142,433	138,293	150,087
Cold-rolled and other	188,597	196,428	243,175	141,567	136,556	165,125
Total	402,604	433,610	545,784	284,000	274,849	315,212
Total steel	423,466	457,768	579,492	312,393	303,787	353,844

Source: Statistics Canada, Trade of Canada; Compilation by Mineral Development Sector.
Note: The values in this table relate to the tonnages shown in Table 7.
pPreliminary.

Table 9. Canada, trade in steel by country, 1971-73[1]

	Imports from			Exports to		
	1971	1972	1973p	1971	1972	1973p
	(000 net tons)					
United States	785.2	835.7	1,055.9	1,294.0	1,236.0	1,178.6
Britain	164.0	175.8	168.7	43.5	63.3	55.6
ECSC[2] countries	364.2	536.2	410.7	41.7	62.9	118.1
Other European[3]	146.4	162.7	141.5	12.2	59.5	39.3
Africa	0.2	6.0	4.6	7.2	3.9	10.4
Japan	886.4	775.1	601.7	0.5	0.2	9.7
Other Asian	2.1	1.6	3.2	44.0	34.2	52.0
Latin America	–	3.5	8.2	172.7	142.8	165.2
Middle East	–	–	–	15.3	12.8	57.3
Oceania	6.4	27.1	5.2	25.0	20.1	11.2
Total	2,354.9	2,523.7	2,399.7	1,656.1	1,635.7	1,697.4

Source: Statistics Canada, Trade of Canada; Compilation by Mineral Development Sector.
[1]Products included are those listed in Table 7.
[2]European Coal and Steel Community (ECSC). Excludes Britain in 1973.
[3]Includes the U.S.S.R. and Satellites.
pPreliminary; – Nil.

Total metallics, excluding ferroalloys, charged to steelmaking furnaces amounted to 9.5 million tons of pig iron, up 13.8 per cent from 1972, and 7.5 million tons of scrap, up 13.3 per cent from the previous year. In addition, 167,000 tons of reduced pellets grading about 92 per cent iron were charged to electric furnaces by Sidbec-Dosco Limited. Of the scrap charged, some 4.2 million tons consisted of home scrap and 3.3 million tons were purchased.

In 1973, some 5.124 million tons of coke were used to produce 9.229 million tons of pig iron. The coke rate, the amount of coke consumed per ton of pig iron produced in blast furnaces, was therefore 0.52, about the same as in 1972. Some 7.626 million tons of coal was used to produce 5.333 million tons of coke or 1.43 tons of coking coal were required for each ton of coke produced. The three integrated steel producers in Ontario obtain most of their coal from either subsidiaries or from joint-venture mines in the United States; the remainder is purchased on a spot basis. About a quarter of Sysco's requirements is also purchased from the United States and about three quarters from Devco, a federal crown corporation which mines coal in Sydney, Nova Scotia. Considerable quantities of Alberta bituminous coal will be tested by the Ontario integrated producers in 1974.

In the United States' and Canadian Great Lakes markets, Lake Erie base prices increased at the beginning of 1973 by 4.7 per cent for natural ore and 3.8 per cent for iron ore pellets. The Hanna Mining Company departed from traditional procedures when it raised prices in March amounting to 20 cents a ton for natural ore and 3/10 of a cent a unit of iron contained in pellets to cover increases in rail and vessel rates. A further increase of 2.2 per cent was obtained for pellets in October and an across-the-board increase in the Lake Erie base prices was obtained at the beginning of 1974. Therefore, pellets that were costing 28.0 cents a unit in 1972 increased to 29.1 cents a unit in 1973, and to 29.4 cents in early 1974.

Scrap prices more than doubled during 1973 and increased again early in 1974. While most steel producers raised steel prices to compensate for the sharply rising prices at the end of the year, some electric steel companies applied a $20 to $40 a ton surcharge to their steel product prices. The rise in prices reflected the imbalance between supply and demand for raw materials. Consumption of purchased iron and steel scrap in steel furnaces and foundries amounted to 4.1 million tons representing an increase of 19.8 per cent over the purchased scrap consumed in 1972.

To supply the increased requirements, domestic scrap production increased by 46 per cent to 3.8 million tons, but this increase in supply was offset somewhat by a decrease in imports of 18 per cent which amounted to 1.0 million tons and an increase in exports of 200,000 tons which amounted to 700,000 tons. Normally, Canada is deficient in domestic supply with shortfalls being made up from imports in considerable quantities. Because of burgeoning steel production in the United States and the concomitant increase in scrap demand, embargoes were placed on scrap exports by that country which is Canada's principal supplier. At the same time, when world demand for scrap threatened Canada's supplies, Canada also placed an embargo on its exports.

The sharply increased demand for scrap that caused prices to go up, in turn stimulated the recovery of much needed supplies. The higher prices for scrap made it worthwhile for the scrap producer to gather, transport and process scrap at greater expense than had heretofore been normal. However, it is quite possible that this increase over normal supply was at the expense of inventory which would have normally come on to the market at some future date at lower prices. If this assumption is correct, further shortages within the next few years can be expected.

The Ontario integrated steel producers reported price increases for coal anywhere from 5 to 11 per cent in 1973. This stable price structure was due to United States price controls, but with their removal on April 1, 1974, prices rose by as much as 40 per cent. The expiration of labour contracts at United States coal mines in 1974 could cause labour difficulties and possible shortages. Any agreement will call for increased wages and consequently an increase in the price of United States coal.

Table 10. Canada production, trade and apparent consumption of crude steel, 1964-73

	Crude Steel Production	Imports[1]	Exports[1]	Indicated Consumption[2]
	(000 net tons equivalent ingots)			
1964	9,128	2,135	1,485	9,778
1965	10,068	2,892	1,235	11,725
1966	10,020	2,096	1,290	10,826
1967	9,701	1,981	1,368	10,314
1968	11,198	1,884	2,079	11,003
1969	10,048	2,935	1,423	11,560
1970	12,346	2,189	2,299	12,236
1971	12,170	3,136	2,130	13,176
1972	13,073	3,355	2,126	14,302
1973^p	14,755	3,162	2,203	15,714

Source: Statistics Canada.
[1]From Trade of Canada, adjusted to equivalent crude steel by Mineral Development Sector.
[2]Production plus imports, less exports with no account taken for stocks.
^{p}Preliminary.

World review

World production of raw steel increased by more than 10 per cent in 1973 compared with 1972, which was a record year. The following increases were recorded in the major producing areas: 23 per cent in Japan; 13 per cent in the United States; 9 per cent in western Europe; and 4 per cent in eastern Europe. With 150 million tons of production, the United States was the largest steel producing country displacing the U.S.S.R. which produced 144 million tons. Third was Japan with 132 million tons, West Germany with 44 million tons and France with 28 million tons. Among the developing countries, Brazil led with 7.9 million tons, followed by India with 7.6 million tons and Mexico with 5.2 million tons. Only three countries reported a decrease in production–Denmark, Chile and Venezuela.

Exports of steel from market economy countries expanded considerably, notable from Japan which, with an increase of 4.3 million tons over 1972, exported a record 27.4 million tons and surpassed the previous record established in 1971. Exports from the nine EEC countries including intra-EEC trade increased by about 1.9 million tons to 56.3 million tons. The most significant increases were in sales to Asiatic countries, the eastern European countries and Latin America. By contrast, exports to the United States decreased. For the world as a whole, total exports are estimated to have increased from 1972 by about 7 million tons to 119 million tons including intra-bloc trade.

Steel prices

Under the pressure of an expanding demand and because of a steep rise in production costs, mainly for raw materials and wages, the international prices of finished steel products rose sharply in 1973, thus accentuating a trend that began in the previous year.

In Canada, a general rise in the price of rolled steel of 3.2 per cent in April was followed by sharp increases for certain products in November and December. With further increases in January 1974, prices increased by as much as 10 per cent over the full range of products in less than a year. Steel prices fob plants for the first quarter of 1974 stood at $181 a ton for galvanized; $176 a ton for cold-rolled; $164 a ton for structurals; $157 a ton for plate; $169 a ton for merchant bars and $141 a ton for hot-rolled sheet and coil. These compared favourably with United States base prices which were priced as much as 20 per cent higher than Canadian steel. The United States prices did not include surcharges for zinc and scrap and were also artificially low due to United States price controls. Japanese prices cif Eastern United

Table 11. Consumption of iron ore by process, 1972-73 (000 net tons)

1973	Direct Shipping	Concentrates	Pellets	Mine Sinter[1]	Total
A. Sinter plant[2]	331	48	245	54	678
B. Direct reduction[3]	–	–	231	–	231
C. Blast furnace*	565	–	11,199	2,212	13,976
D. Steelmaking furnace					
Open-hearth	51	–	86	–	137
Oxygen	–	–	41	–	41
Electric	4	–	5	–	9
Grand total	951	48	11,807	2,266	15,072
1972					
A. Sinter plant[2]	116	42	241	111	510
C. Blast furnace*	351	–	10,016	1,948	12,315
D. Steelmaking furnace					
Open-hearth	52	–	155	–	207
Oxygen	–	–	35	–	35
Electric	4	–	2	–	6
Grand total	523	42	10,449	2,059	13,073

[1]Produced from siderite ore at Wawa by The Algoma Steel Corporation, Limited.
[2]Ore too fine to be charged to blast furnace–is screened of and then sintered.
[3]Sidbec-Dosco Limited reduction plant began operation in 1973 at an annual rate of 400,000 tons a year. The reduced iron produced from the shaft furnace is then melted and refined along with scrap in electric steelmaking furnaces.
*Excludes 1,949,000 tons consumed by Quebec Iron and Titanium Corporation for the production of pig iron and titania slag in 1973 and 2,264,000 tons in 1972.

States were anywhere from 31 per cent to 200 per cent higher than Canadian base prices.

The price increases reflect the increased costs for labour and raw materials. One integrated producer recorded cost increases in 1973 of 56 per cent for steel scrap; 23 per cent for zinc; 17 per cent for tin; and 11 per cent for coal as well as 12 per cent for electric power. On average, the cost of labour increased some 13 per cent over 1972.

Notwithstanding the record demand for steel, the composite price of United States steel increased only marginally because of federal price controls. The demand was sufficiently high to sustain price levels that would have produced a substantially higher margin on sales if steel markets had been permitted to function freely. Foreign steel, unhampered by price controls, were being sold to United States consumers at prices significantly higher than those that domestic producers were being permitted to charge.

Steel price increases in the United States have been limited since the start of economic controls in August, 1971. In June, 1973, the Phase IV freeze forced steel

Table 12. World production of crude steel, 1971-73

	1971	1972	1973[p]
	('000 net tons)		
North America, total	136,825	151,198	170,358
Canada	12,170	13,073	14,755
Mexico	4,212	4,884	5,181
United States	120,443	133,241	150,422
South America, total	11,045	12,126	12,464
Western Europe, total	165,066	179,419	193,597
Belgium and Luxembourg	19,495	22,035	23,643
France	25,198	26,515	27,849
West Germany	44,437	48,176	54,587
Italy	19,238	21,842	23,159
Netherland	5,603	6,156	6,208
Total ECSC	113,971	124,724	135,446*
Britain	26,647	28,026	29,435
Other	24,448	26,669	28,716
Eastern Europe, total	182,703	191,416	198,973
Czechoslovakia	13,299	14,027	14,523
Poland	14,035	14,855	15,554
U.S.S.R.	133,456	138,891	144,403
Other	21,913	23,643	24,493
Africa and Middle East, total	6,135	6,668	7,228
Far East, total	130,658	143,424	170,113
China	23,149	25,353	26,455
India	6,692	7,275	7,384
Japan	97,617	106,814	131,529
Other	3,200	3,982	4,745
Australia and other Oceanian	7,444	7,442	8,295
World, total	639,876	691,693	761,028

Sources: Statistics Canada; United States: Annual Statistical Report, American Iron and Steel Institute, and for 1973 Survey of Current Business, March, 1974. Japan: Annual Report, Japan Iron and Steel Federation. European Common Market Countries: Statistisches Bundesamt, Dusseldorf; Bulletin de la Chambre Syndicale de la Siderurgie Française, January, 1974. Other Western European – Statistisches Bundesamt, Dusseldorf; Metal Bulletin March, 1974. Eastern European Countries – Bulletin de la Chambre Syndicale de la Siderurgie Française, December, 1973. Far East Other – Statistisches Bundesamt, Dusseldorf: Metal Bulletin, January, 1974.
*Excluding Britain which joined the ECSC in 1973.
[p]Preliminary.

Table 13. Forecast of rolled steel and steel castings supply and demand (000 net tons)

	1975	1980	1985	2000	
				High	Low
A. Rolled steel and semis and ingots					
Domestic shipments	10,084	12,395	14,844	23,047	22,400
Plus producer exports	1,629	2,237	2,940	5,624	2,900
Total producer shipments	11,713	14,632	17,784	28,671	25,300
Imports	2,445	3,539	4,834	9,921	4,800
Apparent consumption	12,534	15,934	19,678	32,968	27,200
B. Raw steel equivalents*					
Domestic shipments	13,012	16,007	19,188	29,841	29,001
Plus producer exports	2,070	2,860	3,773	7,259	3,721
Total producer shipments	15,082	18,867	22,961	37,100	32,722
Imports	3,115	4,536	6,218	12,824	6,174
Apparent consumption	16,127	20,543	25,406	42,665	35,175
C. Steel castings					
Domestic shipments	178	201	225	295	295
Plus producer exports	27	27	27	27	27
Total producer shipments	205	228	252	322	322
Imports	15	15	15	15	15
Apparent consumption	193	216	240	310	310
D. Total raw steel (B + C)					
Domestic shipments	13,190	16,208	19,413	30,136	29,296
Plus producer exports	2,097	2,887	3,800	7,286	3,748
Total producer shipments	15,287	19,095	23,213	37,422	33,044
Imports	3,130	4,551	6,233	12,839	6,189
Apparent consumption	16,320	20,759	25,646	42,975	35,485

*Derived by adding forecast tonnages of ingots and semis to tonnages of rolled steel adjusted to raw steel equivalents by dividing by a factor of 0.77 (i.e., one ton of raw steel is equivalent to 0.77 ton of rolled steel).

producers to roll back announced industry-wide price increases announced for flat-rolled steel products. When the freeze expired, steel prices were held in check by the Cost of Living Council during special hearings and reviews. When price relief was finally granted to steel producers late in 1973, the Council forced a further delay, by deferring the cost-justified price increase until January 1, 1974. During 1973, the composite price increased from 9.363 cents a pound to 9.432 cents a pound. One major steel company estimated that steel prices should have been some 6 per cent higher than they were, to recover the cost increases.

Japan's export prices were somewhat higher than the base prices of the EEC during 1973 and the early part of 1974. However, its domestic prices were anywhere from $67 to $100 less than those for its exports*. The ability of Japan to increase its exports is evidence of Japan's outstanding cost competitiveness. Since the advent of the natural resources crisis in 1973, it has been generally conceded that Japan's advantages in the procurement of raw materials have been largely negated. However, the large disparity between Japan and its competitors, in terms of labour costs per unit of output, has remained relatively unchanged because of further enlargement in the scale of operations and rationalization of existing facilities.

In 1965, over 50 per cent of Japan's steel exports were to Europe and North America. By 1973, restriction on exports to these areas and other factors brought the level to about 35 per cent, while exports to developing countries in such areas as Southeast Asia, Latin America and the Mid-East advanced. These countries are unable to supply their own requirements and their dependence on outside supplies has benefitted Japan. Rising prices for its primary commodities and the consequent buildup of foreign exchange reserves of the Mid-East countries has enabled rapid industrialization to occur with its consequent demand for steel. With an increase in imports of 57.7 per cent to 3.0 million tons in 1973, China promises to be a growing market for Japanese steel.

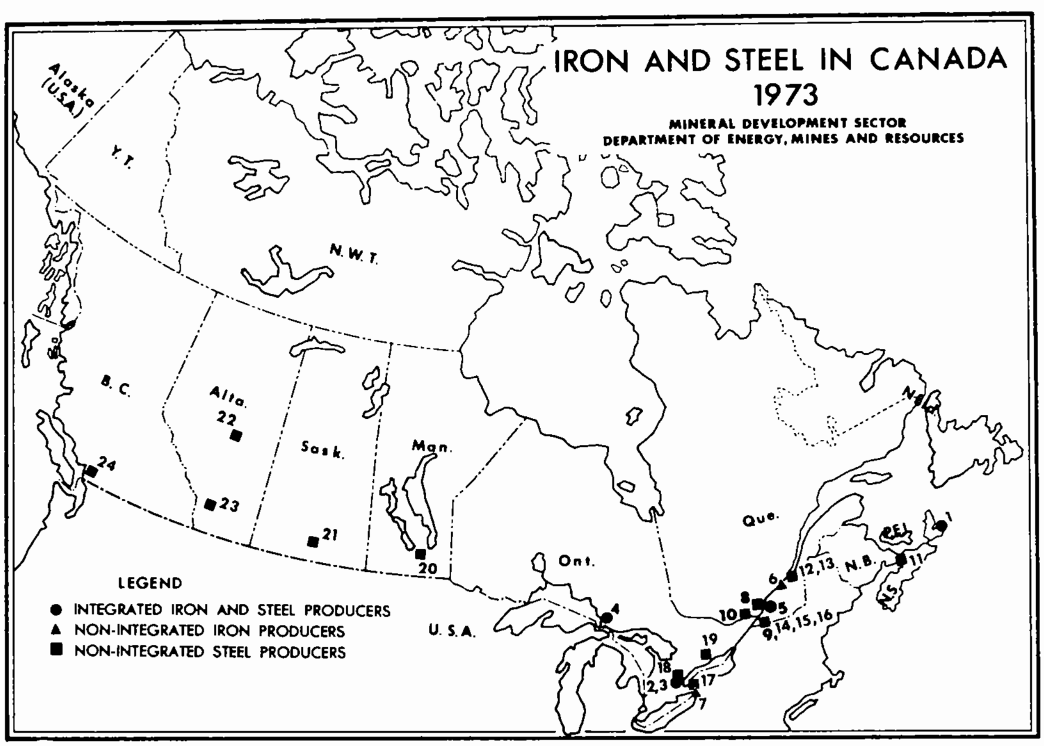
*Source: Nomura Weekly Economic and Financial Report (No. 1420, May 13, 1974)

Forecast

The outlook for the Canadian steel industry in 1974 appears good notwithstanding recent statistics on the real growth of Gross National Product which steel consumption generally reflects. The growth rate of the Gross National Product (in terms of 1961 dollars), which increased by an estimated 7.1 per cent in 1973 following two years of 5.8 per cent growth, is expected to be lower for 1974. At mid-year, government statistics indicated a real growth rate of 6.8 per cent for the first quarter and little or no growth for the second quarter.

Notwithstanding the slower economic growth projected for the year, steel production continued at capacity levels throughout the first half of the year. Strong demand from the construction and most other steel-consuming industries should offset the slack from cutbacks in the North American automobile production. Therefore, because the overall domestic demand for steel products is expected to continue to exceed production capabilities, any growth in steel production in 1974 will depend largely on when the anticipated 1.7 million tons of capacity are brought on stream during the year. A negative factor could be shortfalls in supplies of iron ore and coal that could result from labour strikes in the transportation and mining sectors. Taking all the possible factors of demand and supply into consideration, steel production is forecast at 15.3 million tons, up 4 per cent from 1973.

A total of 15.3 million tons of crude steel production is forecast for Canada for 1974. Because of buoyant demand factors, the increase of 4 per cent will be largely dependent on the timing of new production facilities to be brought on stream during the year. For 1975, 1980, 1985 and 2000, consumption is forecast at 16.3, 20.8, 25.6 and 35.5 million tons while production is expected to reach 15.3, 19.1, 23.2 and 33.0 million tons. These forecasts are based on forces already at work and do not make allowances for fundamental changes or actions by industry and/or government.



Integrated iron and steel producers (numbers refer to numbers on map)

1. Sydney Steel Corporation (Sydney)
2. Dominion Foundries and Steel, Limited (Hamilton)
3. The Steel Company of Canada, Limited (Hamilton)
4. The Algoma Steel Corporation, Limited (Sault Ste. Marie)
5. Sidbec-Dosco Limited (Contrecoeur)*

Nonintegrated iron producers

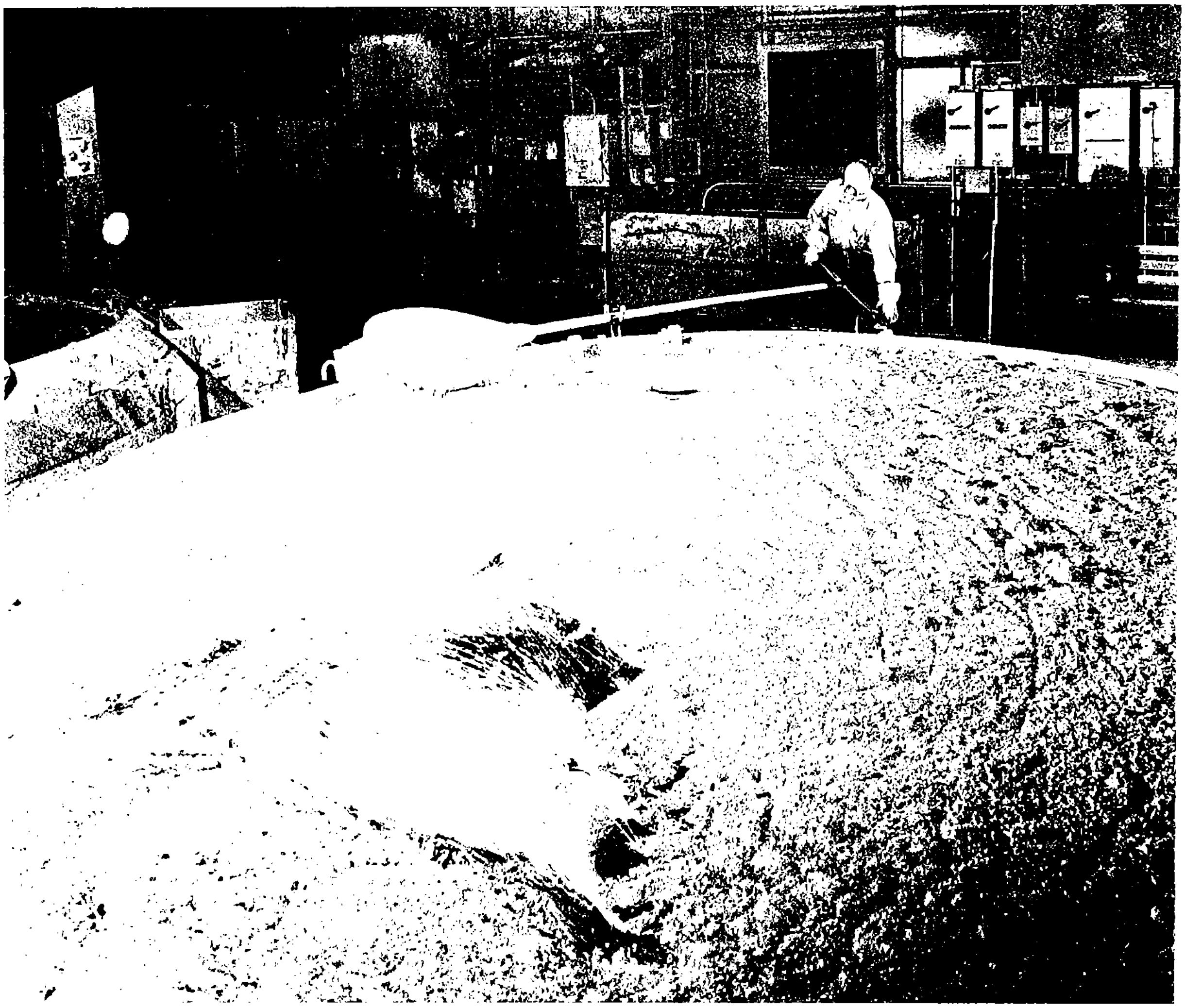
6. Quebec Iron and Titanium Corporation (Sorel)
7. Canadian Furnace Division of Algoma (Port Colborne)

Principal nonintegrated steel producers

8. The Steel Company of Canada, Limited (Contrecoeur**)
9. QSP Ltd. (Montreal) – to start in 1975
10. Ivaco Industries Limited*** (L'Orignal, Ontario)
11. Enamel & Heating Products, Limited (Amherst)
12. Atlas Steels Division of Rio Algom Mines Limited (Tracy)
13. Colt Industries (Canada) Ltd. (Sorel)
14. Canadian Steel Foundries Division of Hawker Siddeley Canada Ltd. (Montreal)
15. Canadian Steel Wheel Limited (Montreal)
16. Sidbec-Dosco Limited (Montreal)
17. Atlas Steels (Welland)
18. Burlington Steel Division of Slater Steel Industries Limited (Hamilton)
19. Lake Ontario Steel Company Limited (Whitby)
20. Manitoba Rolling Mills Division of Dominion Bridge Company, Limited (Selkirk)
21. Interprovincial Steel and Pipe Corporation Ltd. (Regina)
22. Premier Works of Stelco (Edmonton)
23. Western Canada Steel Limited (Calgary)
24. Western Canada Steel Limited (Vancouver)

---

*Reduction facilities installed in 1973.
**Rolling facilities only. Electric furnace plant to be installed in 1974.
***Rolling facilities only. Electric furnace plant to be installed in 1975.



Skimming the dross from a pot of molten lead prior to casting lead pigs (ingots) at Cominco Ltd., Trail, B.C. (Cominco photo).

Lead

M. GAUVIN

In 1973, Canada's production of lead, based on lead recovered from domestic ores and concentrates and the recoverable lead content of ores and concentrates exported was estimated at 385,864 short tons*, an increase of 4.4 per cent from 1972. Higher metal prices in 1973 as well as increased production raised the value of Canadian lead production by $10.6 million to $124.5 million, 9.3 per cent above that of 1972. The increase in production resulted mainly from substantially higher output in the Northwest Territories. The total mine output of lead, expressed as the lead content of domestic ores and concentrates produced, was estimated at 427,441 tons compared with 407,887 tons in 1972. A six-month labour strike at the Buchans Unit of American Smelting and Refining Company reduced Newfoundland's output by almost half, and the national rail strike constrained output in other provinces. Two mines were reopened during the year. The H.B. mine of Cominco Ltd. at Salmo, British Columbia started production early in 1973 and Nigadoo River Mines Limited dewatered its mine in New Brunswick and reconditioned the plant in preparation for production at the end of the year. In the Sturgeon Lake district of northwestern Ontario, Sturgeon Lake Mines Limited began to construct a 1,200-ton-a-day concentrator and to prepare its orebody for open-pit mining scheduled to begin at the end of 1974.

Primary refined lead output totalled 206,012 tons compared with 205,978 tons in 1972. The lead refinery of Cominco Ltd., at Trail, British Columbia, with a capacity of 210,000 tons annually, and that of Brunswick Mining and Smelting Corporation Limited at Belledune, New Brunswick, are Canada's only producers of primary lead metal. The conversion of the Belledune plant from an Imperial Smelting Process lead-zinc blast furnace to a conventional lead blast furnace processing lead concentrates only was completed during the year. It has a capacity of 70,000 tons of refined lead annually.

Most of the lead ores and concentrates from western Canada were treated by Cominco Ltd. at Trail, British Columbia; the remainder were treated at plants in northwestern United States, Europe and Japan. Lead concentrates produced in eastern Canada, excluding those of Brunswick Mining and Smelting Corporation smelted at Belledune, were shipped to Trail or to smelters in the United States and Europe.

Exports of lead contained in ores and concentrates increased to 222,407 tons in 1973 from 178,576 tons in 1972. The major portion of these exports, 143,669 tons or 64.1 per cent, was shipped to Japan. Most of the remainder was shipped to smelters in West Germany, the United States and Belgium. Metal exports in 1973 were 125,181 tons, down from 140,841 tons in 1972. Britain and the United States continued to be the major customers. Imports of refined lead metal were 4,011 tons in 1973 compared with 11,520 tons in 1972.

Canadian consumption of primary and secondary lead metal in 1973 was 76,130 and 42,952 tons, respectively, compared with 70,334 tons of primary and 54,090 tons of secondary lead in 1972.

United States imports and stockpiles

The United States government stockpile at the end of 1972 had a lead inventory of 1.09 million tons which at the end of 1973 had been reduced to 874,330 tons because of sales by the General Services Administration (GSA). In March 1973, the President introduced an omnibus stockpile disposal bill which would authorize the GSA to sell a substantial portion of all stockpiled materials and in April the stockpile objective for lead was reduced from 530,000 tons to 65,100 tons. The GSA sold 211,541 tons during 1973 leaving a total of 809,230 tons excess to stockpile requirements at the end of the year.

United States imports of lead metal and lead in ores and concentrates totalled 280,606 tons in 1973, a sharp reduction from 1972 when total imports were 344,800 tons but still above the 265,009 tons imported in 1971. The United States also exported 66,576 tons of lead materials, excluding scrap, in 1973, compared with 8,376 tons in 1972. Imports of lead in ores and concentrates declined by 65,160 tons. Lower imports, higher exports, greater consumption and small increase in production in the United States were balanced by large releases of lead by the General Services Administration. This change in lead movements, (the volume of United States lead exports was the highest since 1939), was triggered by high world lead prices coupled with price controls in the United States which were not removed until 6 December, 1973. Complaints filed against Canadian and Australian producers of lead under United States

*All tons are short tons of 2,000 pounds avoirdupois unless otherwise stated.

Table 1. Canada, lead production, trade and consumption, 1972-73

	1972		1973p	
	(tons)	($)	(tons)	($)
Production				
All forms[1]				
Yukon Territory	111,461	34,392,366	113,749	36,718,000
Northwest Territories	90,220	27,838,277	111,068	35,853,000
British Columbia	97,575	30,107,615	100,901	32,570,000
New Brunswick	45,490	14,036,449	39,727	12,824,000
Ontario	10,605	3,272,413	12,442	4,016,000
Newfoundland	12,202	3,765,175	6,499	2,098,000
Quebec	1,676	517,031	1,094	353,000
Nova Scotia	–	–	322	104,000
Manitoba	196	60,344	62	20,000
Total	369,425	113,989,670	385,864	124,556,000
Mine output[2]	407,887		427,441	
Refined production[3]	205,978		206,012	
Exports				
Lead contained in ores				
Concentrates				
Japan	108,246	21,340,000	143,669	32,547,000
West Germany	20,832	2,970,000	25,699	4,356,000
United States	26,148	3,967,000	23,078	3,529,000
Belgium and Luxembourg	9,806	1,354,000	14,515	3,286,000
Brazil	–	–	7,820	1,326,000
Italy	4,986	692,000	6,839	668,000
Finland	–	–	399	156,000
India	392	97,000	388	131,000
Other countries	8,166	1,215,000	–	–
Total	178,576	31,635,000	222,407	45,999,000
Lead in pigs, blocks and shot				
Britain	49,372	11,544,000	54,608	18,670,000
United States	75,402	19,242,000	52,898	15,022,000
India	3,535	856,000	5,051	1,436,000
Netherlands	6,224	1,465,000	3,460	1,210,000
West Germany	1,352	307,000	2,041	783,000
Italy	1,543	339,000	1,824	520,000
Pakistan	–	–	1,300	362,000
Japan	165	39,000	827	298,000
Iran	–	–	578	163,000
Israel	1	2,000	560	155,000
Denmark	–	–	471	139,000
Hong Kong	324	83,000	253	99,000
Other countries	2,923	678,000	1,310	399,000
Total	140,841	34,555,000	125,181	39,256,000
Lead and lead alloy scrap (gross weight)				
Netherlands	1,118	202,000	13,786	3,687,000
South Korea	677	86,000	3,368	609,000
France	–	–	1,956	439,000
Britain	264	62,000	731	348,000
Denmark	173	53,000	870	324,000
West Germany	7,756	995,000	738	171,000
Other countries	2,319	482,000	2,485	619,000
Total	12,307	1,880,000	23,934	6,197,000

Table 1 (concl'd)

	1972		1973^p	
	(tons)	($)	(tons)	($)
Exports (concl'd)				
Lead fabricated materials not elsewhere specified				
United States	6,770	2,216,000	9,592	3,683,000
Britain	58	13,000	161	134,000
Korea South	–	–	109	39,000
Other countries	17	10,000	133	47,000
Total	6,845	2,239,000	9,995	3,903,000
Imports				
Lead pigs, blocks and shot	11,520	2,929,000	4,011	1,288,000
Lead oxide; litharge, red lead, mineral orange	2,380	717,000	1,995	751,000
Lead fabricated materials not elsewhere specified	324	204,000	1,247	599,000
Total	14,224	3,850,000	7,253	2,638,000

	Primary	Secondary[4]	Total	Primary	Secondary[4]	Total
			(short tons)			
Consumption						
Lead used for, or in the production of						
antimonial lead	2,101	29,835	31,936	1,457	27,129	28,586
battery and battery oxides	31,418	2,844	34,262	31,371	3,011	34,382
cable covering	3,305	440	3,745	2,903	..	2,903
chemical uses: white lead, red lead, litharge, tetraethyl lead, etc.	22,374	4,566	27,337	26,708	3,891	31,122
copper alloys: brass, bronze, etc.	397			427	96	
lead alloys						
solders	2,543	1,841	4,384	5,028	1,263	6,291
others (including babbitt, type metals, etc.)	243	4,639	4,882	524	..	524
semifinished products: pipe, sheet, traps, bends, blocks for caulking, ammunition, foil, collapsible tubes, etc.	5,511	825	6,336	4,556	371	4,927
Other	2,442	9,100	11,542	3,156	7,191	10,347
Total, all categories	70,334	54,090	124,424	76,130	42,952	119,082

Source: Statistics Canada.
[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable lead in domestic ores and concentrates exported. [2] Lead content of domestic ores and concentrates produced. [3] Primary refined lead from all sources. [4] Includes all remelt scrap lead and scrap lead used to make antimonial lead.
[p] Preliminary; – Nil; .. Not available.

Table 2. Canada, lead production, trade and consumption, 1963-73

	Production		Exports				
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total	Imports Refined[3]	Consumption[4]
			(tons)				
1963	201,165	155,000	53,756	97,144	150,900	1,741	77,958
1964	203,717	151,372	80,357	95,867	176,224	73	82,736
1965	291,807	186,484	106,964	129,065	236,029	71	90,168
1966	300,622	184,871	112,934	106,468	219,402	626	96,683
1967	317,963	193,235	126,194	132,320	258,514	438	93,953
1968	340,176	202,100	143,853	138,781	282,634	152	94,660
1969	318,632	187,143	140,175	107,090	247,265	131	105,915
1970	389,185	204,630	165,912	152,821	318,733	2,199	93,437
1971	405,510	185,554	214,354	136,884	351,238	4,632	94,617
1972	369,425	205,978	178,576	140,841	319,417	11,520	124,424
1973[p]	385,864	206,012	222,407	125,181	347,588	4,011	119,082

Source: Statistics Canada.
[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus the estimated recoverable lead in domestic ores and concentrates exported. [2] Primary refined lead from all sources. [3] Lead in pigs and blocks. [4] Consumption of lead, primary and secondary in origin.
[p] Preliminary.

antidumping laws helped slow the import of lead into the United States.

In March 1973 the Lead and Zinc Act of 1973, consisting of two bills H.R. 6191 and H.R. 6437, was introduced in the United States House of Representatives. It calls for a two-year suspension of the import duty on zinc contained in zinc concentrates and quarterly quotas of 125,000 tons of zinc metal, 40,000 tons of lead metal and 24,000 tons of lead contained in ores and concentrates. Imports up to the quota levels would enter at the current duties and imports above these limits would be subject to a 19 per cent *ad valorem* duty. No action had been taken on these bills at the end of the year.

In February 1973 a complaint was filed with the United States Bureau of Customs by the Bunker Hill Co. charging Australian and Canadian lead producers with dumping in 1972 when United States domestic lead prices were low. A summary investigation was completed on 13 March, 1973 with the decision that the information received tends to indicate that prices of the merchandise sold for export to the United States were less than the prices for home consumption. The United States Bureau of Customs then instituted an inquiry which, on 9 October, 1973, determined that primary lead metal from Australia and Canada was being sold at less than fair market value under United States antidumping laws. The Treasury then referred the cases to the Tariff Commission which on 10 January, 1974 found that a domestic industry was, or is likely to be, injured by reason of imports of primary lead metal sold at less than fair value.

World production and consumption

Noncommunist world mine production of lead, according to statistics published by the International Lead and Zinc Study Group, was 2.86 million tons in 1973, practically unchanged from the 2.87 million tons produced in 1972. Small increases in some producing countries were balanced by similar sized decreases in other countries. The United States retained its position as the world's leading producer followed by Canada and Australia. Noncommunist world production of primary and secondary refined lead totalled an estimated 3.74 million tons, an increase of 34,000 tons over 1972.

Mine production of lead in the United States dropped 2 per cent below the 43-year high level of production established in 1972. Production in the State of Missouri represented 80 per cent of the United States mine production of lead. Refined lead produced at primary refineries in the United States totalled 755,000 tons in 1973, compared with 703,844 tons in 1972.

Consumption of lead in the noncommunist world rose in 1973 to a record high of 3.83 million tons, an increase of 4.2 per cent from the previous high established in 1972. The United States remained the world's largest consumer using 1.54 million tons, some 56,000 tons more than 1972 and some 40 per cent of total world consumption. Net shipments from noncommunist countries to socialist countries increased in 1973 compared with 1972. The excess of consumption and net trade balances with socialist countries over production has been balanced by drawdowns in producers' stocks and releases from noncommercial stockpiles.

One new smelter began production in 1973, an Imperial Smelting Process plant with an annual capacity of 33,000 tons of lead bullion at Titor Veles, Yugoslavia. No new lead smelters are scheduled to commence operation in 1974. New smelters or expansions that are planned to start operation in 1975 or later are listed in Table 5.

In 1973, four new mines started production, the largest being St. Joe Minerals Corporation's Brushy Creek mine in Missouri with an operating rate of 50,000 tons of lead a year. In Greenland, the Black Angel mine of Vestgron Mines Limited (61.5 per cent controlled by Cominco Ltd.) with a capacity of 28,000 tons of lead a year was brought into production. Two small producers, one in Peru and one in Japan, started operating during the year. Four lead producing mines with a total lead producing capacity of 30,000 tons a year ceased operation. In 1974, six new or expanding mines are expected to add 33,000 tons to world producing capacity.

Outlook

Canada's mine production of lead in 1974 is forecast to be some 410,000 tons and with reasonably stable world economic conditions is expected to remain near this level for the next three years. Canadian lead metal production is expected to rise by 20,000 tons to 225,000 tons a year with the smelter of Brunswick Mining and Smelting Corporation Limited reaching full operating capacity.

Table 3. Location of new or expanded smelter capacity

Expected start-up Year		Increase in Capacity
		(short tons a year)
1975	India, Visakhapatnam, new electrolytic plant	11,000
	Spain, Cartegna, expansion of existing plant with capacity of 82,000	5,000
	Spain, Linares, expansion and replacement of existing plant with capacity of 22,000	36,000
	Mexico, Torreon and Monterrey, expansion of existing plants with capacity of 130,000	27,500
1976	India, Tundoo, expansion of existing plant with capacity of 4,000	6,500
1978	Peru, Bayovar, new plant	110,000

Source: International Lead and Zinc Study Group Monthly Bulletins, Various publications.

World lead mine and metal production are expected to expand strongly by close to 5 per cent in 1974. Major increases in mine production are expected in Greenland, Yugoslavia, Peru, Australia and the United States. Metal production increases are expected in Australia and Europe. Consumption is forecast to rise by only 1 per cent, with most of this increase expected to be in Europe.

The major uses of lead are in batteries and in the form of lead additives to gasoline. In 1973 over 1.6 million tons of lead were used in the manufacture of batteries throughout the noncommunist world, twice as much as in 1960 when batteries accounted for only one third of total consumption. While battery life has increased, and the weight of lead per battery has decreased, the consumption of lead for batteries is growing faster than total lead consumption. If the present trend continues, batteries could account for over 50 per cent of the total refined lead consumed by 1980. The brightest future for the metal still appears to be its use in lead-acid batteries, not only for original installation and replacement batteries in the growing output of gasoline-powered vehicles but also as the power source in the rapidly developing battery-powered passenger vehicle. When battery manufacturers are able to meet the challenges of making major improvements in the power-to-weight ratios in batteries and efficient fast recharging, we can expect an unprecedented growth in the consumption of battery lead. Antiknock additives have grown strongly in recent years to reach 12 per cent of world consumption of lead and 20 per cent of consumption of lead in the United States. This application of lead may now have reached its peak and is expected to plateau near its current consumption level.

The use of lead in many of its historical applications such as type metal, cable sheathing and paints is expected to gradually decline. However, as a basic paint for rust and corrosion protection in structural and highway use, lead is still the preferred base material and this use will continue to grow. The future of lead as a building material continues to grow. The slowly developing home and industrial building market could also grow into a major consumer of lead as a soundproofing, waterproofing and decorative material.

World consumption of lead during the next two years is expected to increase at the rate of between 1 and 1.5 per cent annually. World production is expected to rise significantly above consumption, and it will require prudence on the part of producers as well as reduced releases from the United States government stockpile to maintain a balance between supply and demand.

Table 4. Noncommunist world mine production of lead, 1972-73

	1972	1973p
	(tons)	
United States	644,700	625,800
Canada	424,400	433,700
Australia	425,900	428,500
Peru	176,400	197,300
Mexico	196,000	183,000
Yugoslavia	117,200	123,800
Sweden	81,800	81,700
Republic of South Africa	65,000	69,700
Spain	72,800	68,400
Ireland	65,700	63,900
Japan	69,900	58,300
West Germany	45,500	42,900
Argentina	44,100	39,700
Italy	37,200	30,000
Morocco	103,600	. .
Zambia	34,600	. .
Other countries	262,200	411,600
Total	2,867,000	2,858,300[1]

Source: International Lead and Zinc Study Group, *Monthly Bulletin,* May 1974.
[1]Total includes estimates for those countries for which figures are not available.
pPreliminary; . . Not available.

Canadian developments

Newfoundland. American Smelting and Refining Company, Buchans Unit, was again the only lead producer in Newfoundland. The company operates a 1,250-ton-a-day concentrator at Buchans in the central part of the province and produces lead, zinc and copper concentrates. Production was much lower than in 1972 due to a strike which halted production for over six months. Ore reserves are adequate to support production for another six years and, in addition, large tonnages in low-grade disseminated zones are being evaluated for possible future production.

Nova Scotia. Dresser Minerals Division of Dresser Industries, Inc. at Walton, Nova Scotia milled a surface stockpile of ore accumulated from previous operations. The mine continues to operate as a barite producer and will possibly mine small quantities of lead-zinc ore as a salvage operation. The Gays River deposit of Imperial Oil Limited and Cuvier Mines Ltd. was under active exploration in 1973. The companies estimate ore reserves of 27.6 million tons averaging 2.75 per cent lead and 3.39 per cent zinc. A feasibility study is underway to determine if the property will be brought into production.

New Brunswick. Total lead mine production increased in the province during the year. Heath Steele Mines Limited near Newcastle milled a record tonnage of ore. As part of a $12 million expansion it started sinking the number 5 shaft, which is scheduled to be completed in 1974, at a depth of 3,000 feet. An addition to the concentrator will increase capacity to 4,000 tons a day and production is planned at that rate in 1976. Nigadoo River Mines reopened its mine near Bathurst after being closed since January 1972. The mine was dewatered in preparation for production to start in 1974. Ore reserves at the time of closure were 1,248,000 tons grading 3.23 per cent lead, 3.22 per cent zinc, 4.04 ounces silver a ton and some values in bismuth and cadmium.

Brunswick Mining and Smelting Corporation Limited substantially increased the lead-zinc ore reserves at its No. 12 mine near Bathurst to 84.7 million tons grading 3.84 per cent lead, 9.38 per cent zinc, 0.27 per cent copper and 2.79 ounces silver a ton. The open-pit operation at its No. 6 mine is due to terminate early in 1976 after which time all ore for the concentrator will come from the No. 12 mine. A new shaft is to be sunk to a depth of 4,300 feet with equipment capable of hoisting 11,000 tons of ore a day. At Belledune, the company completed the

Table 5. Noncommunist world production[1] of refined lead, 1972-73

	1972	1973p
	(tons)	
United States	1,186,000	1,175,500
West Germany	299,200	329,200
United Kingdom	298,300	272,700
Japan	246,200	251,900
Australia	229,800	242,500
Canada	208,600	206,100
France	206,000	205,500
Mexico	175,700	193,900
Spain	114,600	110,000
Belgium	102,300	107,700
Peru	82,700	86,300
Republic of South Africa	75,000	73,500
Italy	76,300	63,800
Sweden	49,900	53,600
Argentina	43,700	41,700
Yugoslavia	96,400	. .
Other countries	216,800	327,300
Total	3,707,500	3,741,200

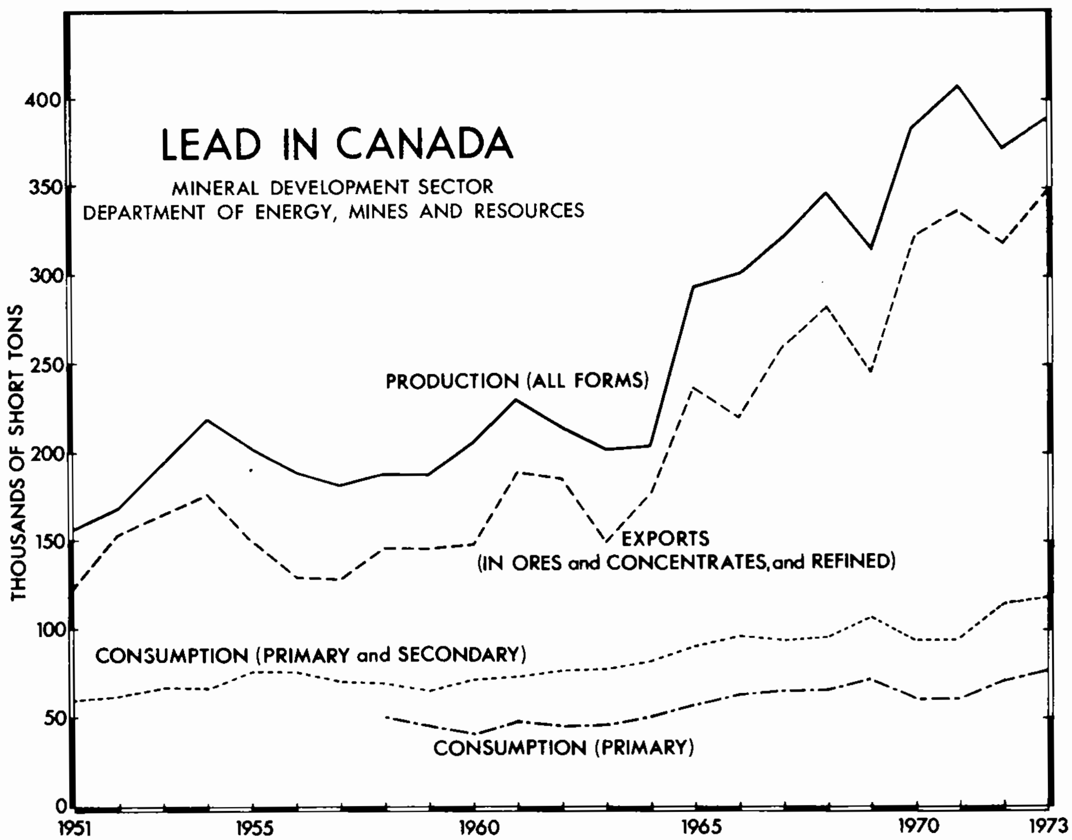
Source: International Lead and Zinc Study Group, *Monthly Bulletin,* May 1974.
[1]Total production by smelters or refineries, of refined pig lead, plus the lead content of antimonial lead – including production on toll in the reporting country – regardless of the type of source material, i.e., whether ores, concentrates, lead bullion, lead alloys, mattes, residues, slags or scrap. Remelted pig lead and remelted antimonial lead are excluded.
pPreliminary; . . Not available.

conversion of its smelter from an Imperial Smelting Furnace (ISF) to a straight lead blast furnace changing its capacity for primary lead metal from 33,000 to 70,000 tons a year. The changeover includes the addition of two large kettles to increase lead refining capacity and major additions to ventilation and dust control systems. The smelter was attaining production targets at the end of the year.

Ontario. Lead production in Ontario rose 17.3 per cent during the year due to the first full year of production of Mattabi Mines Limited at Sturgeon Lake which milled high-grade ore from its open pit. In the same area, Sturgeon Lake Mines Limited began construction of a 1,200-tons-a-day concentrator and mine scheduled for completion at the end of 1974. Ore reserves of this open-pit orebody are estimated at 2,110,600 tons, averaging 1.47 per cent lead, 10.64 per cent zinc, 2.98 per cent copper and 6.14 ounces silver per ton.

British Columbia. Cominco Ltd. reopened its H.B. mine near Salmo which had been closed since late 1966. The rated capacity of 1,000 tons of ore a day was reached in March 1973. The mining rate at Cominco's Sullivan mine increased to 2.2 million tons annually in spite of difficulties encountered with spontaneous oxidation of sulphides in certain areas of the mine which resulted in "hot" ores. Refined lead production at Trail was adversely affected by the national rail strike during the summer. Cominco's metallurgical works at Trail, which include a lead smelter and refinery, treats concentrates from its own mines, from Pine Point Mines Limited and from custom suppliers. Reeves MacDonald Mines Limited continued to operate at lower rates; mining could terminate in 1974 unless new reserves are outlined by exploration work on the adjoining property of Helca Mining Company.

Northwest Territories. Output by Pine Point Mines Limited, 69 per cent owned by Cominco Ltd., at its zinc-lead property near Pine Point on the south shore of Great Slave Lake increased by 10 per cent over that of 1972. During the year the concentrator was modified to increase capacity to 11,000 tons a day and improve metallurgy. The first of the Coronet orebodies was prepared for open-pit production in



1974. Underground development of the M-40 orebody was undertaken using a Dosco continuous miner which successfully produced 24,000 tons of ore in 1973. Increased output is expected from this orebody in 1974.

An underground program consisting of a 5,300-foot declined adit and 600 feet of drifting was completed at the Polaris property of Arvik Mines Ltd. on Little Cornwallis Island. Together with extensive underground diamond drilling, this work provided more detailed information on the grade, tonnage and mining conditions which prevail at this 25 million ton orebody grading over 20 per cent combined lead-zinc. A shipment of 3,600 tons of ore was sent out for metallurgical testing. At year-end, a production feasibility study was underway. Mineral Resources International Limited completed a feasibility report that recommended its Strathcona Sound zinc-lead-silver deposit on Baffin Island be put into production at a rate of 1,200 tons of ore a day. The ore reserves of this deposit are estimated at 6.9 million tons averaging 14.1 per cent zinc, 1.4 per cent lead and 1.77 ounces silver a ton. The shipping season at Strathcona Sound is estimated at two months compared with thirty-five days at Little Cornwallis Island.

Yukon Territory. Production in the Yukon Territory increased slightly in 1973 compared with 1972. At the lead-zinc-silver property of Anvil Mining Corporation Limited near Faro milling continued at the same rate as in 1972. The expansion of the concentrator from 8,000 to 10,000 tons a day was completed at the end of the year. This will allow the company to treat lower grade ore at a higher milling rate and maintain its concentrate output. The company now has sufficient reserves outlined for fifteen years of operation. Lead production was unchanged at the silver-lead-zinc property of United Keno Hill Mines Limited near Mayo. Because of higher silver prices the Keno mine was reopened and is also being used as a base to develop the Shamrock "J" structure. The Dixie and Townsite adits, which were developed in 1972, have failed to develop as much ore as expected and were placed on a salvage basis at year-end.

Lead in gasoline

The automobile was first seriously considered as a source of atmospheric pollution in the late 1940's in California because of its emission of carbon monoxide, unburnt hydrocarbons and oxides of nitrogen. Reactions between unburnt hydrocarbons and oxides of nitrogen produce ozone and other oxidants which cause photochemical smog to form in special atmospheric conditions. This smog causes irritation of the eyes and respiratory system, damages crops and vegetation, attacks rubber and reduces visibility. Some components of automotive exhausts, such as polynuclear aromatic and phenolic compounds, are suspected of being cancer-producing and cancer-accelerating agents. Recent concern has centred on the use of lead in gasoline, which many claim has already brought or will bring the amount of lead in the atmosphere up to levels that might constitute a hazard to public health. The results of studies carried out to date tend to indicate that there is no demonstrable relationship between the concentration of lead in the air of main cities and the concentration of lead in the blood of individuals living in those areas.

Lead antiknock additives, tetraethyl lead (TEL) and tetramethyl lead (TML), are widely used in motor fuels to increase their resistance to knock. TEL and TML have different physical properties and lead content, but their antiknock behaviour is determined principally by their lead content. The antiknock quality of gasoline is measured by a scale of research octane numbers (RON). Nearly all grades of gasoline contain lead, the amount added depending on the quality of the base stock of the fuel and the final octane rating required. Efficient high compression internal combustion engines now require a fuel with a high RON number.

The United States Environmental Protection Agency (EPA) promulgated a final regulation in 1973 requiring the general availability of at least one grade of lead-free gasoline by 1 July, 1974 to protect the catalytic emission control devices that will be fitted on many of the 1975 model automobiles. This fuel with the required RON for efficient engine operation is now available in many service stations in the United States and Canada and can also be used in other late model automobiles.

The Clean Air Act of 1970 in the United States requires that by 1975 automotive emissions of hydrocarbons and carbon monoxide be reduced to about 10 per cent of their 1971 level and that by 1976 the oxides of nitrogen be reduced to about 10 per cent of their 1971 level. Following several appeals by United States automobile manufacturers and a series of public hearings, the EPA announced in April 1973 that it was deferring for one year the 1975 nationwide emission standards required for hydrocarbons and carbon monoxide and set somewhat lower standards for the State of California. This was followed in July by a decision to suspend the proposed 1976 standard for oxides of nitrogen for one year and adopt a far less stringent interim standard.

The Canadian government announced that it will not follow the U.S. policies on auto emissions and has set less severe standards. These Canadian standards can be met without the use of catalytic converters. The government is concerned with the cost of converters, increased fuel consumption and lower performance. It thinks that better engine design, possibly of the type of the Compound Vortex Combustion Control (CVCC) engine, will produce the desired results in pollution reduction and efficient use of fuels.

In November 1973, the EPA announced new regulations to gradually reduce the lead content of gasoline. Under the new regulations, the average lead content for all grades of gasoline would have to be reduced to the equivalent of 0.44 gram a litre by January 1, 1975 and gradually reduced to 0.33 gram a litre by 1978 compared with a current average of 0.53 gram a litre, Canada has proposed to limit lead in gasoline to 0.55 gram a litre by 1975 and most European countries now have, or are proposing, a limit of 0.40 gram a litre from 1 January, 1976.

While further reductions after 1976 are being considered, more information is required on how much crude oil and gasoline consumption would rise as a result of reductions in lead content before any proposals are made. Further studies of the impact of lead in gasoline on public health are being proposed in the United States so that decisions can be based on solid facts.

Uses

Lead has many useful chemical and mechanical properties and because of this versatility it has a variety of industrial applications. It is soft, ductile, alloys readily with other materials, has good corrosion resistance, a high boiling point, a low melting point and a high specific gravity. Lead is one of the oldest metals known to man and since medieval times has been used in piping, building materials, solders, paint, type metal, ammunition and castings.

Lead is used mainly in lead-acid storage batteries, the bulk of which is used for starting, lighting and ignition (SLI) in automobiles and trucks. Recent improvements in battery manufacture have significantly reduced the weight of lead in a battery unit and increased the average battery life and performance. However, lead usage in SLI batteries is expected to continue to grow. This growth will be added to by the rapid expansion in the use of electrically-powered industrial trucks. Major battery manufacturers have been developing attractive battery-powered cars, buses and utility trucks and have been test driving them in normal driving cycles for the past three years in the United States. The United States Postal Service has ordered 350 electric-powered delivery vehicles and it is estimated that each vehicle will use about 700 pounds of lead for its batteries. The Postal Service has plans to expand this fleet to over 6,000 vehicles in 1977. Japan has a five-year, government-funded program for developing commercially competitive electric-powered vehicles. Several Japanese cities have electric buses in service which use lead-acid batteries. The use of electric-powered road vehicles is spreading throughout Europe. In Great Britain over 30,000 electrics are in operation and it is claimed that these vehicles are cost effective. Recreational and household uses have also helped increase the demand for lead-acid storage batteries. Maintenance-free, sealed lead-acid batteries are now making an impact on the SLI market and are standard equipment on some new automobiles today. They have the advantage of being able to be used in almost any position and can be removed from the normal under-the-hood location to make room for anti-pollution devices.

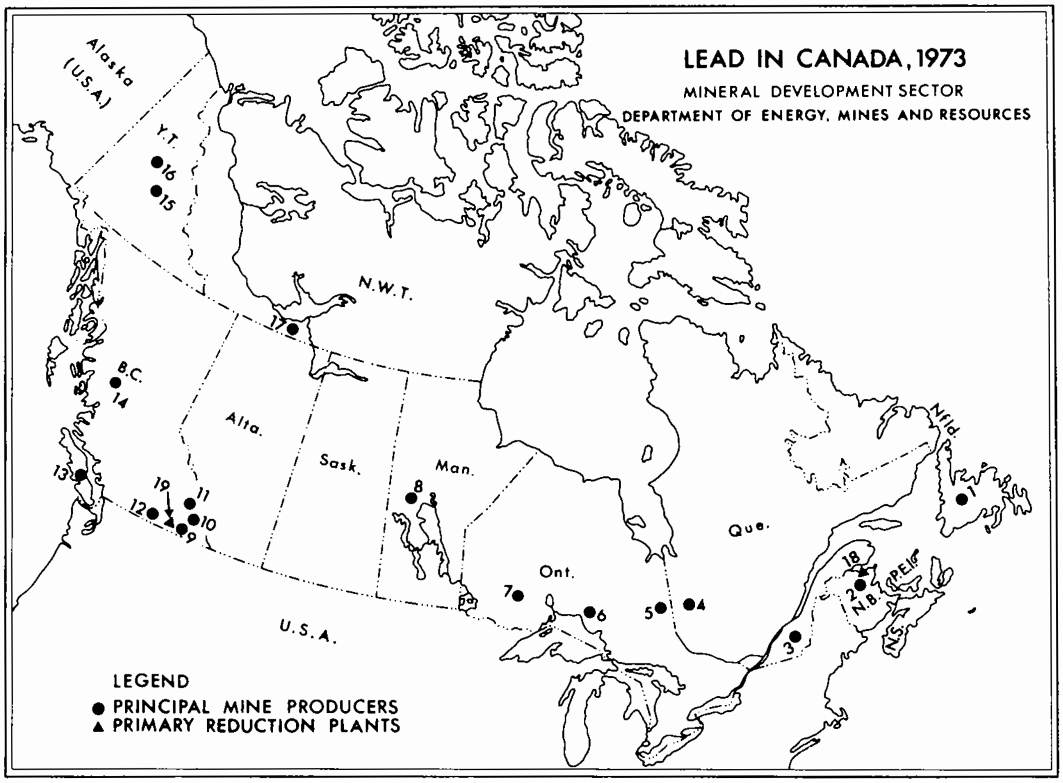
The next most important use of lead is as an antiknock additive in gasoline. Lead consumed for batteries and gasoline additives in 1973 accounted for over 63 per cent of the total lead consumption in the United States. The metal is also used extensively for cable sheathing, collapsible tubes, caulking materials, corrosive-liquid containers, galvanizing spelter and lead-base babbitts.

The commercial and residential construction industry is a growing market for lead in the form of soundproofing material, exterior roofing and decorative panels, waterproofing, flashing and construction panels. Because of its unique sound control characteristics there is an expanding use for lead in sound attenuation both as sheets and lead-composition panelling. Composite thermal-acoustical panels are now being used to contain the noise from industrial plants. The International Lead Zinc Research Organization, Inc. has designed and constructed an all-metal house requiring a minimum of maintenance and containing approximately 1½ tons of lead and zinc. Lead-coated steel sheeting that combines lead's corrosion resistance and sound-barrier properties with the strength of steel is now available for many building applications. In the allied field of vibration isolation, lead-asbestos antivibration pads are now being widely used in foundations for office buildings, hotels and apartments exposed to severe vibration from nearby heavy traffic. Because of its sound control qualities lead is also used in the mounting of various types of equipment including air-conditioning systems, heavy industrial equipment and commercial laundry machines.

The use of chrome yellow (lead chromate) paints on highways for pavement marking is growing because it is the most versatile low-cost pigment available for traffic control paints.

Miscellaneous uses include automotive wheel weights, ship ballast, terne steel and various alloys, and as lead-ferrite for permanent magnets in small electric motors. Relatively new uses are for leaded-porcelain enamel in coating aluminum and for radiation shielding against gamma rays in nuclear power reactors, nuclear-powered ships and submarines and shipping casks for transporting radioactive materials. Continuing research has developed new and promising markets for organometallic lead compounds in such applications as antifouling paints, wood and cotton preservatives, lubricant-oil additives, polyurethane foam catalysts, molluscicides, antibacterial agents and rodent repellents.

Refined lead is marketed in several grades that vary mainly according to the content of impurities, including silver, copper, arsenic, antimony, tin, zinc, iron and bismuth. The three principal grades are



Principal mine producers

(numbers refer to numbers on map)

1. American Smelting and Refining Company (Buchans Unit)
2. Brunswick Mining and Smelting Corporation Limited (Nos. 12 and 6 mines)
   Heath Steele Mines Limited
3. Sullivan Mining Group Ltd. Cupra Division
   D'Estrie Mining Company Ltd.
4. Manitou-Barvue Mines Limited
5. Ecstall Mining Limited
6. Noranda Mines Limited, Geco Division
   Willroy Mines Limited
7. Mattabi Mines Limited
8. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake, Ghost Lake mines)
9. Reeves MacDonald Mines Limited (Annex mine)
10. Cominco Ltd. (Sullivan mine)
11. Kam-Kotia Mines Limited (Silmonac mine)
12. Teck Corporation Limited (Beaverdell mine)
13. Western Mines Limited
14. Bradina Joint Venture
15. Anvil Mining Corporation Limited
16. United Keno Hill Mines Limited
17. Pine Point Mines Limited

Primary reduction plants

18. Brunswick Mining and Smelting Corporation Limited, Smelting Division
19. Cominco Ltd.

Table 6. Principal lead (mine) producers in Canada, 1973 and (1972)

Company and Location	Mill Capacity	Grade of Ore Milled (principal metals) Lead	Zinc	Copper	Silver	Ore Produced	Lead in Concentrates and Direct Shipping Ores	Remarks
	(tons ore/day)	(%)	(%)	(%)	(troy oz/ton)	(tons)	(tons)	
Newfoundland								
American Smelting and Refining Company, (Buchans Unit), Buchans	1,250 (1,250)	6.48 (7.18)	11.51 (12.89)	1.00 (1.13)	3.45 (3.73)	124,000 (291,000)	7,633 (19,791)	Production halted by strike from March 15 to October 3.
Nova Scotia								
Dresser Minerals Division of Dresser Industries, Inc., Walton	140 (140)	6.68 (–)	1.00 (–)	0.27 (–)	5.43 (–)	8,178 (–)	547 (–)	Milled surface stockpile of ore. May possibly salvage small quantities in conjunction with barite operation.
New Brunswick								
Brunswick Mining and Smelting Corporation Limited, Bathurst	9,850 (9,500)	2.81 (2.77)	7.00 (7.15)	0.34 (0.32)	2.53 (2.43)	3,288,081 (3,257,559)	66,415 (66,931)	A new shaft will be sunk at No. 12 mine to a depth of 4,300 ft. and a hoisting capacity of 11,000 tons of ore a day
Heath Steele Mines Limited, Newcastle	3,100 (3,000)	1.64 (1.46)	4.90 (3.93)	0.86 (1.13)	1.83 (1.70)	1,077,816 (835,867)	11,026 (7,739)	Presently sinking new shaft to 3,000 ft. depth and expanding concentrator to 4,000 tons a day capacity.
Nigadoo River Mines Limited, Bathurst	1,000 (1,000)	– (–)	– (–)	– (–)	– (–)	– (–)	– (–)	Dewatered the mine and refurbished mill equipment in preparation to start production in 1974.
Quebec								
Manitou Barvue Mines Limited, Golden Manitou Mine, Val-d'Or	1,600 (1,600)	0.30 (0.33)	2.07 (1.16)	. . (. .)	. . (4.68)	197,312 (60,234)	400 (134)	The concentrator also custom treated copper ore from Louvem Mining Company Inc. and was operating near capacity at year-end.

Table 6 (cont'd)

Company and Location	Mill Capacity	Grade of Ore Milled (principal metals) Lead	Zinc	Copper	Silver	Ore Produced	Lead in Concentrates and Direct Shipping Ores	Remarks
	(tons ore/day)	(%)	(%)	(%)	(troy oz/ton)	(tons)	(tons)	
Quebec (cont'd)								
Sullivan Mining Group Ltd., Cupra Division, Stratford Centre	1,500 (1,500)	0.66 (0.60)	4.88 (3.97)	2.41 (2.24)	1.09 (0.99)	89,814 (117,339)	327 (632)	Mill treats ore from the D'Estrie division and Clinton Copper Mines Ltd. on a custom basis.
D'Estrie Mining Company Ltd., Stratford Centre	custom-treated	0.74 (0.72)	3.16 (3.28)	2.74 (2.70)	1.23 (1.21)	130,265 (109,138)	541 (706)	
Ontario								
Ecstall Mining Limited, Timmins	10,000 (10,000)	0.33 (0.39)	9.78 (10.14)	1.61 (1.44)	3.72 (4.35)	3,609,657 (3,628,501)	8,080 (8,663)	Installation of underground crushing equipment complete. The mine was supplying 2,000 tons of ore per day to the concentrator at the end of 1973 and is expected to supply 1,000,000 tons in 1974.
Mattabi Mines Limited, Sturgeon Lake	3,000 (3,000)	1.06 (1.27)	11.37 (11.97)	1.10 (1.27)	5.31 (4.99)	1,111,765 (438,838)	4,757 (987)	Completed first full year of operation. All ore was mined from the open pit and plans are being made to mine the underground reserves.
Noranda Mines Limited, Geco Division, Manitouwadge	5,000 (5,200)	0.20 (0.15)	4.53 (4.30)	1.70 (2.12)	1.63 (1.93)	1,463,585 (1,815,164)	1,664 (2,095)	Production interrupted by a strike from April 12 to June 10.

Table 6 (cont'd)

Company and Location	Mill Capacity	Grade of Ore Milled (principal metals) Lead	Zinc	Copper	Silver	Ore Produced	Lead in Concentrates and Direct Shipping Ores	Remarks
	(tons ore/day)	(%)	(%)	(%)	(troy oz/ton)	(tons)	(tons)	
Ontario (cont'd)								
Willroy Mines Limited, Manitouwadge	1,700 (1,700)	0.17 (0.14)	2.74 (3.27)	0.98 (1.10)	1.42 (1.41)	430,486 (431,067)	386 (320)	Surface exploration work curtailed. Ore reserves at year-end were 715,835 tons grading 0.34% copper, 3.98% zinc and 1.38 ounces silver per ton.
Manitoba-Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon	8,500 Central mill at Flin Flon treats the ore from all the company's mines						163[1] (205)	Only Chisel Lake and Ghost Lake mines have appreciable lead content.
Chisel Lake mine, Snow Lake, Man.		0.39 (0.30)	9.40 (9.30)	0.60 (0.90)	0.95 (0.90)	182,447 (209,100)		
Ghost Lake mine, Snow Lake, Man.		0.31 (0.30)	11.71 (9.40)	1.90 (1.80)	1.20 (1.20)	99,719 (35,800)		
British Columbia								
Bradina Joint Venture, Houston	600 (600)	1.02 (0.89)	4.57 (4.45)	0.43 (0.42)	4.88 (5.31)	98,471 (111,024)	676 (611)	Operations suspended on August 31 due to uneconomic operations.
Cominco Ltd., Sullivan mine, Kimberley	10,000 (10,000)	4.97 (10.8% combined Pb, Zn)	4.99	. .	1.76 . .	2,214,415 (1,925,099)	99,235 (93,253)	Production difficulties encountered due to spontaneous oxidation of sulphide ore in some sections of the mine.
H.B. mine, Salmo	1,250 (1,250)	1.6 (–)	4.2 (-)	– (–)	. . (–)	351,682 (–)	2,838 (–)	Production recommenced in February. The mine had been shut down since 1966.

Table 6 (concl'd)

Company and Location	Mill Capacity	Grade of Ore Milled (principal metals) Lead	Zinc	Copper	Silver	Ore Produced	Lead in Concentrates and Direct Shipping Ores	Remarks
	(tons ore/day)	(%)	(%)	(%)	(troy oz/ton)	(tons)	(tons)	
British Columbia (cont'd)								
Consolidated Columbia River Mines Ltd., Ruth-Vermont mine, Golden	500 (500)	3.69 (–)	5.08 (–)	0.09 (–)	5.02 (–)	26,957 (–)	640 (–)	Mine reopened and production started in October on a trial basis.
Kam-Kotia-Burkam Joint Venture, Silmonac mine, Sandon	150 (150)	5.36 (5.81)	5.41 (6.62)	– (–)	14.45 (16.44)	13,949 (27,429)	717 (1,503)	Continuing operations depend on current exploration and development work.
Reeves MacDonald Mines Limited, Annex and Reeves mines, Remac	1,000 (1,000)	1.67 (0.59)	4.49 (7.07)	– (–)	1.06 (1.91)	191,438 (180,188)	2,822 (905)	Exploration in progress to determine if future operations warranted and tailing disposal facilities to be built.
Teck Corporation Limited, Beaverdell mine, Beaverdell	115 (115)	0.62 (0.72)	0.61 (0.76)	0.003 (0.003)	12.36 (18.23)	37,202 (37,091)	229 (268)	Exploration and development continue to locate new ore.
Western Mines Limited, Buttle Lake, Vancouver Island	1,000 (1,100)	1.28 (0.68)	8.29 (6.02)	1.39 (1.85)	4.60 (. .)	354,420 (374,022)	4,270 (2,545)	Exploration tunnel driven east from Myra Falls mine to explore adjoining Price property.
Northwest Territories								
Pine Point Mines Limited, Pine Point	11,000 (10,000)	2.9 (2.7)	6.01 (6.2)	– (–)	. . (. .)	3,896,357 (3,809,729)	105,706 (96,025)	Concentrator modified to increase capacity and improve metallurgy.
Yukon Territory								
Anvil Mining Corporation Limited, Faro	8,000 (8,000)	4.88 (4.63)	6.37 (6.22)	– (–)	. . (. .)	2,899,145 (2,905,530)	119,306 (117,561)	Expansion of concentrator facilities to 10,000 tons per day completed at end of year.
United Keno Hill Mines Limited, Elsa, Husky, No Cash mines, Mayo District	550 (550)	4.00 (4.61)	1.00 (3.19)	– (–)	34.62 (34.23)	94,819 (80,646)	3,631 (3,516)	Reopened Keno 700 mine and will also develop the Shamrock ore zone from this mine.

Source: Company Reports. [1]Lead content of lead concentrates only. – Nil; . . Not available.

corroding, chemical, and common desilverized lead. The corroding grade has the highest purity and is used chiefly in the manufacture of pigments, battery oxides and tetraethyl lead. Common lead is used mostly in industrial and home construction, while chemical lead possesses superior creep and corrosion resistance and is ideally suited for cable sheathing.

Prices

The price of lead in Canada rose during 1973. From January 1 to March 11 the Canadian price of lead, fob Toronto and Montreal was 15 cents a pound, the same as the last two months of 1972. On March 12 the price was raised to 16 cents where it remained until October 15 when it was raised to 17.5 cents. This price prevailed until year-end. The price of common lead in the United States, fob New York, rose from 14.5 cents at the beginning of the year to 16.5 cents on May 2, the ceiling under price controls instituted by President Nixon in August 1971. It remained at this level until price controls were removed by the Cost of Living Council on December 6 and the price of lead was immediately raised by American producers to a split price of 18-19 cents a pound where it remained at year-end. The price of Canadian lead sold in the United States was changed from the prices quoted above on October 15 because of antidumping charges which had been filed in the United States against Canadian producers. The pricing was changed so that the price of Canadian lead sold in the United States was 1.5 cents higher than that sold in Canada. With the findings of the Tariff Commission on January 10, 1974 this differential was increased to 2.5 cents. On the London Metal Exchange lead opened the year at £131.00 a metric ton (13.9 cents a pound Can.) and rose erratically during the first half of 1973 and then levelled off. During November and December it rose rapidly to an all-time high closing price of £295 (31.2 cents Can.) on December 4 and dropped to £244 at year-end.

Table 7. United States consumption of lead by end-use, 1972-73

	1972	1973^p
	(tons)	
Storage batteries	726,592	769,447
Gasoline antiknock additives	278,340	274,410
Solder, type metal, terne metal and bearing metals	107,652	112,007
Ammunition and collapsible tubes	88,720	84,339
Pigments	89,214	108,766
Cable sheathing	45,930	43,005
Sheet and pipe	41,447	44,685
Caulking	22,483	20,057
Miscellaneous	84,876	84,493
Total reported[1]	1,485,254	1,541,209
Estimated undistributed consumption	–	–
Grand total	1,485,254	1,541,209

Source: United States Department of the Interior, Bureau of Mines, Mineral Industry Surveys, Lead Industry in December 1973, Lead Industry in May, 1974.
[1]Includes lead content of scrap used directly in fabricated products.
^{p}Preliminary; – Nil.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
32900-1	Ores of metals, not otherwise provided for	free	free	free
33700-1	Lead, old, scrap, pig and block, per lb.	free	free	1¢
33800-1	Lead, in bars and in sheets	5%	5%	25%

United States

Item No.		Noncommunist Countries	Designated Communist Countries
		(¢ per lb)	(¢ per lb)
		Effective December 20, 1971	
602.10	All lead-bearing ore, on lead content	0.75	1.5

Tariffs (concl'd)

		Noncommunist Countries	Designated Communist Countries
		(¢ per lb)	(¢ per lb)
		Effective December 20, 1971	
	Unwrought lead		
624.02	Lead bullion, on 99.6% of lead content	1.0625	2.125
624.03	Other, on lead content		
624.04	Lead waste and scrap, on 99.6% of lead content		

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972) T.C. Publication 452.

Lime

D. H. STONEHOUSE

Carbonate rocks, commonly known as limestones, can be classified according to their content of the minerals calcite ($CaCO_3$) and dolomite ($CaCO_3 \cdot MgCO_3$). They range from calcium limestone, containing less than 10 per cent magnesium carbonate to magnesian limestone, containing between 10 and 40 per cent magnesium carbonate and to dolomite, containing between 40 and 45.65 per cent magnesium carbonate. High-calcium limestones are those with less than 3 per cent total impurities. Limestones vary in colour, texture and hardness as well as in chemical composition, giving rise to a wide range of applications. Quicklime (CaO or $CaO \cdot MgO$) is formed by the process of calcination, in which limestones are heated to the dissociation temperature of the carbonates (as low as 402°C for $MgCO_3$ and as high as 898°C for $CaCO_3$) and held at that temperature over sufficient time to release carbon dioxide. Although the word 'lime' is used generally, and wrongly, to refer to pulverized limestone as well as to forms of burned lime, strictly speaking it should refer only to calcined limestone (quicklime) and its secondary products, slaked lime and hydrated lime. The former is the product of mixing quicklime and water, the latter of slaked lime dried and possibly reground.

Calcining is done in kilns of various types but essentially those of vertical or rotary design are used, having over the years incorporated many adaptations to the standard designs. Of comparatively recent design are the rotary hearth, travelling grate, fluo-solid and inclined vibratory types.

Canadian industry and developments

Lime plants have been established near urban and industrial centres in Canada where there are large reserves of suitable limestone and where most of the major consumers of lime are situated. Lime is a high-bulk, low-cost commodity and it is uncommon to ship it long distances when the raw material for its manufacture is available in so many localities. The more heavily populated and industrialized provinces of Ontario and Quebec together produced about 85 per cent of Canada's total lime output in 1973, with Ontario contributing two thirds of Canada's total. More limited markets in the other provinces resulted in much lower production in those areas. Commercial lime (lime that is normally produced for shipment and use off the plant site) was not produced in 1973 in Nova Scotia, Prince Edward Island, Newfoundland and Saskatchewan, the needs in each of these provinces being supplied from plants in neighbouring provinces or states.

During 1973, 18 companies operated a total of 24 lime plants in Canada: 1 in New Brunswick, 4 in Quebec, 11 in Ontario, 3 in Manitoba, 4 in Alberta and 1 in British Columbia. A total of 82 kilns was available–23 rotary, 55 vertical, 1 vibratory-grate and 3 rotary-grate. Preliminary returns indicate that lime production in 1973 was 1,826,000 tons, excluding some captive production such as that from pulp and paper plants that burn sludge to recover lime for reuse in the causticization operation, and that produced by a large iron and steel complex for its own use.

Atlantic provinces. In 1968, at Aguathuna, near Stephenville on the west coast of Newfoundland, Sea Mining Corporation Limited constructed a new plant designed to produce mangesium hydroxide from seawater. Although the plant was never operated commercially, a rotary kiln which was to produce lime for captive use in the extraction process was put into service during 1969 and 1970 to supply some quicklime for waste neutralization application on the island's east coast. This market is now supplied by Quebec-based lime producers.

Havelock Lime Works Ltd. began production of a high-calcium quicklime early in 1971, utilizing a newly installed, 100-ton-a-day rotary kiln at the company's

Table 1. Canada, lime production and trade, 1972-73

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Production[1]				
By type				
Quicklime	1,474,225		1,575,838	
Hydrated lime	256,086		250,162	
Total	1,730,311	26,732,421	1,826,000	28,421,000
By province				
Ontario	1,192,197	18,475,204	1,228,000	19,036,000
Quebec	291,542	3,836,045	316,000	4,264,000
Alberta	128,397	2,331,028	132,000	2,385,000
Manitoba	. .	978,791	. .	1,228,000
British Columbia	. .	460,845	47,000	878,000
New Brunswick	. .	650,508	. .	630,000
Total	1,730,311	26,732,421	1,826,000	28,421,000
Imports				
Quick and hydrated				
United States	28,623	745,000	16,208	517,000
France	32	15,000	40	22,000
Britain	24	1,000	–	–
Total	28,679	761,000	16,248	539,000
Exports				
Quick and hydrated				
United States	295,406	4,034,000	372,126	5,497,000
Greenland	–	–	684	37,000
Panama	210	5,000	200	7,000
Bermuda	94	2,000	40	1,000
Guyana	408	9,000	–	–
Other countries	18	1,000	32	1,000
Total	296,136	4,051,000	373,082	5,543,000

Source: Statistics Canada.
[1] Producers' shipments and quantities used by producers.
. . Not available; ^{p}Preliminary.

quarry site at Havelock, New Brunswick. Markets currently include mineral processing operations and pulp and paper industries mainly within the province as well as a growing export trade. Havelock Processing Ltd. now operates the company's crushed limestone plant which has been expanded to offer a range of products from coarse aggregate through washed and screened sizes for asphalt and concrete application, to finely pulverized filler material. Snowflake Lime, Limited, which for many years produced lime at Saint John, has not rebuilt its lime-making facility following a fire in 1968. The quarries are still supplying crushed stone to the local construction industry.

Quebec. At Joliette, Domtar Chemicals Limited, Lime Division, produces quicklime and hydrated lime from a high-calcium Trenton limestone for the steel and pulp and paper industries. Shipments are made to Atlantic consumers as well as to Quebec and Ontario.

Dominion Lime Ltd. produces high-calcium quicklime and hydrated lime from Silurian limestone at Lime Ridge, near Sherbrooke. Additional production capacity was activated during the year, resulting in an increase in output of over 30 per cent. Markets include steel, pulp and paper, construction and agricultural industries.

A high-calcium Ordovician limestone of the Beekmantown Formation has been mined for many years by Shawinigan Chemicals Division of Gulf Oil Canada Limited, near Bedford, for use in the company's carbide plant at Shawinigan. The quality of the limestone, containing less than 2 per cent silica and

Table 2. Canada, lime, production, trade and apparent consumption, 1964-73

	Production[1]					
	Quick	Hydrated	Total	Imports	Exports	Apparent Consumption[2]
			(short tons)			
1964	1,249,394	291,333	1,540,727	20,791	106,343	1,455,175
1965	1,340,386	280,018	1,620,404	25,334	239,334	1,406,404
1966	1,293,982	261,055	1,555,037	29,249	180,864	1,403,422
1967	1,178,109	244,790	1,422,899	22,113	90,125	1,354,887
1968	1,219,271	236,742	1,456,013	24,770	85,263	1,395,520
1969	1,388,109	246,753	1,634,862	41,226	195,160	1,480,928
1970	1,401,008	246,946	1,647,954	33,785	200,614	1,481,125
1971	1,340,935	257,319	1,598,254	26,445	283,738	1,340,961
1972	1,474,225	256,086	1,730,311	28,679	296,136	1,462,854
1973p	1,575,838	250,162	1,826,000	16,248	373,082	1,469,166

Source: Statistics Canada.
[1] Producers' shipments and quantities used by producers. [2] Production plus imports less exports.
p Preliminary.

0.015 per cent phosphorus, makes it a highly acceptable material for the production of calcium carbide. Hydrated lime made during calcium carbide-acetylene manufacture is sold for commercial use.

Ontario. Domtar Chemicals Limited, Lime Division, operates a limestone quarry and a lime plant at Beachville. The high-calcium limestone is mined, crushed, screened and used primarily as feed to the lime plant which has both vertical and rotary kilns. At Hespeler, Domtar produces lime, crushed stone and agricultural limestone. The lime plant has vertical kilns and produces high-quality, white quicklime. Both plants also produce hydrated lime.

The Beachville plant of Cyanamid of Canada Limited, containing a rotary kiln and a calcimatic kiln, was sold to Dominion Foundries and Steel, Limited (Dofasco) of Hamilton during the early months of 1973. Major renovations to be completed in late 1973 will more than double the plant's lime producing capacity in order to supply increased demands for lime by Dofasco's basic oxygen furnaces. The plant will be operated as BeachviLime Limited.

In a buoyant market for lime, Cyanamid continued to produce at its Niagara Falls plant which was scheduled for phase-out because of a decreasing demand for carbide. Limestone for use as open-hearth and blast-furnace flux, for portland cement manufacture and as a pulverized stone is also produced at Beachville.

Through a subsidiary, Chemical Lime Limited, The Steel Company of Canada, Limited at Hamilton is supplied with flux stone and with high-calcium lime from a quarry and lime plant near Ingersoll. Vertical kilns were installed at the lime plant in 1959. A new rotary kiln of 325-ton-a-day capacity was installed in 1971 to supply projected requirements of the company's steel manufacturing facilities at the Hilton Works.

Near Amherstburg, Allied Chemical Canada, Ltd. mines a high-calcium limestone for the production of lime which is used, along with salt from a nearby brine field, in the manufacture of soda ash. Canadian Gypsum Company, Limited produces a dolomitic lime near Guelph. Bonnechere Lime Limited, which operated kilns at Carleton Place and at Eganville for many years, discontinued the manufacture of lime in mid-1970.

Early in 1969, Reiss Lime Company of Canada, Limited began construction of docking facilities on Lake Huron, just west of Spragge, to import limestone from the Rogers City area in Michigan for the manufacture of lime to be used in uranium processing. Production of high-calcium lime began in mid-1970 at an initial capacity of 65,000 tons a year. The company is owned by Denison Mines Limited and C. Reiss Coal Co., Wisconsin, U.S.A.

Steetley of Canada (Holdings) Limited produces dead-burned dolomite at Dundas for refractory uses.

Western provinces. Effective March 1, 1972, the assets of the Production Division of The Winnipeg Supply and Fuel Company, Limited were acquired by Steel Brothers Canada Ltd. Included were the quarry and lime plant at Spearhill, the quarry at Falconer and the lime plant at Fort White. The Spearhill operation produces a white, high-calcium lime, and limestone from Falconer, trucked to Fort White, is processed using conventional equipment before introduction to a vibratory grate calciner. Quicklime is supplied to chemical, metallurgical and construction industries as well as to a growing market in the sewage treatment

Table 3. Canadian lime industry, 1973

Company	Plant Location	Type of Quicklime
New Brunswick		
1. Havelock Lime Works Ltd.	Havelock	High-calcium
Quebec		
2. Dominion Lime Ltd.	Lime Ridge	High-calcium[2]
3. Domtar Chemicals Limited	Joliette	High-calcium[2]
4. Gulf Oil Canada Limited Shawinigan Chemical Division	Shawinigan	High-calcium[2]
5. Quebec Sugar Refinery[1]	St-Hilaire	High-calcium
Ontario		
6. The Algoma Steel Corporation, Limited[1]	Sault Ste. Marie	High-calcium
7. Allied Chemical Canada, Ltd.[1]	Amherstburg	High-calcium
8. BeachviLime Limited	Beachville	High-calcium
9. Canadian Gypsum Company, Limited	Guelph	Dolomitic[2]
10. Cyanamid of Canada Limited[1]	Niagara Falls	High-calcium
11. Chromasco Corporation Limited[1]	Haley	Dolomitic
12. Domtar Chemicals Limited	Beachville	High-calcium
	Hespeler	Dolomitic[2]
13. Reiss Lime Company of Canada, Limited	Spragge	High-calcium
14. The Steel Company of Canada, Limited	Ingersoll	High-calcium
15. Steetley of Canada (Holdings) Limited	Dundas	Dolomitic
Manitoba		
16. The Manitoba Sugar Company, Limited	Fort Garry	High-calcium
17. Steel Brothers Canada Ltd.	Spearhill	High-calcium
	Fort Whyte	High-calcium and dolomitic
Alberta		
18. Canadian Sugar Factories Limited[1]	Taber	High-calcium
	Picture Butte	High-calcium
19. Steel Brothers Canada Ltd.	Kananaskis	High-calcium
20. Summit Lime Works Limited	Hazell	High-calcium
British Columbia		
21. Steel Brothers Canada Ltd.	Kamloops	High-calcium
22. Texada Lime Ltd.	Fort Langley	High-calcium

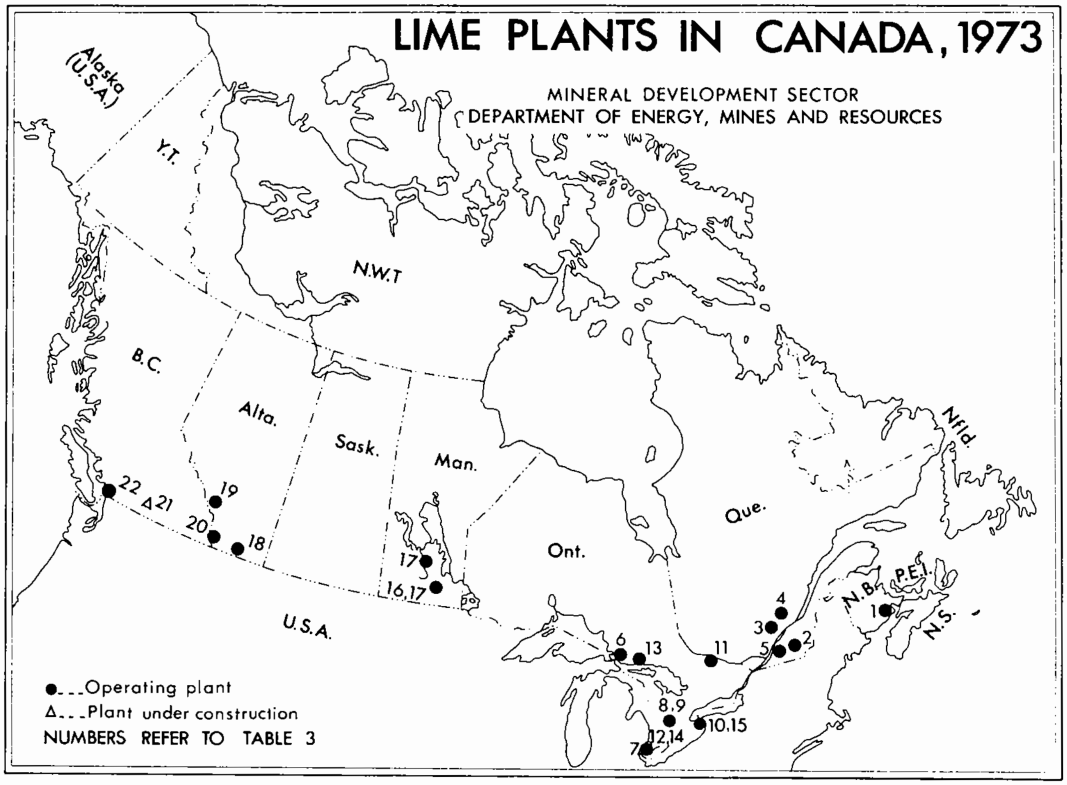
[1]Production for captive use. [2]Hydrated lime produced also.

field. Limestone is supplied to The Manitoba Sugar Company, Limited.

Steel Brothers Canada Ltd. put a new rotary-kiln lime plant into operation early in 1968 at Kananaskis to replace the vertical, hanging kilns operated for many years. Limestone is quarried about 7 miles west of the plant site to provide kiln feed for the production of quicklime and hydrated lime. A second rotary kiln went on stream early in 1972, doubling the production capacity of the plant. A new plant under construction at Kamloops, British Columbia, by Steel Brothers is expected to be operative during 1975.

Summit Lime Works Limited, near Crowsnest, produces high-calcium limestone for use at sugar refineries, dolomitic and high-calcium stone for metallurgical use, high-calcium quicklime and hydrated lime for the chemical, metallurgical and construction industries.

During 1971 Texada Lime Ltd. constructed a calcimatic-kiln lime plant at Fort Langley, British Columbia capable of producing up to 200 tons a day. Limestone is barged from Texada Island and the product—a high-calcium quicklime—is marketed throughout the mining and pulp and paper producing



regions of British Columbia. The plant went on stream in February 1972. MacDonald Consultants Ltd. of Vancouver, in partnership with M C Q Industries of Columbus, Ohio, were responsible for the design and development of the project. In late 1973 Texada Lime Ltd. was sold to Columbia Lime Products Limited.

Markets, outlook and trade

The metallurgical industry provides the largest single market for lime. With the increased application of the basic oxygen furnace (BOF) in the steel industry, lime consumption increased greatly in certain areas of the United States and Canada. It is likely that the rate of increase will level during the next year or so. The addition of hydrated lime in the pelletizing of iron ore concentrates has resulted in a stronger, more stable pellet and could develop as a substantial market for lime.

The pulp and paper industry is the second largest consumer of lime, most of which is used in the preparation of digesting liquor and in pulp bleaching.

The uranium industry uses lime to control hydrogen-ion concentration during uranium extraction, to recover sodium carbonate and to neutralize waste sludge. In the production of beet sugar, lime is used to precipitate impurities from the sucrate. It is used also in the manufacture of many materials such as calcium carbide, calcium cyanamide, calcium chloride, fertilizers, insecticides, fungicides, pigments, glue, acetylene, precipitated calcium carbonate, calcium hydroxide, calcium sulphate, magnesia and magnesium metal.

The rapidly growing concern for care and treatment of water supplies and the appeal for enforced antipollution measures should result in greater use of lime for water and sewage treatment. The removal of SO_2 from hydrocarbon fuels either during the burning procedure or from the stack gases by either wet or dry scrubbing will necessitate the use of lime and will undoubtedly develop a major market for this commodity as SO_2 emission regulations are developed. Lime is effective, inexpensive and can be regenerated in systems where the economics would so dictate.

Table 4. Canada, consumption of lime, quick and hydrated, 1971-72
(producers' shipments and quantities used by producers, by use)

	1971		1972[p]	
	(short tons)	($000)	(short tons)	($000)
Chemical and metallurgical				
Iron and steel plants	435,996	5,968	596,509	8,397
Pulp mills	163,479	2,548	190,253	3,065
Nonferrous smelters	75,039	1,032	65,714	974
Sugar refineries	35,372	681	30,116	544
Cyanide and flotation mills	49,017	627	47,702	633
Water and sewage treatment	62,468	1,026	69,152	1,113
Other industrial[1]	610,611	9,184	523,276	8,000
Construction				
Finishing lime	29,214	778	46,993	1,389
Mason's lime	30,293	679	24,347	479
Sand-lime brick	21,922	308	22,481	325
Agricultural	8,500	177	10,352	218
Road stabilization	9,082	162	13,317	271
Other uses	112,765	1,265	103,944	1,252
Total	1,643,758	24,435	1,744,156	26,660

Source: Statistics Canada.
[1]Includes uranium plants, glass works, fertilizer plants, tanneries and other miscellaneous industrial uses.
[p]Preliminary.

Table 5. World production of quicklime and hydrated lime, including dead-burned dolomite sold or used 1971-72

Country	1971	1972[p]
	(thousand short tons)	
U.S.S.R.	23,100	24,300
United States	19,591	20,290
West Germany	11,641	12,031
Japan	10,934	11,166
France	4,900	4,900
Poland	4,142	4,456
Italy	4,630	4,400
East Germany	3,097	3,200
Belgium	3,311	3,168
Czechoslovakia	2,485	2,590
Romania	2,481	2,535
Brazil	2,200	2,200
Yugoslavia	1,755	1,888
Canada	1,730	1,826
Other countries	10,670	10,717
Total	106,667	109,667

Sources: U.S. Bureau of Mines *Minerals Yearbook* Preprint 1972; and Statistics Canada.
[p]Preliminary.

Soil stabilization, especially for highways, offers a potential market for lime. However, not all soils have the physical and chemical characteristics which react properly with lime to provide a dry, impervious, cemented and stable roadbed. Hydrated lime added to asphalt hot mix prevents the asphalt from stripping from the aggregate. This could become more important as new technologies relating to asphalt maintenance and repair are adopted and as the sources of good clean aggregate become scarce.

Production of lime-silica bricks, blocks, and slabs has not been as popular in Canada as in European countries. These lightweight, cellular, insulating masonry forms have many features attractive to the building construction industry.

Although quicklime and hydrated lime are not of relatively high monetary value, they are transported considerable distances in bulk or in packages if a market exists. Freight costs can represent a large part of the consumer's cost. Production costs have been significantly increased as a result of higher energy costs. Limestones are well distributed in Canada, but it does not necessarily follow that a lime-consuming industry will produce lime for captive use—lime producers will usually offer competitive prices. Nevertheless, some major users do produce lime for their own use and, especially in the United States in recent years, iron and steel producers have integrated backwards into lime manufacture.

Canada is a net exporter of lime.

Prices

Canadian lime prices quoted in Canadian Chemical Processing of December – 1973

Lime, carloads, fob works, bulk, per ton	
Ontario, quicklime	$16.50
Ontario, hydrated	$17.00

Tariffs

Canada

Item No.	British Preferential	Most Favoured Nation	General
29010-1 Lime	free	free	25%

United States

Item No.	On and After Jan. 1, 1972
512.11 Lime, hydrated	free
512.14 Lime, other	free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States (Annotated), 1972 TC Publication 452.

Lithium

G.H.K. PEARSE

Lithium, having a specific gravity of 0.534, is the lightest element that is solid at ordinary temperatures. It is a soft, ductile, silvery-white metal that oxidizes rapidly in air and reacts readily with water. Lithium finds a diversity of specialized uses as mineral, industrial compound and metal. The principal ore minerals are spodumene, petalite, lepidolite and amblygonite occurring in pegmatite bodies.

Lithium deposits have been mined in the United States since 1889 and in Europe and Africa since the early 1900's. Lithium was used solely in a pharmaceutical preparation until near the end of the 19th century when it became important as an ingredient in special glasses. The Edison cell storage battery using lithium hydroxide was invented in 1908. Shortly after The First World War a hardened lead-base bearing alloy containing 0.04 per cent lithium was developed in Germany. Very little further research and development was done on lithium until The Second World War. During the war and continuing to the present, uses have multiplied dramatically and consumption has increased more than twentyfold in the last 25 years.

Canada's only significant producer of lithium, Quebec Lithium Division of Sullivan Mining Group Ltd., near Amos, Quebec, began production in 1955. Concentrates were shipped to United States under contract with Lithium Corporation of America until 1959 when the contract was cancelled. Production was then suspended, but was resumed on a reduced scale in 1960 to supply a new lithium chemicals plant. The mine was finally closed in 1965 in the face of a strike and reduced markets and prices. However, the high-grade lithium zone at Tantalum Mining Corporation of Canada Limited's deposit at Bernic Lake, Manitoba has recently been evaluated and is slated for production by early 1977.

Consumption of lithium products is increasing steadily under the stimulus of aggressive research and development by major producers in the United States. However, reserves of lithium in the United States, by far the world's principal consumer, are considerable; making access to that market from outside difficult.

Occurrences, production and developments in Canada

There are five known areas in Canada where substantial reserves of lithium occur. The Val-d'Or–Amos area in northwestern Quebec, in which the Quebec Lithium mine is located, has been the principal producer. Numerous spodumene-bearing pegmatites occur in northwestern Ontario, principally in the Nipigon district. Small amounts of amblygonite and lepidolite have been produced in the Winnipeg River district of southeastern Manitoba since their discovery in 1924. More recently, in this area, Tantalum Mining Corporation of Canada Limited, a wholly-owned subsidiary of Chemalloy Minerals Limited, has delineated large reserves of spodumene ore at its Bernic Lake tantalum deposit. Several deposits have been explored in the Herb Lake area of northern Manitoba.

Amblygonite was recovered from two deposits in the Yellowknife–Beaulieu district, Northwest Territories, and small shipments were made between 1945 and 1955. Deposits in this district are currently considered too remote to be commercially viable.

Quebec. *Sullivan Mining Group Ltd., Quebec Lithium Division, Amos.* The Quebec Lithium property is underlain by numerous parallel pegmatite dykes trending easterly in a zone some 8,000 by 2,000 feet in the contact area between greenstones and granodiorite of the Lacorne batholith. Individual dykes are as much as 2,000 feet long and 100 feet wide. Total reserves have not been made known by the company but these are probably over 20 million tons grading 1.2 per cent Li_2O. Plant start up was in 1955 with a throughput of 1,000 tons of ore a day by 1957. Upon cancellation of the contract with Lithium Corporation of America, production was temporarily suspended in 1959 and resumed at a reduced rate of about 250 tons a day in 1960 to supply the newly built lithium chemical plant. A strike curtailed production in October 1965 and, in the face of dwindling markets and prices, management decided to close down operations and await more favourable developments in the industry. Stocks on hand were disposed of over the following two years. Total production from the mine was around 1 million tons of ore.

Other lithium properties of interest occur in the area.

Ontario. *Lithium deposits of the Nipigon district.* The first of numerous spodumene pegmatites southeast of Lake Nipigon was discovered in 1955. Exploration activity which followed outlined several deposits with significant tonnages and grades. The principal property in the area is that of Big Nama Creek Mines Limited which is underlain by an en echelon dyke set totalling 2,800 feet in length and averaging 60 feet in width, and a parallel dyke to the south 800 by 60 feet. Diamond drilling to date has indicated 4.2 million tons grading 1.06 per cent Li_2O to a depth of 1,000 feet. Jean Lake Lithium Mines Limited and Ontario Lithium Company Limited have outlined 1.7 million tons grading 1.3 per cent and 2 million tons grading 1.09 per cent Li_2O, respectively. Other deposits of less than one million tons, which carry values up to 2 per cent lithia, occur in the district.

Development work done by Big Nama Creek Mines included the construction of a headframe, surface buildings, and the sinking of a shaft to 503 feet. Work was suspended in 1957.

Other occurrences. Other properties of interest have been explored in northwestern Ontario; one in particular near Lac La Croix, about 70 miles east-southeast of Fort Frances, has an indicated 1.5 million tons grading 1.20 per cent lithia over a strike length of 1,600 feet to a depth of 500 feet.

Manitoba. *Tantalum Mining Corporation of Canada Limited, (Tanco) Bernic Lake.* Numerous complex, zoned pegmatites, bearing a variety of minerals are known in the Cat Lake–Winnipeg River district of southeastern Manitoba. Tantalum Mining Corporation's deposit at Bernic Lake has the double distinction of being the world's largest tantalum deposit and the only known commercial deposit of pollucite, the principal source of cesium. A spodumene zone containing 5 million tons of 3 per cent Li_2O over a width of 30 feet occurs in the main pegmatite sill and exploratory drilling underground penetrated a hitherto unknown spodumene bearing sill beneath the present workings. The main zone is possibly the richest orebody of its kind in the world and the product is extremely low in iron and other impurities. A few tons of lepidolite were shipped from the Bernic Lake property prior to the mid-1950's.

A loan from the Manitoba Development Corporation was secured by Tantalum Mining Corporation in February 1972, for the construction of a pilot mill to produce spodumene concentrates. Trial shipments to customers during 1973 confirmed the product's suitability for ceramic purposes. In May 1974, Kawecki Berylco Industries, Inc. of New York (KBI), acquired 24.9 per cent of Tanco. KBI, a major specialty metal producer, will assist in engineering feasibility studies for lithium production. The proposed plant, with an annual output of 12 to 15 million pounds of Li_2CO_3 and a ceramic grade product of 100,000 units of Li_2O (15,000 tons) is expected to start up in early 1977. The plant will produce heavy media, flotation and lithium chemical products.

Several other occurrences in the Cat Lake–Winnipeg River district contain over 1 million tons of reserves grading 1.2 per cent or more lithia. Petalite, amblygonite, and other less common lithium minerals occur particularly at the east end of Bernic Lake. Beryllium, tin, columbium, tantalum, rare earth and other elements occur in the pegmatites of this area.

Herb Lake district. The two principal occurrences in the Herb Lake district of northern Manitoba contain 2 to 3 million tons of spodumene ore grading 1.2 to 1.4 per cent Li_2O.

Northwest Territories. Many lithium-bearing pegmatites are known in the Yellowknife–Beaulieu district of the Northwest Territories. There are reserves of several tens of millions of tons in the district, principally of spodumene ore, but also including significant tonnages of amblygonite. The remote location and market conditions for lithium preclude exploitation of these deposits at present.

Other Canadian occurrences. Lithium pegmatites are known in several localities in the Appalachians, and two occurrences are reported from the Revelstoke district in British Columbia. These are currently only of mineralogical interest.

Uses

The unique physical and chemical properties of lithium and its compounds have given rise to a diversity of uses which continue to increase. The metal is employed in metallurgical applications as an alloy constituent and as a scavenger and deoxidizer of other metals. Lithium is the most electro-positive of the elements, which, with its light weight, makes it attractive as an anode material in batteries. This application is actively being explored and, within the last two years, several promising developments have been reported. The minerals lepidolite, petalite and spodumene find use as constituents in special glasses, ceramics, enamels, and as welding and brazing fluxes. Lithium chemicals are used in lubricating greases; as a catalyst in numerous organic chemical processes, e.g., rubber making and vitamins; as a dry chlorine vehicle for sanitation purposes; and in pharmaceutical preparations. The use of lithium carbonate in aluminum production cells increases recovery, reduces power requirements and reduces fluorine gas emission. Other lithium chemical applications include use in air conditioning, generation of oxygen and as an electrolyte in batteries.

World review

The United States is the world's principal producer and by far the greatest consumer of lithium products. Prior to the start of The Second World War production was little more than 100 tons of lithia (Li_2O)

equivalent a year.* In 1973, world production was estimated to be 14,200 tons, two thirds of which was consumed by the United States.

Table 1. United States consumption of lithium[1], 1968 and 2000

	1968	2000 (ranges)
	(short tons Li_2O)	
Ceramics, glass	1,700	2,100 – 7,100
Grease	1,420	5,800 – 8,600
Humidity control	730	1,400 – 2,600
Welding, brazing	900	3,750 – 6,400
Alloying, etc.	620	2,000 – 4,100
Other	280	1,200 – 1,700
Total	5,650	16,250 – 30,500

Source: *Mineral Facts and Problems, 1970.*
[1]Figures converted to Li_2O equivalent.

All three producers in the United States also manufacture lithium chemicals. Foote Mineral Company mines spodumene at Kings Mountain, North Carolina and recovers lithium carbonate from brines at Silver Peak, Nevada. In May 1973, Foote opened a plant at Kings Mountain to produce low-iron spodumene by their recently developed thermal process. In March 1974, the company announced plans to construct a 12 million-pound-a-year lithium carbonate plant at Kings Mountain slated to start up in 1976. American Potash and Chemical Corporation recovers lithium carbonate from brines at Searles Lake, California. Lithium Corporation of America, a subsidiary of Gulf Resources & Chemical Corporation, mines spodumene at Bessemer City, North Carolina and plans recovery from Great Salt Lake near Ogden, Utah.

The United States also imports lithium in the form of chemicals and minerals such as petalite and lepidolite for use in special glasses. Imports reached some 800 tons a year by 1967 and have since dropped to an estimated 230 tons in 1973. Exports of lithium products are about 1,200 tons a year.

Rhodesia was producing some 1,600 tons per year and was the primary supplier of United States import requirements until the United Nations embargo.

Other major producers include the U.S.S.R., the People's Republic of China, and Southwest Africa.

World reserves of lithium were conservatively estimated by the United States Bureau of Mines in 1968 to be about 6 million tons of contained lithium (12.9 million tons Li_2O), 5.25 million tons of which occur in the United States. Canada's reserves were estimated to be about 200,000 tons. More recent figures and the addition of reserves known in Ontario, the Northwest Territories and other localities in Manitoba, which were not included, raise known reserves to over 400,000 tons of contained lithium (1 million tons Li_2O). Total world reserves are an order of magnitude more than adequate to meet anticipated requirements for the balance of the 20th century.

*Production and consumption figures given are short tons of Li_2O equivalent except where otherwise indicated. These figures can be converted to lithium metal equivalent by dividing by 2.143.

Table 2. World lithium production, 1971-73

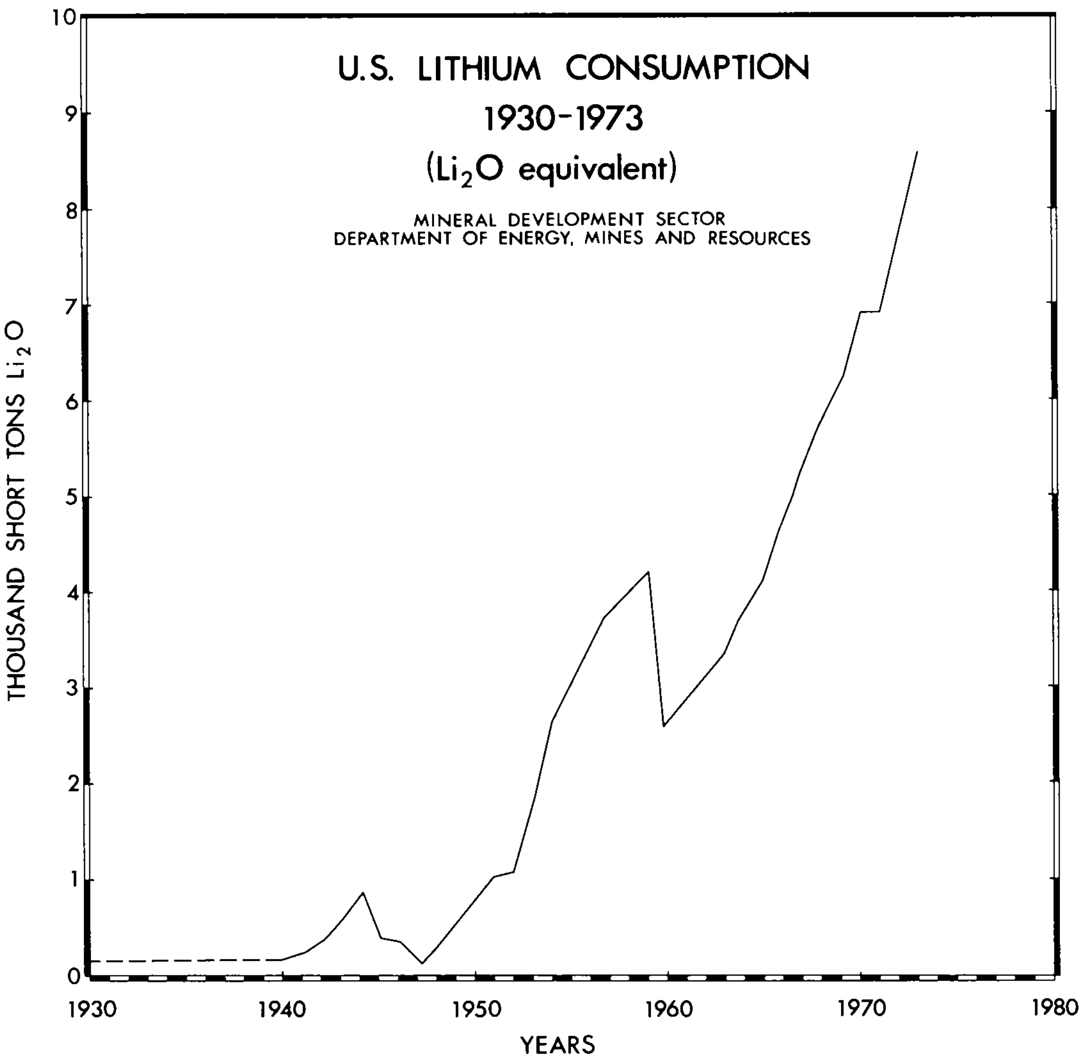
	1971	1972	1973^e
	(short tons Li_2O)		
United States	$7,000^e$	$7,800^e$	$9,200^e$
Argentina	7	7	10
Australia	77	49	20
Brazil	280	280	300
Mozambique	14	–	–
People's Rep. of China	650	700	700
Portugal	22	32	30
Southwest Africa	490	350	400
Rhodesia	$1,500^e$	$1,750^e$	1,000
U.S.S.R.	$1,500^e$	$1,750^e$	2,500
Total	11,500	12,700	14,200

Sources: Various, including U.S. Bureau of Mines Commodity Data Summaries, January 1972, 1973 and 1974, and Mineral Development Sector estimates.
^{e} Estimated. – Nil.

Outlook

The lithium industry is small in comparison with other segments of the mining and chemical industries. However, it has grown steadily since the end of The Second World War and continued growth at moderate rates is assured for the long-term. Annual lithia consumption in the United States was estimated to be between 16,250 and 30,500 tons by the year 2000, based on projections made by the U.S. Bureau of Mines in 1968. It is noteworthy that "other uses" were expected to expand from 280 tons in 1968 to as much as 1,700 tons by the year 2000.

Since the 1968 forecast, several breakthroughs in battery technology have been announced and the potential for such use as a power source for automobiles and for peak power generation has become evident. One estimate for peak power installation requirements is an initial 5,400 tons of lithia. Annual requirements for electric cars, assuming they prove feasible, could reach 30,000 tons by the turn of the century. World energy requirements will have to be met ultimately by thermonuclear reactors, the simplest form of which would utilize lithium, both as



Sources: Various, including U.S. Bureau Mines Publications, and Mineral Development Sector estimates.

a heat transfer medium and a source of tritium for the reaction. The first practical plant is unlikely to be constructed until after the end of the century, but research requirements in this area may well expand significantly before that. The surge in lithium consumption in the United States during the 1950's, which peaked in 1959, was probably due to procurements for thermonuclear research. Consumption figures for this purpose are kept secret, but an estimate of over 7,000 tons between 1953 and 1959 can be made from the accompanying graph, which was constructed from numerous sources of qualitative and quantitative information. Fusion research uses may, therefore, easily exceed 1,000 tons per annum during the 1990's. Given these developments, consumption in the United States could well exceed 50,000 tons per annum by 2000 or double the forecast high made in 1968.

Magnesium

J.J. HOGAN

Magnesium is the third most abundant element in the earth's crust; and is more plentiful than iron or aluminum. It is found in minerals such as dolomite, magnesite, brucite and olivine, also in seawater, brines and evaporite deposits. Magnesium is consumed mostly in the form of non-metallic compounds, principally magnesium refractories. Only about 10 per cent of consumption, on a magnesium content basis, is as magnesium metal.

The metal is produced by two basic processes. One is by electrolysis of magnesium chloride derived from seawater and brines. The other is a silicothermic process whereby magnesium ore, such as dolomite or magnesite, is mixed with ferrosilicon and reduced at high temperatures. All Canadian production is by the latter method, which is suitable for small plants. The electrolytic method has become popular in large-scale plants utilizing low-cost electric power. The amount of electric power required to produce magnesium electrolytically is 8-9 kWh a pound, higher than the 7-8 kWh required to produce a pound of aluminum by the conventional Hall-Heroult process, and considerably higher than for the silicothermic process, including production of the ferrosilicon.

Canada

The only Canadian producer of primary magnesium is Chromasco Corporation Limited (formerly, Dominion Magnesium Limited). This company has operated a mine and smelter at Haley, Ontario, 50 miles west of Ottawa, since 1942.

A high quality (98%) dolomite ore, low in impurities such as silica and the alkali metals, is mined from an open pit and calcined in a rotary kiln to produce dolime. Using the silicothermic process (Pidgeon Process), dolime is mixed with ferrosilicon in a ratio of about 5 to 1. This mixture is briquetted and charged in batch lots into retorts which are externally heated in furnaces, using natural gas as the main fuel. Under vacuum and at controlled high temperature, the magnesium content is reduced, vaporized and condensed in crystalline rings known as "Crowns" in the water-cooled head sections of the retorts. The plant has an annual capacity of 12,000 tons* of magnesium metal but operated well below capacity in 1973. A minor amount of the furnace capacity was used in the production of calcium.

The Company produces ingots of magnesium metal in the following grades and purities: commercial 99.90 per cent; high-purity 99.95 per cent; and refined 99.98 per cent. Magnesium alloys are produced to all specifications. Other magnesium products include master alloys, rods, bars, wire and structural shapes. The Pidgeon process is particularly suited for production of the purer forms.

To produce commercial-grade magnesium, the crowns are simply remelted and cast into ingots. This grade is suitable for general fabrication purposes and for alloying with aluminum, and represents the major proportion of production. The high-purity grade is used mostly for the formation of Grignard reagents (alkyl-magnesium-halides which react to form a variety of organic and inorganic compounds). The refined grade is in demand for chemical laboratory use and as a reducing agent for titanium, zirconium, uranium and beryllium.

Production of magnesium in 1973, according to a preliminary report by Statistics Canada, was 5,830 tons valued at $4,319,000 compared with 5,924 tons in 1972 valued at $4,537,125. Production was well below the 10,637-ton output reached in 1969.

In 1973, domestic consumption of magnesium was 7,293 tons, a 23 per cent increase from the 5,923 tons consumed in 1971. Consumption of magnesium in Canada has shown an upward trend, although some fluctuation has occurred, and has doubled since 1963. The aluminum alloys industry was the predominant outlet for magnesium, but the casting industry also consumed appreciable amounts of the metal. Magline of Canada Limited, of Renfrew, Ontario, a magnesium fabricator, announced that it planned to spend $560,000 to expand its plant to increase the output of products being fabricated and to fabricate new products.

Canadian imports of magnesium metal and alloys in 1973, were 5,050 tons, a small increase over the 4,457 tons imported in 1972 and much above the long term trend for alloys and metals shown in Table 2. Exports of Canadian magnesium in 1973 were 3,264 tons, compared with 2,872 tons in 1972. Canadian production, imports and exports of magnesium in 1973 were in comparatively close balance with consumption. Exports of magnesium metal have entered the United States duty free under the Canadian – United States Defense Production Sharing Program, but this program recently has operated on a reduced scale. Although the United States duty on magnesium ingots and further-processed products has been progressively reduced in accordance with the Kennedy Round of trade negotiations under the General Agree-

*The short tons of 2,000 pounds is used throughout.

ment on Tariffs and Trade, only in certain high-purity items can the Canadian product find a market in the United States except under the above-mentioned program. In the form of ingots, a 20 per cent United States tariff remains whereas the comparable Canadian tariff is 5 per cent.

Table 1. Canada, magnesium production and trade, 1972-73

	1972		1973p	
	(short tons)	($)	(short tons)	($)
Production[1] (metal)	5,924	4,537,125	5,830	4,319,000
Imports				
Magnesium metal				
United States	3,247	2,447,000	5,050	3,817,000
U.S.S.R.	1,100	1,000	–	–
Other countries	110	642,000	. . .	1,000
Total	4,457	3,090,000	5,050	3,818,000
Magnesium alloys				
United States	209	283,000	435	505,000
Britain	142	292,000	121	330,000
West Germany	1	8,000	. . .	2,000
Total	352	583,000	556	837,000
Exports				
Magnesium metal				
United States	1,228	976,000	536	781,000
Britain	1,197	845,000	951	687,000
People's Republic of China	220	144,000	846	581,000
Switzerland	–	–	310	218,000
West Germany	–	–	197	132,000
France	67	49,000	100	72,000
Hungary	47	33,000	–	–
Israel	16	26,000	42	71,000
Argentina	–	–	98	69,000
Australia	16	25,000	42	60,000
Colombia	9	14,000	33	45,000
Brazil	–	–	55	40,000
India	36	26,000	34	26,000
Korea, South	9	6,000	15	14,000
Uruguay	6	13,000	2	6,000
South Africa	11	8,000	–	–
New Zealand	3	4,000	2	3,000
Hong Kong	3	3,000	–	–
Belgium and Luxembourg	4	3,000	–	–
Singapore	–	–	1	1,000
Total	2,872	2,175,000	3,264	2,806,000

Source: Statistics Canada.
[1] Magnesium metal in all forms and in magnesium alloys produced for shipment, less remelt.
pPreliminary; – Nil; . . . less than 1 ton.

World review

World production of primary magnesium in 1973 was 260,000 tons, as shown in Table 4, compared with 256,000 tons in 1972. The United States retained its dominant position, accounting for almost 32 per cent of world output, followed by the U.S.S.R. and Norway. Secondary magnesium adds to the effective supply in some countries, notably the United States, which produced an estimated 15,000 tons of secondary metal. For the fiscal year 1972-73, Japan produced 5,687 tons of secondary metal. West Germany also recovers substantial amounts of magnesium from secondary sources.

A further source of magnesium metal is the stockpile held by the United States government. The General Services Administration (GSA) disposed of 69,516 tons of stockpiled magnesium in 1973, up substantially from 7,737 tons released in 1972. In 1974, the GSA is expected to dispose of all the magnesium metal remaining in the stockpile. Stockpile metal must be reprocessed and cleaned, at an approximate cost of 2 to 3 cents a pound, before it can be used in most applications.

A shortage of magnesium metal would have occurred in 1973 if it were not for the metal made available to the market from GSA sales. By far the largest producer in the United States is The Dow Chemical Company. Modifications and improvements to its plant at Freeport, Texas, increased output by 10 million pounds a year to an annual rated capacity of 240 million pounds. N L Industries, Inc., at Rowley, Utah, reported that technical problems were being encountered in bringing its production rate up to the planned 45,000 tons a year, and that it was operating at below one-half capacity. The Aluminum Company of America (Alcoa) announced that its subsidiary, Northwest Alloys, Inc., planned to construct a 40,000-ton-a-year magnesium plant at Addy, Washington, with a completion date scheduled for 1975. The plant will use the Magnotherm process patented by Pechiney Ugine Kuhlmann Development, Inc., and will also produce ferrosilicon for use by Alcoa and other metal producers. The American Magnesium Company plans to bring its 10,000-ton-a-year plant, in Texas, into production in 1974. In Norway, Norsk Hydro Elektrisk Kvaelstofaktieselskab plans to expand its

Table 2. Canada, magnesium production, trade and consumption, 1963-1973

	Production[1] Metal	Imports Alloys	Imports Metal	Exports Metal	Exports	Consumption[2] Metal
	(short tons)	(short tons)		(short tons)	($)	(short tons)
1963	8,095	. .	. .	. .	3,676,725	3,641
1964	9,353	187	1,594	. .	3,951,386	3,762
1965	10,108	166	1,641	. .	4,456,255	4,499
1966	6,723	330	3,011	. .	3,452,000	5,137
1967	8,887	206	1,493	. .	3,696,000	5,054
1968	9,929	302	2,403	. .	4,261,000	5,654
1969	10,637	431	2,023	. .	4,726,000	5,672
1970	10,353	256	2,036	7,669	5,562,000	4,937
1971	7,234	152	1,827	2,917	2,227,000	6,276
1972	5,924	352	4,457	2,872	2,175,000	5,923
1973[p]	5,830	556	5,050	3,264	2,806,000	7,293

Source: Statistics Canada.
[1]Magnesium metal in all forms and in magnesium alloys produced for shipment, less remelt. [2]Consumption, as reported by consumers.
[p]Preliminary; . . Not available.

Table 3. Canada, consumption of magnesium, 1963 and 1968-73

	1963	1968	1969	1970	1971	1972[p]	1973
				(short tons)			
Castings[1]	314	601	793	850	1,316	1,110	1,001
Extrusions[2]	355	926	529	474	375	494	232
Aluminum alloys	2,569	3,713	3,710	3,123	3,972	3,924	4,317
Other uses[3]	403	414	640	490	613	395	1,743
Total	3,641	5,654	5,672	4,937	6,276	5,923	7,293

Source: Statistics Canada.
[1]Die, permanent mould and sand. [2]Structural shapes, tubing, forgings, sheet and plate. [3]Cathodic protection, reducing agents, deoxidizers, and other alloys.
[p]Preliminary.

plant at Heroya from 40,000 to 55,000 tons of magnesium output a year. The company also announced plans to construct a 50,000-ton-a-year magnesium plant at Mongstad, Norway and expects to have it in operation by 1980. For the fiscal year 1972-73, Japanese production of primary magnesium was 10,942 tons, an increase of 9 per cent over 1972. Total production of primary and secondary metal was 16,629 tons, a small increase over the previous year.

Statistics on world consumption of magnesium metal are incomplete. Consumption of magnesium in the noncommunist world in 1973 was estimated to be over 200,000 tons. United States was by far the largest world consumer of the metal and accounted for 125,000 tons of the world's total. In 1972, France consumed an estimated 6,000 tons and Britain 6,060 tons. For the fiscal year 1972-73, consumption in Japan was 19,717 tons, an increase of 15 per cent over 1971-72. The consumption of magnesium in West Germany is unknown, but the automotive industry is a large consumer of the metal. A large part of Norway's magnesium production is exported to West Germany.

Table 4. World primary magnesium production

	1963	1972	1973[e]
	(thousands of short tons)		
United States	75.8	120.8	122.4
U.S.S.R.	35.0	60.0	60.0
Norway	22.7	40.2	40.0
Japan	2.7	12.0	12.0
Italy	6.1	8.3	10.0
Canada	8.9	5.9	5.8
Other noncommunist countries	7.8	7.7	9.0
Other communist countries	1.0	1.1	1.0
Total	160.0	256.0	260.2

Sources: Statistics Canada; U.S. Bureau of Mines.
[e]Estimated.

Technology

Three recent technological developments are expected to have an impact on the growth of the magnesium industry. The first is fluxless melting. To prevent melted magnesium from oxidizing, a salt flux cover may be used. Associated with fluxing are undesirable effects such as hydrochloric acid fumes and metal losses due to entrapment in a sludge which sinks to the bottom of the melt. Fluxless melting uses a heavy inert gas, sulphur hexafluoride (SF_6) in place of a flux. At Volkswagen's-Hannover plant in West Germany eight melting furnaces are melt-protected by this method and metal loss in the furnace is about 0.35 per cent. Research at Battelle Memorial Institute in the United States indicates that fluxless melting of magnesium will receive wide acceptance but will not completely replace flux protection.

The second development is the hot-chamber die-casting machine. It was developed in West Germany and Italy and is being used, on a commercial basis, in Europe. Cost reduction through faster cycling, lower metal loss and thinner walled castings is claimed for these machines. Technology developed to date indicates that the main application of hot-machines will be for casting of small parts, especially those of difficult shapes. Cold-cast machines will continue to be used for the larger castings.

The third development is the use of magnesium as a desulphurizer in the steel industry and it could develop into a significant market for the metal.

Uses

The major use of magnesium is in aluminum alloys where it provides hardness and strength. More magnesium is utilized in aluminum alloys than in magnesium alloys. Because of its high strength-to-weight ratio, magnesium is used in structural application; i.e., those which involve load-carrying components. Although magnesium weighs only two thirds as much as aluminum, the latter metal can be substituted for magnesium in most structural applications, and a higher price has often placed magnesium at a disadvantage.

Typical structural uses of magnesium are in aircraft (particularly helicopters), missiles and space exploration vehicles, luggage frames, and materials-handling equipment such as gravity conveyors and hand trucks. Magnesium castings are used extensively in power lawnmowers, chain saws, typewriters and electronic equipment. The European automotive industry utilizes considerable quantities of magnesium, mainly in the form of engine blocks and other castings. However, the metal has been unable to gain a foothold in North American automobile manufacturing, its cost and somewhat questionable corrosion resistance being major disadvantages. Nevertheless, the increased weight of automobiles due to safety and pollution control devices should provide increased opportunities for utilization of magnesium. New technical developments in fluxless melting and die casting should make magnesium more competitive.

Nonstructural applications, which have grown more quickly than structural uses, account for about 75 per cent of the consumption of magnesium. A rapidly growing sector of this market is for aluminum alloy beverage cans which contain about 2.5 per cent magnesium. Other important nonstructural uses of magnesium are as an alloying element for ductile iron, as a reducing agent in the production of titanium for cathodic protection, in the chemical industry for Grignard reagents, and an antiknock fuel additive. One of the largest potential uses of magnesium, if it is accepted by the steel industry, is in a desulphurization process. This would be a destructive use of magnesium in which no secondary material would be generated, and might result in sales to the steel industry of as much as 40,000 tons a year.

Table 5. Estimated world primary magnesium capacity, 1973

	Company Name	Location	Annual Capacity
			(short tons)
Canada	Chromasco Corporation Limited	Haley, Ontario	12,000 (F)
France	Société Générale du Magnesium (Pechiney)	Marignac	9,900 (F)
Italy	Societe Italiana per il Magnesio e Leghe di Magnesio, Milan	Bolzano	7,700 (F)
Japan	Furukawa Magnesium Company	Oyama	7,300 (F)
	Ube Kosan KK	Ube	6,600 (F)
Norway	Norsk Hydro-Elektrisk Kvaelstofaktieselskab	Heroya, near Porsgrund	48,000 (E)
United States	The Dow Chemical Company	Freeport, Texas	125,000 (E)
	N L Industries, Inc.	Rowley, Utah	5,000 (E)
U.S.S.R.	Various		57,000 (E)

Source: Société française de minerais & métaux, and various others.
Process: (F) – Ferrosilicon; (E) – Electrolytic.

Prices

The Canadian domestic quotation at the end of 1973 for pure magnesium and for standard alloys was 42 cents a pound, fob Haley, Ontario, an increase of 9.25 cents a pound during the year.

United States magnesium prices, in U.S. currency, quoted in *Metals Week* of December 14, 1973, were as follows:

Magnesium metal, per lb, in 10,000-lb lots	
pig 99.8%	38.25 cents
notched ingot	39.00 cents
Magnesium die-casting alloy AZ91B ingot, per lb	33.75 cents

In December 1973, Dow Chemical Company, the major world producer, announced price increases of 3.75 cents and 3 cents a pound on magnesium metal pig and ingot, respectively, to be effective January 1, 1974. Also, the prices of magnesium alloys were to be increased at the same time from 5 to 8.25 cents a pound, with the largest increase affecting die-casting grade.

Outlook

Over the short-term, magnesium could be in short supply as world demand for metals increases. Additional supplies expected from new plants have not been forthcoming because prospective suppliers have experienced technical problems in bringing their plants into operation. In 1973, large quantities of magnesium made available to industry from the United States stockpile prevented a shortage occurring. This buffer situation will be of short duration because the GSA expects to dispose of all magnesium metal remaining in the stockpile during 1974. Short supply and inflationary pressures will result in rising prices of the metal in 1974. The United States producers expected that primary magnesium production would be increased by 100,000 tons by the end of 1975, but it appears that this metal will not be available until a later date because of technical problems being experienced in bringing the plants on stream. Supply of magnesium metal should be adequate to meet medium-term requirements. The long-term projection shows an annual growth rate of 8 per cent. New uses discussed under technology could increase this growth rate. The automotive industry is investigating the use of magnesium in many applications in automobiles to reduce the overall weight and effect a saving in energy consumption.

As with most metals, the long-term growth rate of magnesium metal could be adversely affected by the escalating cost of energy.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
35105-1	Magnesium metal, not including alloys, in lumps, powders, ingots, or blocks	5	5	25
34910-1	Alloys of magnesium, ingots, pigs, sheets, plates, strips, bars, rods and tubes			
34915-1	Magnesium scrap	free	free	free
34920-1	Sheet or plate, of magnesium or alloys of magnesium, plain, corrugated, pebbled, or with a raised surface pattern, for use in Canadian manufactures (expires 31 October 1975)			
34925-1	Extruded tubing, of magnesium or alloys of magnesium, having an outside diameter of five inches or more, for use in Canadian manufactures (expires 28 February 1975)	free	free	25

United States

Item No.		On and After January 1	
		1971	1972
628.55	Magnesium, unwrought, other than alloys; and waste and scrap (duty on waste and scrap suspended to June 30, 1973)	24%	20%
628.57	Magnesium, unwrought alloys, per lb on Mg content	9.5¢+4.5%	8¢+4%
628.59	Magnesium metal, wrought, per lb on Mg content	8¢+4%	6.5¢+3.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972) TC Publication 452.

Manganese

M.A. BOUCHER

Canada does not produce manganese ore. Known deposits contain either insufficient tonnage or less than ore-quality grades to be considered economically important. Because of a strong demand for steel, Canada's imports of manganese ore were higher in 1973 than in 1972. Worldwide, a strong demand for steel which was not met by any substantial increase in world production of manganese ore created a tight supply.

Canada

In 1973, Canada imported 145,557 short tons of manganese (Mn content) in ores and concentrates valued at $7,274,000; this compares with 98,177 tons valued at $5,074,000 in 1972. Imports of ferromanganese including spiegeleisen were 26,511 short tons valued at $4,880,000 and imports of silicomanganese were 10,750 valued at $2,006,000. These compare with 1972 figures of 18,895 tons valued at $3,238,000 and 16,637 tons valued at $2,960,000.

Union Carbide Canada Limited, Metals and Carbon Division, uses metallurgical grade ore to manufacture medium and low-carbon ferromanganese and silicomanganese. Union Carbide expanded its ferroalloy plant at Beauharnois, Quebec with the addition of a 55,000 KVA ferromanganese electric furnace. The furnace started up in November 1973; the energy consumption for each ton of 79% Fe-Mn produced is around 2,300 KWH.

Chromium Mining & Smelting Corporation, Limited produces manganese alloys at its plant in Beauharnois, Quebec.

The adoption of the basic oxygen process has not affected overall manganese consumption to any real extent, but has brought about a greater use of lower carbon grades of ferromanganese.

Because of the demand for high-strength low-alloy steels in pipelines in Canada the use of low carbon grades of ferromanganese is expected to grow faster here than in other countries.

Imported electrolytic manganese is used by Atlas Steels, Division of Rio Algom Mines Limited in the manufacture of low-carbon stainless steel. It is also used by the aluminum, magnesium and copper-alloy industries.

Among principal Canadian consumers of ferromanganese are – The Steel Company of Canada, Limited, Sydney Steel Corporation, The Algoma Steel Corporation Limited, Dominion Foundries and Steel, Limited, Atlas Steels. In Canada, about 13 pounds of ferromanganese and 4 pounds of silicomanganese are used in the production of each ton of crude steel.

Consumers of battery-grade ore are: Union Carbide, Consumer Products Division, Clerite Burgess, Ray-O-Vac Division of ESB Canada Limited and Mallory Battery Company of Canada Limited. Total Canadian consumption of battery-grade ore is in the order of 2,000 tons a year.

World production, trade and consumption

World production of manganese (Mn) ores was an estimated 22.8 million short tons in 1972 compared with 23.2 million tons in 1971. World manganese production growth rate is in the order of 5 per cent a year. As shown in Table 3, the U.S.S.R. is the largest single producer of manganese with about 35 to 40 per cent of world's production. The U.S.S.R. share has remained virtually unchanged over the years indicating that their output has kept pace with the expansion in the rest of the world. Other major producers are South Africa, Gabon, Brazil, India, Australia and the People's Republic of China. U.S.S.R. and China are the only main producers of manganese ore that consume large amounts domestically; thus, approximately three quarters of the ore produced is traded internationally. The developing countries account for 35 per cent of world production and 60 per cent of world trade in manganese.

Some countries, like India, South Africa and Brazil, in addition to exporting ore, process a part of it into ferromanganese and other ferroalloys and export manganese. Gabon, on the other hand, exports virtually all the ore produced. Manganese in the form of ferroalloys is exported also by some countries, notably Norway and France, which import the ore for that purpose. Other major suppliers such as South Africa, India and Brazil use approximately a quarter of their supplies domestically. The People's Republic of China exports about 10 per cent of its 1-million-ton-a-year output, mainly to Japan.

Among the centrally planned economy countries, the Soviet Union accounts for practically all the exports, which go principally to other centrally planned economy countries in Europe. However, the U.S.S.R. retains around 85 per cent of the ore produced for the purpose of domestic processing. Outside the centrally planned economies countries, the main consumers are the developed market economies while the main suppliers with the exception of South Africa and Australia, are the developing countries.

The large consumers; i.e., the United States, the European Economic Community and Japan depend almost entirely on foreign supplies.

Table 1. Canada, manganese, trade and consumption, 1972-73

	1972		1973p	
	(short tons)	($)	(short tons)	($)
Imports				
Manganese in ores and concentrates[1]				
Gabon	30,222	1,450,000	38,504	2,418,000
United States	6,591	923,000	48,023	2,175,000
Brazil	33,173	1,411,000	25,579	1,308,000
Zaire	14,461	725,000	16,124	611,000
South Africa	–	–	12,838	541,000
U.S.S.R.	3,322	165,000	4,071	197,000
Mexico	113	8,000	415	24,000
Other countries	10,295	392,000	3	–
Total	98,177	5,074,000	145,557	7,274,000
Ferromanganese, including spiegeleisen[2]				
United States	3,444	1,010,000	12,130	2,510,000
France	2,913	468,000	5,613	837,000
Norway	–	–	5,072	759,000
South Africa	12,217	1,702,000	3,626	749,000
Japan	47	11,000	70	25,000
Other countries	274	47,000	–	–
Total	18,895	3,238,000	26,511	4,880,000
Silicomanganese, including silico spiegeleisen[2]				
United States	8,431	1,666,000	7,285	1,448,000
Yugoslavia	356	63,000	1,105	221,000
Norway	6,943	1,079,000	1,213	198,000
South Africa	–	–	1,147	139,000
South Korea	907	152,000	–	–
Total	16,637	2,960,000	10,750	2,006,000
Exports				
Ferromanganese[2]				
United States	2,122	60,000	3,177	530,000
Jamaica	156	28,000	156	35,000
Total	2,278	88,000	3,333	565,000
Consumption[2]				
Manganese ore				
Metallurgical grade, Battery and chemical grade	183,175	..	188,072	..

Source: Statistics Canada.
[1] Mn content; [2] Gross weight.
p Preliminary; – Nil; .. Not available.

Table 2. Canada, manganese imports, exports and consumption, 1963-73

	Imports			Exports	Consumption	
		Ferromanganese				
	Manganese Ore[1]	Under 1% Silicon	Over 1% Silicon	Ferro-manganese	Ore	Ferro-manganese
	(gross weight, short tons)					
1963	106,891	22,639	2,355	10	92,270	58,555
1964	62,813	21,830	1,744	3,359	138,959	66,203
1965	89,480	34,562	787	3,817	119,289	61,352
1966	184,103	49,118	1,931	5,722	152,536	68,360
1967	82,659	16,044	4,202	4,339	137,395	61,667
1968	69,209	27,941	1,344	1,018	124,904	71,470
1969	107,954	24,524	4,599	5,512	168,485	70,305
1970	126,823	19,721	1,075	562	169,586	82,356
1971	110,885	21,558	1,790	381	174,761	76,420
1972	98,177	18,895	16,637	2,278	183,175	76,371
1973^p	145,557	26,511	10,750	3,333	188,072	. .

Source: Statistics Canada.
[1] From 1964, Mn content, prior years gross weight.
^{p}Preliminary; . . Not available.

Table 3. World production of manganese ores

	Mn^e	1970	1971	1972^p
	(per cent)	(thousands of short tons)		
Country				
U.S.S.R.	. .	7,541	8,067	8,598
Republic of South Africa	30+	2,954	3,568	3,606
Gabon	50-53	1,602	2,057	2,135
Brazil	38-50	2,071	2,868	2,127
India	. .	1,820	2,029	1,790
Australia	46	828	1,158	1,331
People's Republic of China	30+	1,100	1,100	1,100
Ghana	48+	447	660	549
Republic of Zaire	42+	382	427	407
Mexico	35+	302	294	325
Japan	28-45	298	314	287
Hungary	30-	186	184	184
Morocco	53	124	112	105
Bulgaria	30+	36	45	45
Italy	30-	55	34	28
Anglo	30+	25	25	27
Thailand	46-50	26	15	22
Chile	41-47	29	26	18
Iran	42+	10	6	6
Botswana	30+	53	89	1
Fiji	30-50	27	8	–
Ivory Coast	32-47	25	–	–
Other countries[1]		146	84	141
Total		20,087	23,170	22,832

Source: U.S. Bureau of Mines, *Minerals Yearbook 1972.*
[1] Includes some 20 countries, each producing less than 35,000 tons a year.
^{e}Estimated; ^{p}**Preliminary**; . . Not available; – Nil.

Manganese alloys

The most widely used manganese alloy is high-carbon ferromanganese consumed by the steel industry to the extent of about 15 pounds for each ton of crude steel produced. For 1973, world steel production was 761 million short tons; this indicates that nearly 6 million pounds of high-carbon ferromanganese were consumed by the steel industry.

Table 4. Main producers of high-carbon ferromanganese, 1972

(thousands of short tons)

U.S.S.R.	1,100	India	154
United States	744	Belgium	132
Japan	518	United Kingdom	121
France	496	Canada	88
Eastern Bloc	330	Spain	88
Norway	275	Australia	77
South Africa	248	People's Republic of China	180[e]
Germany	231	Total	4,782

Source: Société Commerciale des Mines Minerais et Métaux.
[e]Estimated.

Note: In addition to the producers shown there are smaller producers in Italy, Sweden, Brazil and Mexico.

Table 5. Ferromanganese consumption in terms of steel production, 1972

	Steel Production	Ferro-Manganese consumption		Steel Production	Ferro-Manganese consumption
	(thousands of short tons)				
U.S.S.R.	139,000	1,100	United Kingdom	28,000	192
United States	136,000	990	France	26,000	209
Japan	107,000	506	Italy	22,000	143
Eastern Bloc	52,000	385	Canada	13,000	93
Germany	48,000	330	Spain	10,000	77
Benelux	28,000	209			

[e]Estimated.
Source: Société Commerciale des Mines Minerais et Métaux.

The figures in Table 5 are estimates only because consumption varies according to the quality and the type of steel produced, the process used for making steel and the production of cast iron.

The two traditional processes used to make high-carbon ferromanganese are the blast furnace and the electric furnace. The blast furnace is mainly used in France, Germany, UK and in parts of the United States, where coke is relatively cheap; the electric furnace is generally used in Norway, Canada and India where electricity is relatively cheap.

The high-carbon ferromanganese industry had to overcome a difficult period due to an overcapacity and tough competition in the steel recession of 1971-72. In 1973, the price level has substantially increased due to a sharp price increase of the manganese ores, coke, power, wages and a strong demand from the steel industry.

Silicomanganese is the second largest use for manganese but its tonnage is about 20 per cent of high-carbon ferromanganese. Japan, the United States and Norway are the major producers. Silicomanganese is mostly produced from electric furnaces.

Manganese metal is only consumed in small quantities. Its main use is as an alloy in nonferrous metals and particularly in aluminum, where iron is not desired.

The major producers of manganese metal in 1972 in short tons were: the United States 23,000; Japan 13,000 and South Africa 13,000. The major consumers of manganese metal in 1972 in short tons were: the United States 25,000, Japan, 7,000, West Germany 5,000, United Kingdom 3,000, Canada 3,000, Sweden 3,000 and Italy 2,000.

Uses

About 95 per cent of the manganese produced in the world is consumed by the steel industry either as high-carbon ferromanganese, medium and low carbon ferromanganese or silicomanganese; it is also used by the steel industry in its pure form as manganese metal. Manganese is used in steel as an additive element to neutralize the deleterious effects of sulphur and as a deoxidizer. Manganese is essential to steel production and has no substitute.

Table 6. Principal manganese additives

	Manganese	Silicon	Carbon
	(per cent)		
Ferromanganese			
High-carbon (standard)	74-82	1.25 max.	7.53 max.
Medium-carbon	74-85	1.50 max.	1.50 max.
Low-carbon	80-85	7.00 max.	0.75 max.
Silicomanganese	65-68	18-20 max.	0.6-3.0
Spiegeleisen	16-28	1.00-4.50	.65
Electrolytic metal	99.87	0.025	0.004

World consumption and reserves

World consumption is 23 million tons annually. World reserves of manganese are extremely large even when manganese from nodules is excluded. Land-based reserves are as follows:

Country	Reserves (contained metal) in million short tons
South Africa	300 – 1,000
U.S.S.R.	400 – 2,000
Gabon	200
Brazil	100
Australia	50+
India	180
People's Republic of China	20

Source: United Nations (A/AC. 138/36, May 1971)

Deep-sea mining

Manganese production from deep-sea mining is not expected to be very large because manganese prices are low and good quality ore is available from land-based operations in large amounts from several suppliers. Manganese production from nodules will probably be on the market by 1980 ± 3 years.

Outlook

The world steel production will probably reach 1 billion short tons by the end of the seventies or early eighties, which will require about 8 million tons of high-carbon ferromanganese or roughly one third more than was consumed in 1973. Because of environment problems and the regulations to be imposed by governments in the United States, Japan and Western Europe against air pollution and also due to the high pricing policy to be expected for coke and power following the energy crisis, it can be expected that new capacities will be installed in countries such as South Africa, Brazil, India or Mexico where large deposits of manganese ores are available, or in countries such as Norway or Canada where electricity is relatively less expensive. It is believed that expansion growth rates will be slowed down in countries such as the United States, France, Germany, UK, Belgium and Japan.

Table 7. United States, consumption of manganese, ferroalloys and metal, 1971-73

	1971	1972	1973
	(short tons, gross weight)		
Ferromanganese			
High-carbon	770,734	804,878	934,847
Medium-and-low-carbon	128,277	141,362	162,318
Silicomanganese	122,913	120,836	141,623
Spiegeleisen	19,677	19,120	20,700
Manganese metal	27,523	30,205	37,775

Source: United States Bureau of Mines, *Minerals Yearbook 1971* and U.S. 1972 Preprint for 1972, Mineral Industry Surveys for 1973.

Prices

A strong demand for steel unmatched with a substantial increase in manganese ore production created a short supply. This short supply, combined with higher transportation costs, pushed the price of the ore from 63 to 68¢ a long-ton unit in 1972 to 85 to 95¢ a long-ton unit at the end of 1973.

United States prices in U.S. currency, published by Metals Week of December 22, 1972 and E.M.J. December 1973.

	December 22, 1972	December 1973
	(¢)	(¢)
Manganese ore, per long-ton unit (22.4 lb) cif U.S. ports, Mn content		
Min. 48% Mn (low impurities)	63-68	85-95
Min. 46% Mn	. .	. .
Ferromanganese, fob shipping point, freight equalized to nearest main producer, carload lots, lump, bulk per long ton of alloy		
	($)	($)
Standard 74-76% Mn	169.5	194.50
78% min. Mn	190	. .
low phosphorous	220	. .
Imported standard 74-76% Mn, delivered Pittsburgh, Chicago	178-180	190-197
	(¢)	(¢)
Medium-carbon, per lb. Mn	. .	. .
"MS" manganese, per lb. Mn	21.0	. .
Low carbon, per lb. Mn		
0.10%C	30.5	. .
0.30%C	29.5	. .
0.75%C	30.5	. .
Ferromanganese silicon, 0.05%C per lb. alloy	16.8	. .
Ferromanganese briquettes, per lb alloy	9.2	. .
Manganese metal, electrolytic metal, 99.9%, per lb. Mn, boxed fob shipping point		
Regular	33.25	33.25
Hydrogen-removed	. .	33.25
4-5%N	34.25	. .
6%N	36.25	. .
Silicomanganese, per lb. of alloy, fob shipping point, freight equalized to nearest main producer, carload lots, lump, bulk		
12½-16% Si, 3% C	9.65	. .
High-Mn, 15.5-17% Si.		
1.75-2.25% C	11.90	. .
16-18½% Si, 2% C	10.65	11.23
18-21% Si, 1½%C	11.38	. .
Briquettes	11.00	. .

. . Not available.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(¢)	(¢)
32900-1	Manganese ore	free	free	free
33504-1	Manganese oxide	free	free	free

Tariffs (concl'd)

35104-1	Electrolytic manganese metal	free	free	20%
37501-1	Ferromanganese, spiegeleisen and other alloys of manganese and iron, not more than 1% Si, in the Mn content, per lb.	free	0.5	1.25
37502-1	Silicomanganese, silico spiegel and other alloys of manganese and iron, more than 1% Si, on the Mn content, per lb	free	0.75	1.75

United States

Item No.		On and After Jan. 1, 1971	On and After Jan. 1, 1972
		(¢ per lb on Mn content)	
601.27	Manganese ore (duty temporarily suspended to end of June 1973)	0.15	0.12
607.35	Ferromanganese, not containing over 1% C	0.3 + 2.5%	0.3 + 2%
607.36	Ferromanganese, containing over 1% but not over 4% C	0.55	0.46
607.37	Ferromanganese containing over 4% C	0.35	0.3
632.32	Manganese metal, unwrought, waste and scrap (duty temporarily suspended on waste and scrap to end of June 1973)	1.5¢ per lb + 11% ad. val.	1.5¢ per lb + 10% ad. val.

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated, (1972), TC Publication 452.

December 1974

Mercury

J.G. GEORGE

The Pinchi Lake mine of Cominco Ltd., some 30 miles north of Fort St. James, British Columbia, was again in 1973 the sole source of Canada's mine output of mercury. In 1973, the Pinchi Lake mill processed 163,000 tons* of cinnabar ore compared with 203,000 tons in 1972. Production was restricted in 1973 to meet market requirements. About 60 per cent of the ore was derived from underground operations with the remainder coming from an open pit which operated during the summer. Beneficiation of the ore consists in concentrating it by flotation, and then roasting the concentrate to produce a mercury vapour which, in turn, is cooled and condensed to produce liquid metallic mercury. In 1973, the roaster produced about 12,500 flasks** of refined mercury. The Pinchi Lake mine's ore reserves at the end of 1973 were 1,600,000 tons containing 120,000 flasks of mercury compared with 1,800,000 tons of ore containing 133,000 flasks of mercury on December 31, 1972.

At its electronic materials plants at Trail, B.C., Cominco Ltd. also produces high-purity mercury metal with metallic impurities totalling ten parts per billion, or less. This specialty metal product is manufactured mainly for special applications in the electronics industry, such as advanced radiation detector materials.

Little exploration and development work was done in 1973 at Canadian mercury mining prospects because the demand for the metal has remained at relatively low levels.

Canadian imports of mercury metal in 1973, at 106,200 pounds, were substantially lower than the 174,700 pounds imported in 1972. Reported consumption of mercury metal in Canada in 1973 was 142,163 pounds, significantly higher than the 114,636 pounds consumed in 1972, mainly because of the greater use of mercury for electrical apparatus which was sufficient to offset a decline in the metal's use in the production of heavy chemicals.

In 1973, Dow Chemical of Canada, Limited, a wholly-owned subsidiary of The Dow Chemical Company of Midland, Michigan, shut down its three chlorine-caustic soda plants using the mercury-cell process. Two of these plants were at Sarnia, Ontario, where a new world-scale chlor-alkali facility of the diaphragm-cell type, which uses no mercury, was completed and brought on stream; the third mercury-cell plant was dismantled at Thunder Bay, Ontario.

*All tons are short tons of 2,000 pounds avoirdupois, unless otherwise stated. **The flask containing 76 net pounds avoirdupois is used throughout.

World review

Estimated world mine production of mercury in 1973 was 276,171 flasks, only slightly less than the 277,621 flasks produced in 1972. Spain continued to be the world's largest mine producer of mercury and, together with Italy, accounted for about 34 per cent of the total output. The seven countries with the largest production, in declining order of output, were Spain, Russia, Italy, Mexico, People's Republic of China, Yugoslavia and Algeria.

According to preliminary statistics for 1973, Spanish mine output of mercury was some 6,000 flasks greater than that of the previous year and Mexican production was almost 25 per cent higher than that of 1972. Italian mercury output declined almost 23 per cent from that of 1972, possibly because of lower grade ores mined and the existence of substantial stocks.

In Spain, the Minas de Almaden Company, whose Almaden mine is the largest and richest mercury producer in the world, continued construction of a new plant at Almaden which was scheduled for completion late in 1974. The plant will use a new process for treating waste residues from its roaster to yield an additional 5,000-10,000 flasks of mercury a year. The current stockpile of residues could reportedly provide an additional 200,000-300,000 flasks. Increased production should also come from Algeria where del Monego, an Italian company, is expected to build a new mercury extraction plant near Annaba, to come on stream about the end of 1974. The U.S.S.R., which continued to increase its mercury production in 1973, plans to build a large mercury mining and metallurgical complex near Magadan on the Chukota Peninsula, in eastern Siberia. Construction plans were reportedly authorized after discovery of a deposit of mercury in commercial quantities. By late 1972. Chinese mercury was reported to be slowly moving into western markets, including the United States, and since then it is believed that larger amounts of Russian, as well as Chinese mercury, have been sold to western countries.

Mine production in the United States continued to decline drastically, and 1973 output of 2,171 flasks was the lowest since record keeping began in 1850. Production was derived from about 10 significant mine producers as against 21 such mines in 1972,

Table 1. Canadian mercury production, trade and consumption, 1972-73

	1972		1973^p	
	(pounds)	($)	(pounds)	($)
Mine production	1,112,412	. .	943,000	. .
Imports (metal)				
United States	22,800	75,000	43,000	157,000
Netherlands	7,600	18,000	29,300	101,000
Spain	56,700	158,000	23,500	88,000
Peru	14,600	44,000	5,700	22,000
Mexico	68,000	172,000	3,800	14,000
Britain	2,000	4,000	600	2,000
Sweden	3,000	13,000	–	–
Total	174,700	484,000	106,200	384,000
Consumption (metal)				
Heavy chemicals	93,860		55,170	
Electrical apparatus	19,134		79,148	
Gold recovery	861		860	
Miscellaneous	781		6,985	
Total	114,636		142,163	

Source: Statistics Canada.
^{p}Preliminary; – Nil; . . Not available.

Table 2. Canadian mercury production, trade and consumption, 1964-73

	Production,	Imports		Exports,	Consumption,
	Metal	Metal	Salts	Metal	Metal
	(pounds)	(pounds)	($)	(pounds)	(pounds)
1964	5,548	293,900	. .	. .	208,304
1965	1,520	1,071,900	. .	. .	415,996
1966	–	404,600	. .	. .	171,588
1967	–	356,300	. .	. .	245,121
1968	430,160	197,900	. .	. .	327,939
1969	1,603,600	133,600	. .	. .	308,814
1970	1,854,400	153,300	. .	. .	340,558
1971	1,406,000	122,000	. .	. .	193,968
1972	1,112,412	174,700	. .	. .	114,636
1973^p	943,000	106,200	. .	. .	142,163

Source: Statistics Canada for all figures with the exception of metal production statistics for 1968 to 1971 inclusive which were obtained directly from Cominco Ltd. and represent output from its Pinchi Lake mine in British Columbia.
^{p}Preliminary; – Nil; . . Not available.

when 7,286 flasks were produced. U.S. mine output of mercury is expected to decline further in 1974, but could increase substantially in 1975 if Placer Amex Inc.'s new mercury property near McDermitt, Nevada, is brought into production, as planned, during the second quarter of 1975. Placer Amex, a wholly-owned subsidiary of Placer Development Limited, has a 51 per cent interest in the McDermitt property with Mineral Exploration Company of New Jersey holding the remaining 49 per cent interest. The McDermitt property is said to be mineable by open-pit methods and ore reserves are reported to be 3.5 million tons grading 10 pounds of mercury a ton (0.5 per cent). Production at a rate of 20,000 flasks of mercury a year is being considered.

The United States is still believed to be the world's

Table 3. World production of mercury

	1969	1972	1973[p]
		(flasks)	
Spain	64,862[1]	53,994	60,000[e]
U.S.S.R.[e]	47,000	50,000	52,000
Italy	48,733	41,801	32,315
Mexico	22,500	22,510	28,000[e]
People's Republic of China[e]	20,000	26,000	26,000
Yugoslavia	14,330	16,419	15,606
Algeria	–	13,361	14,000[e]
Canada	21,200	14,637	12,408
Turkey	6,544	7,963	8,439
Czechoslovakia	435	6,614	7,000[e]
West Germany	–	2,900	5,800[e]
Japan	5,613	5,172	3,742
Philippines	3,478	3,341	3,500[e]
Peru	3,592	3,066	3,100[e]
United States	29,640	7,333	2,171
Ireland	420	1,250	1,000[e]
Other countries	920	1,260	1,090[e]
Total	289,267	277,621	276,171

Sources: 1971 U.S. Bureau of Mines, *Minerals Yearbook*, for 1969. U.S. Bureau of Mines, Mineral Industry Surveys, Mercury in the First Quarter 1974, for 1972 and 1973 figures with the exception of those for Canada which are from Statistics Canada.
[1]Officially reported mercury content of ore mined.
[p]Preliminary; [e]Estimated; – Nil.

largest consumer of mercury, but has always produced less than its requirements. Total consumption in 1973 in the United States of primary, redistilled and secondary mercury was estimated at 54,283 flasks, a slight increase over the 52,907 flasks consumed in 1972. A large portion of U.S. mercury requirements was again derived from imports which totalled 46,076 flasks* in 1973 compared with 29,179 flasks imported in 1972. The largest suppliers in 1973 in declining order of amount supplied were Canada, Algeria, Spain, Yugoslavia and Mexico. Together these countries accounted for more than 93 per cent of total imports by the United States.

The insignificant change in the amount of mercury used in the United States was again attributed mainly to the problem of mercury pollution. The pollution factor became serious early in 1970 when fish caught in Lake St. Clair and Lake Erie were found to contain a high enough level of mercury to be declared unsafe for human consumption. It was eventually proven that the main source of the contamination was the mercury contained in effluents discharged into those waters from chlorine-caustic soda manufacturing plants located in the area concerned. Very little time was required to virtually eliminate any further contamination of these waters, but the problem of how to economically remove the mercury from the bottom of these and other lakes and rivers where it had been dumped for some years remains unsolved. Some plants that have been using mercury cells to produce chlorine and caustic soda have converted to the diaphragm cell process.

*Reported in United States Department of the Interior, Bureau of Mines, Mineral Industry Surveys *Mercury in the Fourth Quarter 1973.*

Table 4. United States mercury consumption, by uses, primary and secondary in origin

	1969	1972	1973[p]
		(flasks)	
Agriculture[1]	2,689	1,836	1,830
Amalgamation	195	–	–
Catalysts	2,958	800	673
Dental preparations	2,880	2,983	2,679
Electrical apparatus	18,490	15,553	18,000
Electrolytic preparation of chlorine and caustic soda	20,720	11,519	13,070
General laboratory use	1,936	594	658
Industrial and control instruments	6,655	6,541	7,155
Paint:			
Antifouling	244	32	32
Mildew-proofing	9,486	8,190	7,571
Paper and pulp manufacture	558	1	. .
Pharmaceuticals	712	578	606
Other[2]	9,134	4,258	2,009
Total known uses	76,657	52,885	54,283
Total uses unknown	715	22	–
Grand total	77,372	52,907	54,283

Sources: 1972 U.S. Bureau of Mines, *Minerals Yearbook*, for 1969 and 1972. U.S. Bureau of Mines, Mineral Industry Surveys, Mercury in the First Quarter 1974, for 1973.
[1]Includes fungicides and bactericides for industrial purposes. [2]Includes mercury used for installation and expansion of chlorine and caustic soda plants.
[p]Preliminary; – Nil; . . Not available.

World consumption of mercury is thought to have dropped slightly again in 1973, partly as a result of further declines in the metal's use in the production of chlorine and caustic soda, and also because of the continuing general public outcry against environmental pollution. In some large industrial nations including the United States, the use of mercury in some of its applications continued to be adversely affected by this unfavourable publicity. One of the metal's two major uses, as a cathode in the electrolytic preparation of chlorine and caustic soda, continued to be a principal target of the ecologists because of the danger of pollution from the effluents. The danger of mercury poisoning has also continued to cut into other outlets for the metal, such as in the agricultural and pulp and paper industries.

In order to try to bring about more stability to the mercury market, partly by agreeing on concerted measures to control supplies and regulate prices, delegates from the major mercury-producing countries met on several occasions during 1973. At the October meeting in Queretaro, Mexico (located in Mexico's major quicksilver producing region), representatives of that country, as well as of Algeria, Italy, Spain, Turkey and Yugoslavia, met and signed an agreement to pursue market stability. This agreement provided for a common price policy which established floor prices for mercury and stipulated that the producers would sell only to agents who would agree to follow their marketing policy. The producers also decided to sponsor a study of the supply and demand situation for mercury and set up an international research institute to investigate new uses for mercury to offset cutbacks in industry because of environmental pollution.

The First International Congress on Mercury, originally scheduled for September 2-7, 1973 in Barcelona, Spain, was postponed to May 6-10, 1974. Sessions were planned to cover several aspects of the mercury industry, including history and economy, geology, reserves, mining, extractive metallurgy, contamination, purification, toxicity, biological effects and uses. The Congress will, for the first time, give mercury producers, consumers, traders and all other interested parties an opportunity to meet and discuss publicly the problems facing the industry.

During the second half of 1972 the price of mercury turned upward, partly as a result of better consumer interest which, in turn, was largely attributed to the general revival in international business and trade. The rising price trend continued in 1973, but dealer quotations for mercury continued to reflect the volatile nature of the metal. The price rise resulted mainly from improved economic conditions and the continued efforts of several of the major producers to curtail production and withhold supplies from the marketplace. The international producer meetings also helped somewhat to stabilize the world market in 1973 although at year-end the situation of many of the small mine producers of quicksilver remained precarious because of rising production costs.

On December 10, 1973, the United States government's Cost of Living Council amended Phase IV of its price and wage controls program applicable to nonferrous metals, thereby decontrolling the mercury price. The control was a formality insofar as mercury was concerned because the price of the metal during the control period never approached the freeze base price of $450-$460 a flask.

At the end of 1973, United States government stockpiles contained a total of 200,062 flasks of mercury, with no disposals from these stocks being made in that year. In April 1973, the mercury stockpile objective was reduced from 126,500 to 42,700 flasks. A bill, H.R. 7153, was introduced in the House of Representatives in April 1973 to obtain authorization to dispose of the total surplus of 157,362 flasks contained in the national and supplemental stockpiles. However, by the end of 1973, no action had been taken by Congress on bill H.R. 7153. Such stocks are, however, exclusive of excess mercury held by the United States Atomic Energy Commission (USAEC). In June 1969, these surplus USAEC stocks, which do not require Congressional authorization prior to being sold, were declared to be 15,000 flasks. Between then and the end of 1972, a total of 7,776 flasks were sold or released to other government agencies, leaving a surplus of 7,211 flasks of USAEC mercury at December 31, 1972. General Services Administration (GSA) continued its offerings of such stocks in 1973 at the rate of 500 flasks (maximum) a month, with metal so released being restricted to domestic consumption. GSA released a total of 2,583 flasks in 1973, leaving a surplus of 4,628 flasks of USAEC mercury at December 31, 1973.

Because of the hazards to health from mercury pollution, the U.S. Food and Drug Administration, early in 1973, banned the use of mercury in skin-bleaching preparations and in cosmetics except as a preservative in certain eye-area cosmetics. On April 6, 1973 the U.S. Environmental Protection Agency (EPA) published the final air emission standard for mercury at 5.1 pounds a day, per plant. These regulations require that an existing plant must comply with the standard within 90 days after promulgation, unless a waiver is granted. If the EPA Administrator grants a waiver, a period of up to two years is permitted. Later in 1973, EPA proposed, in accordance with the Federal Water Pollution Control Act, that mercury and all its compounds be included in its list of toxic pollutants published in 1972. After a waiting period in which consideration will be given to any comments received by EPA, the list will be republished in final form with any modifications which the Administrator deems to be appropriate. At that time, future legislation to ban part or all of the toxic pollutants will be studied. Late in the year, EPA announced that it had established a daily maximum of 0.00014 pound of mercury per 1,000 pounds of product for the quantity of mercury that could be discharged from a mercury-cell chlor-alkali plant after application of best practicable technology currently available.

Outlook

The mercury producers efforts to control the market, together with some decrease in world mercury output, might result in somewhat higher prices in 1974. Such prices could again fluctuate considerably because of the volatile nature of the commodity. If, however, demand for mercury declines even slightly, producers might stockpile some production, or dump it on the market thereby bringing about a decline in prices in 1974. Also, over the next few years mercury prices are expected to continue to fluctuate, mainly because of erratic demands. The fluctuations may not be as severe as in past years if the co-operation now existing between some of the world's leading producers leads to concerted action to stabilize prices.

Adverse publicity from ecological and other sources continues to affect the mercury market, although possibly to a lesser degree than previously. The energy crisis, which commenced late in 1973, adversely affected many industries in 1974 and mercury was not an exception. The resulting fuel shortage began to slow down economic growth in 1974 in many of the major industrial nations and this economic recession could continue to adversely affect the mercury market. The unabated uncertainty in world money markets will be another inhibiting factor.

Because of the recession which began in 1974 in the economies of the United States, Europe, Japan and other countries, the outlook for mercury for 1974 and some years thereafter is thought to be somewhat less favourable than it was a year ago. Also overhanging the market is the substantial quantity of over 200,000 flasks in the United States government's stockpiles and the relatively large unsold stockpiles reportedly held by the Italian producers. Another bearish factor is increased competition from the U.S.S.R. and the People's Republic of China which could dispose of increasing amounts of mercury in western Europe, but not in the United States because of higher import duties obtaining there against imports of mercury from communist countries. The market could also be faced with increased offerings from Turkey, resulting from new cinnabar discoveries and modernization of some of its existing mines.

Yugoslavia is also planning to develop mercury ore deposits near Srednje in the Ozren mountains. The deposits are reported to contain some 300,000 metric tons, grading 0.35 to 9.00 per cent mercury with total mercury content estimated at about 122,000 flasks, based on an average grade of 1.4 per cent. Any significant increase in Yugoslavian mercury output would worsen the current depressed state of the quicksilver market. Offsetting the expected increases in mercury production in Turkey and Yugoslavia is the reported closure at the end of September 1974, of Japan's sole primary mercury producer, the Rynshoden mine in Hokkaido, operated by Hokushin Mining, a subsidiary of Nippon Mining Co. Ltd.

Because of environmental factors, another bearish influence on the mercury market in the medium-term, up to say 1980, is the trend to greater use of the diaphragm cell process in the production of chlorine and caustic soda. At present about two thirds of the chlorine produced in the United States is made in diaphragm cells, whereas in western Europe about 90 per cent is made in mercury cells. While the short-chlorine-supply situation envisaged by the industry over the next few years is spurring expansion of chlor-alkali plants in the United States, none of the half dozen such plants expected to come on stream in 1974 will use the mercury cell. The new $30 million chlor-alkali plant that Canadian Industries Limited has under construction at Bécancourt, Quebec, and plans to start up early in 1975, will use the diaphragm cell. Also, some of the existing plants in the United States, Canada and Japan that were using the mercury cell, have either dismantled their facilities, or converted to the diaphragm cell. The excess secondary mercury released for recycling by such dismantled plants or those making the changeover has a further depressing effect on the already oversupplied mercury market. Countering this general switch to the diaphragm cell are new chlor-alkali plants being constructed in Rumania and Venezuela that are using the mercury cell. Imperial Chemical Industries Limited is also using the mercury cell in a major new extension it is making to its Runcorn chlor-alkali plant in Britain. Insofar as the choice of process is concerned the quality of chlorine produced by the two types of electrolytic cell is similar but, whereas the mercury cell produces 50 per cent caustic soda of high purity, the diaphragm cell produces about 11 per cent caustic soda with a substantial impurity of salt. If the diaphragm cell caustic is to be sold it has to be concentrated and this requires the use of steam as an evaporator. The mercury cell, however, requires substantially more power.

Of particular concern to Canada is the unfavourable effect on its export sales of mercury to the United States market that could result if Placer Amex Inc.'s new mercury property near McDermitt, Nevada is brought into production, as planned, in 1975. If this property eventually becomes a substantial producer, as is now anticipated, a significant portion of Canada's mercury exports would then have to be sold in other foreign markets. In 1973, almost 38 per cent of United States mercury imports came from Canada* although a portion of the Canadian supplies was derived from secondary sources**.

Uses

One of the oldest but now relatively unimportant applications of mercury is for recovering gold and silver from their ores by amalgamation. The two major

* Based on figures contained in U.S. Bureau of Mines, Mineral Industry Surveys, *Mercury in the Fourth Quarter 1973.*

**As stated in U.S. Bureau of Mines, Mineral Industry Surveys, *Mercury in the Second Quarter 1973.*

uses in recent years have been for electrical apparatus and for the electrolytic production of chlorine and caustic soda, although the latter use has been declining. Together, these two uses accounted for almost 58 per cent of mercury consumed in the United States in 1973. Electrical uses include mercury lamps, batteries, rectifier bulbs, oscillators, and various kinds of switches including 'silent' switches for use in the home. Because mercury lamps are adaptable to higher voltage supply lines than those used with incandescent lamps, they are used as fluorescent lamps and for industrial and street lighting purposes. The mercury battery invented in 1944 is basically a dry-cell type battery. It has a relatively long shelf life and can withstand high temperature and high humidity. It is used in Geiger-Muller counters, portable radios and two-way communications equipment, digital computers, electronic measuring devices, hearing aids, guided missiles, and spacecraft.

Other applications are in mildew-proofing paints, industrial and control instruments, pharmaceuticals, insecticides, fungicides, bactericides, and dental preparations, although in some countries some of these uses have recently been restricted or banned by governmental regulations. Several mercury compounds, especially the chloride, oxide and sulphate, are good catalysts for many chemical reactions,

Table 5. Average monthly prices of mercury in 1973 at New York and cif main European port

	New York[1]	Cif Main European Port[2] Low	High
	($ U.S./flask)		
January	282.500	258.11	263.33
February	304.778	286.125	292.625
March	314.364	305.111	310.111
April	290.714	279.286	286.714
May	266.636	255.25	260.25
June	250.571	240.00	247.444
July	275.238	261.444	266.667
August	292.957	272.00	277.625
September	276.053	263.875	268.50
October	294.667	268.444	272.889
November	299.250	284.000	289.222
December	287.000	279.000	285.571

Sources: *'Metals Week'* for New York prices; *'Metal Bulletin'* (London) for cif main European port prices. [1]Prime virgin metal. [2]Prices are cif main European port, min. 99.99%.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
92805-2	Mercury metal	free	free	free
92828-4	Mercuric oxide for manufacture of dry-cell batteries (expires February 28, 1974)	free	free	25%

United States

Item No.		On and after January 1 1970	1971	1972
		(cents per pound)		
601.30	Mercury ore	free	free	free
632.34*	Mercury metal, unwrought, and waste and scrap	17	15	12.5**

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972) TC Publication 452.

*The suspension of duty on waste and scrap was extended until June 30, 1975, as provided by P.L. 93-78.
**Mercury metal entering the United States from the U.S.S.R. and other communist countries is subject to the statutory import duty of 25¢ per pound (equivalent to $19.00 a flask).

including those involved in the making of plastics. Because of its capacity to absorb neutrons the metal has been used as a shield against atomic radiation. One of the more recently developed applications for mercury is in frozen mercury patterns for manufacturing precision or investment castings. Mercury is superior to wax, wood or plastic pattern materials because of its smooth surface and uniform expansion upon heating. New technologies could open up new areas of use in the nuclear field, metal-chloride vapours, plastics, chemicals, amalgams and ion exchange.

Prices

The price of mercury per flask, fob New York, as quoted in *Metals Week,* fluctuated in 1973 between a high of \$330 in February and a low of \$250 in June. Average for the year was \$286.23 a flask compared with an average of \$218.28 for 1972. In 1973, the cif main European port price, as quoted in *Metal Bulletin* (London), fluctuated between a high of \$315 (U.S.) a flask in February and a low of \$235 (U.S.) in June.

The benches in Placer Development Limited's Endako open-pit mine in northern British Columbia form a sharply defined pattern, with the mine concentrator in the background. The mine is a molybdenum producer. (George Hunter photo).

Molybdenum

M.A. BOUCHER

Canadian production of molybdenum was higher in 1973 than in 1972, however preliminary figures indicate that shipments were lower both in terms of value and tonnages. This was partly due to the liquidation of stocks built up by consumers during 1971-72. Worldwide, the molybdenum industry experienced a change from oversupply to undersupply, higher prices and a reduction of inventories. World production, excluding the U.S.S.R., at 152 million pounds of Mo was virtually the same in 1973 as in 1972. The United States remained the major producer with 112 million pounds, followed by Canada with 27 million pounds and Chile with 10 million pounds.

Estimated consumption was up from 141 million in 1972 to 167 million pounds, with the United States continuing to be the largest consumer of molybdenum. United States consumption represents almost 40 per cent of the total noncommunist world consumption; Japan, West Germany, United Kingdom, France and Sweden are other large consumers. Sweden is one of the large consuming countries because of its alloy steel industry. During 1973, Japan's consumption increase of nearly 30 per cent was greater than for any other country.

Generally, the worldwide growth in consumption during the year was the result of record steel production in the U.S., Europe and Japan, together with major increases in the use of molybdenum in chemicals, lubricants and metal. Consumption in 1974 is expected to equal that of 1973. According to various industry and government statistics there was a supply shortage of some 15 million pounds of molybdenum in 1973; this shortage was made up from inventories.

Production

Canada's production (shipments) in 1973 amounted to 27,450,000 pounds valued at $39,188,000 compared with 28,493,007 pounds valued at $44,067,885 in 1972. Some 80 per cent of domestic molybdenum concentrates production in 1973 was provided by the two principal producers : Placer Development Limited, a primary producer Division of Canex Placer Limited and Brenda Mines Ltd. (a coproduct producer) Both producers have mines in British Columbia. The remaining molybdenum production came principally from four, large-tonnage copper mines as a byproduct of copper concentrates operations.

Noranda Sales Corporation Ltd. is the marketing agent for pooled production of molybdenum in concentrates and oxide from four Canadian producers – Endako Mines Division of Canex Placer Limited; Brenda Mines Ltd.; Gaspé Copper Mines, Limited; and KRC Operators Ltd.

Apart from producing concentrates of MoS_2, Canada produces molybdic oxide (MoO_3) from its roasters in British Columbia and Quebec. Canada's roasting capacity is in the order of 23 million pounds of Mo contained in MoO_3. Table 4 shows the names of the companies and their approximate production capacities. Ferromolybdenum is produced in Canada by Masterloy Products Limited, with a plant near Ottawa, Ontario and Fundy Chemical International Ltd. with a plant at Surrey, B.C.

In terms of prices, there is about 20¢ difference between MoS_2 and MoO_3 and 30¢ to 45¢ between the oxide and ferromolybdenum. About half of the extra cost for ferromolybdenum is accounted for by the cost of raw materials (mainly ferrosilicon and aluminum) for the reduction process. The production of ferromolybdenum is not attractive because the process is expensive considering the price differential between the ferro and oxide forms and there is a tendency by the steel industry to prefer molybdic oxide to ferromolybdenum.

Trade and consumption

Almost all Canadian production of ores and concentrates is exported in the form of concentrates and oxide; very little is exported as ferromolybdenum and none as metal. Most exports go to Europe and Japan. Access to the U.S. market is restricted by high tariffs of 12¢ a pound on Mo content of ores and concentrates, and 10¢ a pound plus 3 per cent *ad valorem* for the oxide and ferromolybdenum. Canadian producers follow the Climax price for domestic sales and the United States Tariff effectively prohibits sales of Canadian molybdenum in the United States. Also,

Table 1. Canada, molybdenum production, trade and consumption, 1972-73

	1972		1973p	
	(pounds)	($)	(pounds)	($)
Production (shipments)[1]				
British Columbia	28,041,603	43,260,349	27,450,000	39,188,000
Quebec	451,404	807,536	–	–
Total	28,493,007	44,067,885	27,450,000	39,188,000
Exports				
Molybdenum in ores and concentrates and scrap[2]				
Belgium and Luxembourg	13,939,300	27,189,000	8,941,000	16,947,000
Japan	3,870,500	8,049,000	7,177,400	15,031,000
Britain	5,930,300	10,901,000	4,048,700	7,645,000
West Germany	709,900	1,025,000	1,167,400	1,394,000
Brazil	353,400	712,000	551,500	1,191,000
France	461,700	716,000	638,200	1,065,000
Australia	142,700	279,000	380,600	690,000
United States	241,700	533,000	214,000	591,000
Philippines	110,500	210,000	278,000	523,000
Sweden	725,800	1,123,000	322,600	427,000
India	300,400	663,000	186,800	388,000
Other countries	4,543,100	8,366,000	985,500	1,700,000
Total	31,329,300	59,766,000	24,891,700	47,592,000
Imports				
Molybdic oxide (gross weight)	26,700	36,000	199,400	246,000
Molybdenum in ores and concentrates[3] (Mo content)	385,981	713,725	1,364,335	2,204,715
Ferromolybdenum[3] (gross weight)	74,201	148,884	220,075	309,098
Consumption (Mo content)				
Ferrous and nonferrous alloys	2,553,568r	..	4,290,537	..
Electrical and electronics	15,157	..	16,713	..
Other uses[4]	139,334r	..	127,464	..
Total	2,708,059r	..	4,434,714	..

Source: Statistics Canada, except where noted.
[1]Producers' shipments (Mo content) of molybdenum concentrates, molybdic oxide and ferromolybdenum. [2]Includes molybdenite, molybdic oxide in ore and concentrates. [3]United States exports of molybdenum to Canada, reported by the U.S. Bureau of Commerce, Exports of Domestic and Foreign Merchandise (Report 410), value in U.S. currency. These imports are not available separately in official Canadian trade statistics. [4]Chiefly pigment uses.
pPreliminary; . . Not available; rRevised.

because Climax is the world's largest producer, it has generally been able to keep world prices for molybdenum low, relative to other additives.

Most of the molybdenum consumed by the steel industry is consumed as molybdic oxide. The ratio of consumption between MoO_3 and Fe-Mo varies from year to year, but it is about 2.5/1.0. Because of the increasing costs of raw materials necessary to produce steel compared with the price 5 to 10 years ago and because of the availability of molybdenum concentrates at good prices it is good economics to upgrade many ordinary steels by alloying with molybdenum, so the use of molybdenum in Canada should increase.

Canada has no tariff on ores and concentrates, and in 1971 and 1973, over 1.3 million pounds were imported from the U.S. to be roasted and sold on the Canadian and foreign markets.

Company developments

Canex Placer Limited resumed full production at its Endako mine, near Endako, British Columbia by June 1973. The production rate reached a level of about 15

Table 2. Canada, molybdenum production, trade and consumption, 1963-73

	Production[1]	Exports[2]	Imports		Consumption[5]
			Molybdic oxide[3]	Ferro-molybdenum[4]	
			(pounds)		
1963	833,867	. .	258,765	125,869	1,306,193
1964	1,224,712	. .	490,500	271,605	1,261,454
1965	9,557,191	. .	759,500	398,460	1,702,589
1966	20,596,044	. .	665,500	522,800	1,261,387
1967	21,376,766	23,792,700	452,600	316,692	1,430,895
1968	22,464,273	22,704,500	1,359,300	284,600	1,543,432
1969	29,651,261	25,672,600	76,600	482,609	1,808,772
1970	33,771,716	30,334,000	73,900	65,299	2,286,061
1971	22,662,732	22,944,800	64,600	183,156	1,814,586
1972	28,493,007	31,329,300	26,700	74,201	2,708,059[r]
1973[p]	27,450,000	24,613,200	199,400	220,075	4,434,714

Source: Statistics Canada.
[1] Producers' shipments (Mo content) molybdenum concentrates, oxide and ferromolybdenum. [2] Mo content, ores and concentrates. [3] Gross weight. [4] U.S. exports to Canada reported in United States Exports of Domestic and Foreign Produce, gross weight. [5] Mo content of molybdenum products reported by consumers.
[p] Preliminary; . . Not available; [r] Revised.

million pounds a year of contained Mo in molybdenite (MoS_2) concentrate, and molybdic oxide (MoO_3). Mine production in 1973 was 11,877,998 pounds of molybdenum consisting of 8,494,740 pounds of molybdenum in oxide and 3,383,258 pounds in concentrate. Canex Placer expects to produce 16 million pounds of molybdenum at the Endako mine in 1974. This will consist of 4.4 million pounds of molybdenum in concentrate and 11.6 million pounds of molybdenum in oxide. About 50 per cent of the production is exported to Europe and 35 per cent to Japan.

The Endako Division will enlarge its annual on-site capacity to roast molybdenite concentrate to molybdic oxide from 9.5 million pounds of contained molybdenum to 14.5 million pounds. The expansion program, estimated to cost $4 million, will include an addition of a water scrubbing system to control sulphur dioxide gas emissions.

Brenda Mines Ltd's production of molybdenum concentrate, as a co-product at its copper-molybdenum mine near Peachland, British Columbia, was expected to amount to about 8.3 million pounds of contained molybdenum in 1973. Production in 1973 would have been higher had the mine not been closed for 40 days because of a labour strike and equipment repairs. Brenda exports its molybdenum to Europe, South America and Japan.

Lornex Mining Corporation Ltd. reached its design capacity during the year and production was 3,481,000 pounds of molybdenum in molybdenite concentrate. The company recovers molybdenum as a byproduct from its open-pit copper mine, 28 miles southeast of Ashcroft, British Columbia. The mine's average mill head contained 0.421 per cent copper and 0.018 per cent molybdenum. The mill rate over this period averaged 38,471 tons a day.

Gibraltar Mines Ltd., a subsidiary of Canex Placer Limited, completed its first full-production year in 1973. The company's mine and mill, 10 miles east of McLeese Lake in central British Columbia, has a capacity to produce between 0.5 and 1.0 million pounds of molybdenum a year as a byproduct of its copper mining operation. The molybdenum concentrator circuit commenced operations in May 1973 and production was about 60 tons of concentrate a month (containing 54 per cent MoS_2). Shipments of molybdenum were approximately equal to 1973 production of 493,500 pounds contained in concentrate.

On May 31, KRC Operators, a subsidiary of King Resources Co., Denver, Colorado, closed its mine and mill operations at its Mt. Copeland property, near Revelstoke, British Columbia. The 200-ton-a-day mill began production in April 1970. During its production period, a total of 182,000 tons of ore was treated to produce 2,650,000 pounds of molybdenum concentrates.

Noranda Mines Limited has reopened its Boss Mountain mine in British Columbia. Mill start up commenced December 15, 1973 and full-scale production at an annual rate of 3 million pounds of molybdenum was expected to commence on January 15, 1974. Production at the underground mine, in the Cariboo district, began in May 1965 but was suspended on December 3, 1971. Mill capacity during 1971 was 1,700 tons a day. Reserves on December 31, 1971 were estimated at 2,700,000 tons averaging 0.25 per cent molybdenum. Exploration work was being carried out to extend mine reserves.

American Metal Climax, Inc. (Amax) purchased the assets and property of British Columbia Molybdenum Limited at Alice Arm, British Columbia. British Columbia Molybdenum, a subsidiary of Kennecott Copper Corporation, ceased mine and mill operations on April 23, 1972, because of weak prices in an oversupplied market. The mine produced nearly 18 million pounds of molybdenum from its open-pit mine and 6,000-ton-a-day mill during its four years of operation. Amax entered into agreement with Adanac Mining and Exploration Ltd. to conduct further exploration and a feasibility study of Adanac's Ruby Creek molybdenum deposit near Atlin, British Columbia. Ore reserves were estimated at 104.2 million tons averaging 0.16 per cent MoS_2. Amax will decide prior to December 31, 1975 whether to make a production commitment or return the property to Adanac.

Among copper-molybdenum properties on which feasibility studies have been concluded are those of Highmont Mining Corp. Ltd., Valley Copper Mines Limited, and the J-A deposit of Bethlehem Copper Corporation Ltd., all in the Highland Valley area of British Columbia.

Foreign developments

American Metal Climax, Inc. (Amax) reported continuing progress on its Henderson project, with initial production planned for 1976 at an annual rate of 50 million pounds of contained Mo. Amax announced plans for a major new production facility for ammonium molybdate at Fort Madison, Iowa, to be completed in 1975. The company will then build a new roasting plant at Fort Madison, presumably in time to treat concentrates from the Henderson mine as its production becomes available. Amax also plans to double the capacity of its conversion facility at Rotterdam, the Netherlands, by 1977. The plant has one roasting furnace and a facility that produces molychemicals. A new roasting furnace is being added.

Operations were resumed at Duval's Esperanza property at the first of the year, following a one-year shutdown caused by lack of smelting capacity for the company's copper concentrates. Duval's Sierrita mine produced at its capacity of approximately 14 million pounds of molybdenum a year.

Knaben Molybdaengruber A/S, Kvinesdal, Norway, operator of Europe's only molybdenum mine, shut down operations in the second quarter of 1973 because of rising production costs, declining grade of ore and because the increase in the molybdenum price had not yet become effective.

The U.S.S.R. announced plans to develop a major molybdenum orebody in Mongolia. Mining of 40,000 tons a day of ore by open-pit method is planned, and operations are expected to begin in about five years. Expected molybdenum production as Mo was not revealed.

Table 3. Molybdenum production in ores and concentrates, 1971-73

	1971	1972	1973^e
	(Mo content, '000 pounds)		
United States	109,592	112,138	112,000
Canada	22,663	28,493	27,450
U.S.S.R.	17,600	18,100	. .
Chile	13,935	13,045	10,000
Peru	1,782	1,712	2,000
Norway	811	880	. .
Japan	613	825	. .
South Korea	231	110	. .
Mexico	174	172	. .
Philippines	9	–	–
China	3,300	3,300	. .
Australia	130	130	. .
Other free world	–	–	2,000
Total	170,840	178,905	153,450

Sources: U.S. Bureau of Mines, *Minerals Yearbook 1972;* U.S. Commodity Data Summaries, January 1974; for Canada, Statistics Canada.
^{e}Estimated; . . Not available; – Nil.

Table 4. Canadian molybdenum roasting capacity, 1973

Operator	Roasting capacity
	(pounds Mo contained in MoO_3)
Endako Mines B.C.	14,000,000
Fundy Chemical International Ltd. Duparquet, Quebec	18,000,000

Source: As reported by operators to Mineral Development Sector.

Products and uses

The steel and iron industries are the principal consumers of molybdenum, accounting for over 80 per cent of total consumption. The principal reason for the use of molybdenum in steel is that it increases strength, even at high temperatures, and increases resistance to corrosion. In low concentrations, molybdenum is used for tool steel. With concentration of 4 per cent, molybdenum is used for corrosion resistant stainless steels, and with a concentration of up to 8.5 per cent it is used for high-speed tool steels. The

Table 5. United States consumption of molybdenum by end use, 1972

('000 pounds contained molybdenum)	1972
Carbon steel	1,236
Stainless and heat resisting	5,862
Alloy steel	16,920
Tool steel	3,102
Cast irons	3,678
Superalloys	2,376
Cutting- and wear-resistant materials	..
Welding and hardfacing rod and materials	335
Other alloys and nonferrous alloys	725
Mill products made from metal powder	2,467
Chemical and ceramic uses	
Pigments	1,118
Catalysts	1,442
Other	1,220
Miscellaneous and unspecified	1,127
Total	41,608

Source: United States Bureau of Mines *Minerals Yearbook 1972* Preprint.
. . Not available.

remainder is used as catalysts in the petroleum and chemical industries to desulphurize petroleum products and chemicals, and as metal and base alloys in high-temperature applications as thermocouples, electronics, missile parts and structural parts of nuclear reactors. Molybdenum is also used in the production of pigments for inks, lacquers and paints. Between 60 and 70 per cent of Canadian and U.S. molybdenum consumption is in the form of molybdic oxide, 20 to 25 per cent in the form of ferromolybdenum and about 5 per cent as powder.

Approximately 75 per cent of the total usage of molybdenum in the United States between 1965 and 1970 was for the production of carbon, stainless, heat-resisting alloy and tool steels, and in the manufacture of cast irons. In 1972, alloy steels (containing mainly Cr and Ni) represented 40 per cent of total consumption and stainless steel 20 per cent; about 7 per cent was used in chemicals, 6 per cent in superalloys, 4 per cent as metal and the balance in miscellaneous applications.

Because of the fact that molybdenum is used in several types of steel, e.g., carbon, stainless and tool steels, molybdenum consumption is more properly related to industrial production than to crude steel production.

In 1973, molybdenum consumption continued to grow in high-strength, low-alloy steels (HSLA) containing manganese, molybdenum and columbium. HSLA pipeline steel containing 0.3 per cent molybdenum and 0.052 per cent carbon can be welded under extreme cold conditions which makes it applicable for use in pipelines under low temperature conditions.

Another type of steel that is growing in importance because of its excellent resistance to corrosion and attractive price is the chromium molybdenum ferritic stainless steel containing 18 per cent chromium and 2 per cent molybdenum.

Ore occurrences and grade

Molybdenum (Mo) does not occur in metallic form. Production is from deposits carrying the sulphide mineral molybdenite, MoS_2; other molybdenum-bearing minerals are relatively rare and of minor importance. More than 60 per cent of world production of molybdenum comes from mines where molybdenite is the principal mineral produced; most of the balance comes as a byproduct or coproduct from copper-molybdenum deposits, some from tungsten-molybdenum mines, and minor amounts from molybdenum-bearing uranium ores.

Molybdenite (MoS_2) contains 60 per cent molybdenum (Mo) but the content of mineable ores is generally relatively low, ranging down from about 0.05 per cent MoS_2, or 6 pounds of Mo per ton, to about 0.15 per cent MoS_2, or 1.8 pounds of Mo a ton, among producers whose principal or only product is molybdenite, to as low as 0.015 per cent MoS_2 in some copper-molybdenum deposits now being prepared for production of both metals. A few small, vein-type deposits have limited ore zones with 1 to 2 per cent MoS_2.

Developing technologies

A chemical leaching process that oxidizes sulphide ores to molybdic oxide and also permits the recovery of rhenium is under study by Noranda. The process will eliminate pollution problems associated with the roasting of molybdenite.

Direct production of molybdenum metal from molybdenite is under study at the McGill University, the University of Toronto and the Ontario Development Corporation. A simplified description of the process is described as follows: small particles of molybdenite, in a concentrate obtained by flotation, are injected into a plasma reactor; the temperature in the plasma reactor, in the order of 5,000 to 8,000°C, is high enough to decompose molybdenite directly into metallic molybdenum and gaseous sulphur. It is believed that the process will bring about a considerable reduction in production costs. New applications under study by Amax include catalysts for automobile engine emission control, catalysts for coal gasification, high-strength steel containing molybdenum for stronger automobile bumper systems, high-strength oil well casing for deeper sour oil wells, and improved super alloys for aircraft, industrial gas turbine engines and the use of molybdenum disulphide to be added in oil in order to increase distance between oil changes and lower gasoline consumption.

Prices

During 1971 and 1972, price discounting prevailed because of the oversupply situation. However, because the cost of molybdenum is usually small compared to the cost of the final product, demand for molybdenum is relatively price inelastic. For this reason, Climax Molybdenum Company, the price leader, maintained its official price of $1.72 for its concentrate. Because of dollar devaluation in the U.S. and a stronger demand for molybdenum in 1973, price discounting was eliminated during the year, and as of December 1973 prices were the same as they were in 1969. In terms of Mo content, molybdenite concentrate was selling at $1.72 a pound, molybdic oxide at $1.91 and ferromolybdenum at $2.21.

Prices in U.S. dollars a pound of contained molybdenum, fob shipping point, as reported in Metals Week.

	Prices (Dec. 31, 1973) (U.S. $)
Molybdenum concentrates	
Guaranteed MN 85% MoS_2	1.72
Molybdic Oxide (MoO_3)	
in bags	1.91
in cans	1.92
Ferromolybdenum, 0.12-0.25% C	
5,000 lb lots	
Lump	2.21
Powder	2.27

Outlook

Strong demand and strong prices are expected to continue until the end of 1974. By that time it is probable that the fuel crisis will slow down world steel production which, in turn, will reduce molybdenum consumption.

Tariffs

Canada

Item No.		British Preferential (%)	Most Favoured Nation (%)	General (%)
32900.1	Molybdenum ores and concentrates	free	free	free
35120.1	Molybdenum and alloys in powder, pellets, scrap, ingot, sheets, strip, plate, bars, rods, tubing and wire for use in Canadian manufactures. Expires October 31, 1973	free	free	25
92828.1	Molybdenum oxides and hydroxides	10	15	25
37506.1	Ferromolybdenum	free	5	5
37520.1	Calcium molybdate	free	free	5

Tariffs (concl'd)

United States

Item No.		On and After Jan. 1, 1971	On and After Jan. 1, 1972
		(¢ a lb on Mo content)	
601.33	Molybdenum ores and concentrates	14	12
418.26	Calcium molybdate	12 + 3.5%	10 + 3%
419.60	Molybdenum compounds	12 + 3.5%	10 + 3%
628.72	Molybdenum metal, unwrought	12 + 3.5%	10 + 3%
607.40	Ferromolybdenum	12 + 3.5%	10 + 3%
		(%)	(%)
628.74	Molybdenum metal, wrought	15	12.5
627.70	Molybdenum metal, waste and scrap (suspended)	12.5	10.5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1972).

Natural Gas

W.G. LUGG

The pace of development of Canada's natural gas sector levelled off in 1973 due to a marked slow-down in export growth rate. Nevertheless, by year-end, there were strong indications that the natural gas industry was about to embark on a new expansionary cycle. Net reservoir withdrawals increased by 60 per cent to 3,124,000 MMcf* or 8,558 MMcf/d** compared with 2,913,000 MMcf or 7,980 MMcf/d in 1972. Almost all of the gain was attributed to growth in domestic sales as the volume of exports has essentially reached the maximum allowed under existing permits. Canadian consumers used 1,229,000 MMcf or 3,368 MMcf/d for a gain of 7 per cent over the previous year, and exports to the United States increased by 1% to 1,028,029 MMcf or 2,816 MMcf/d. Imports from the United States remained at about the same level as in 1972, averaging 40 thousand cubic feet a day.

Despite high rates of production and consumption, gross additions to marketable reserves almost kept pace in 1973. The shallow gas trends in southern Alberta and Saskatchewan provided the bulk of new additions such that by the end of 1973 proved marketable reserves amounted to 52.5 trillion cubic feet (tcf) compared with 52.9 trillion cubic feet at the end of 1972.

Continuing strong demand and rising producer prices have provided the impetus for increased exploration in both the frontier and established producing areas. Both the number of wells drilled and aggregate footages increased, reflecting the growing trend in shallow gas exploration. Nevertheless, some important discoveries were recorded in the deeper formations, particularly northeastern British Columbia and the Alberta Foothills belt, in addition to some major finds in Arctic regions.

Pipeline construction increased marginally in 1973, and gas plant construction was down considerably from the previous year. This was due partly to the lack of discovery of new reserves in previous years, but mainly to government restrictions – the federal government security of supply restriction on export growth and the Alberta deferral on gas removal permits until such time as sales price increases are considered to be acceptable. Despite these restrictions, the pipeline industry would seem to be on the threshold of a major construction boom. At year-end, Canadian Arctic Gas Study Limited, a consortium of oil and pipeline companies was preparing to file its application with federal government authorities to build a $5.7 billion natural gas pipeline from Alaska's North Slope and the Mackenzie Delta area of the Northwest Territories down the Mackenzie River Valley to southern markets. This would be the largest construction undertaking in Canada's history, and it would likely have a profound impact on not only the pipeline industry but also the entire Canadian economy.

* MMcf – 1,000,000 cubic feet.

** MMcf/d – 1,000,000 cubic feet a day.

Outlook

The strong domestic demand for natural gas that featured the remarkable growth rate in the natural gas industry in Canada during the past decade will continue in 1974. Recent substantial increases in the well-head price of natural gas will help to ensure an adequate supply-base to meet this demand – in the short term at least. By virtue of well-head price increases, large reserves of gas, formerly considered to be noneconomic, will now be within reach of commercial development. Supplemental to these reserves are large volumes of natural gas in the Suffield area of southern Alberta which are currently being developed by the Alberta government. There is a readily available market in Canada and particularly in Quebec where natural gas usage has not been widespread. An indication of this new interest is the fact that Quebec has contracted with an Alberta-controlled company to take large volumes of previously uneconomic gas at increased prices.

Markets for Canadian gas in the United States are almost unlimited but increased exports will continue to be limited to volumes above those not needed for the domestic market. The NEB, in accordance with federal policy of assuring adequate supplies for the domestic market, has not approved any gas removal export applications since 1971. As a result, export volumes have increased by only those amounts authorized in existing contracts during the past two years. It is not likely that these amounts will be increased significantly in 1974.

Depending on agreement between TransCanada PipeLines Limited and the Alberta government on gas removal prices, net withdrawals should average 9,074 MMcf/d in 1974. All of the increases will be accounted for by domestic sales which should average in excess of 3,570 MMcf/d. Exports are expected to average about 2,816 MMcf/d, the same as last year.

In the long-term, if domestic market growth and the current level of exports to the United States are to be maintained, additional large reserves of natural gas will have to be found in frontier areas such as the Mackenzie Delta and Arctic Islands. Whether or not there will be surpluses for increased exports from these new-found reserves will depend, to a large degree, on the quantity of gas found, the transportation facilities built and the future domestic demand that will have to be satisfied first.

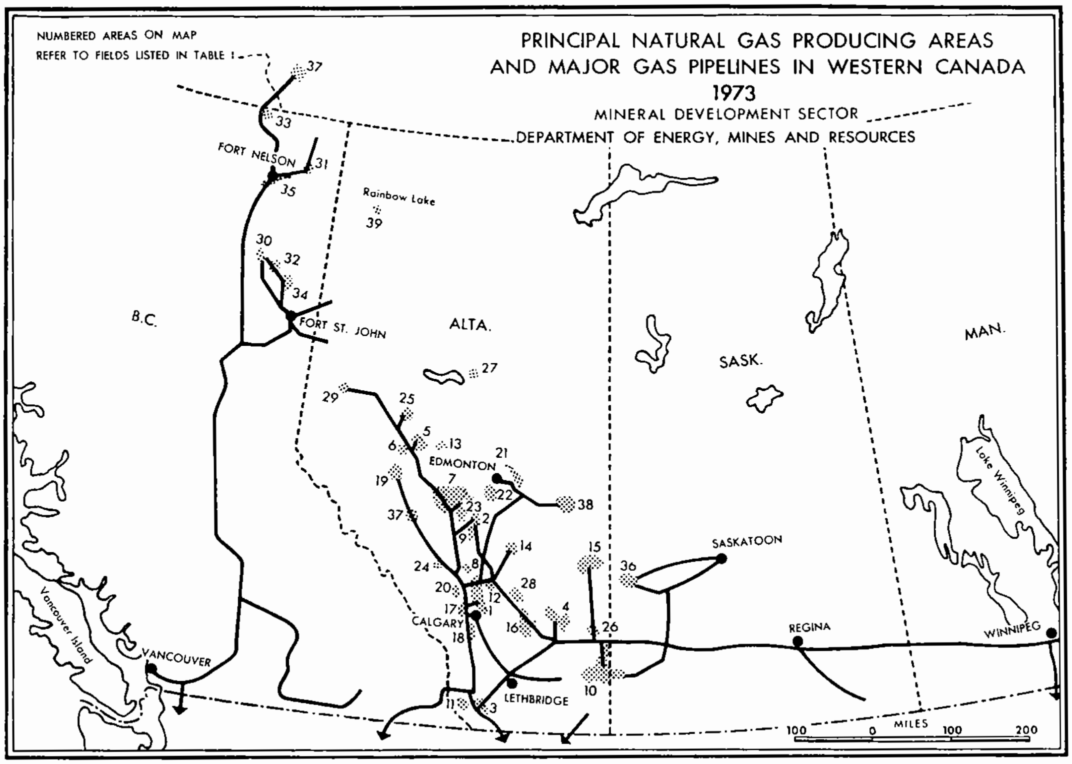
Production

In 1973, net withdrawals of natural gas amounted to 3,124,000 MMcf, or 8,558 MMcf/d, for a 6 per cent

Table 1. Canadian natural gasfields producing 10 million Mcf* or more, 1972-73[1]

(numbers in brackets refer to map locations)	1972 (Mcf)	1973 (Mcf)
Alberta		
Kaybob South (25)	233,232,850	267,225,694
Crossfield (1)	158,464,089	154,279,622
Waterton (11)	148,011,507	130,983,507
Edson (19)	112,332,520	113,778,479
Strachan (24)	112,166,610	107,699,917
Ricinus West (24)	55,648,371	98,203,952
Westerose South (2)	88,294,063	82,745,152
Harmattan Elkton (8)	63,128,991	79,266,610
Medicine Hat (10)	63,981,930	69,646,474
Harmattan East (8)	53,851,992	63,178,812
Windfall (5)	68,506,660	55,586,490
Brazeau River (37)	47,159,152	53,639,078
Carstairs (12)	49,296,115	49,000,161
Gilby (9)	46,854,919	48,162,805
Homeglen-Rimbey (9)	50,169,120	46,812,193
Nevis (14)	44,610,904	46,093,473
Marten Hills (27)	48,276,078	45,651,078
Crossfield East (1)	56,498,282	44,199,096
Pembina (7)	46,167,579	42,994,892
Cessford (4)	44,535,215	42,295,492
Jumping Pound West (17)	64,530,769	40,887,844
Provost (15)	41,013,368	39,588,864
Wildcat Hills (20)	34,869,441	35,722,376
Judy Creek (13)	21,992,600	34,887,249
Ferrier (8)	34,212,335	34,756,330
Dunvegan	–	32,566,544
Minnehik-Buck-Lake (23)	28,592,820	31,528,694
Rainbow (39)	23,859,247	29,334,732
Kaybob (25)	31,565,311	29,302,526
Swan Hills (13)	20,952,107	26,828,355
Lone Pine Creek (1)	22,497,208	25,552,818
Ghost Pine (28)	26,575,010	25,203,076
Westlock (21)	21,371,589	24,583,526
Sylvan Lake (2)	23,493,926	23,409,458
Quirk Creek (18)	23,671,030	22,701,433
Viking-Kinsella (38)	13,917,053	22,477,067
Alderson (10)	18,041,611	22,087,214
Bonnie Glen (22)	13,185,243	19,767,603
Lookout Butte (3)	20,584,867	18,674,348
Hussar (16)	17,829,790	18,611,439
Jumping Pound (17)	16,256,157	18,530,232
Carson Creek (13)	20,444,361	16,765,108
Pine Creek (6)	17,117,760	14,669,580
Wimborne (12)	15,786,604	14,634,039
Bigstone (25)	17,568,897	14,513,273
Carson Creek North (13)	11,377,728	14,412,826
Ricinus	1,169,184	14,189,377
Swan Hills South (13)	13,107,253	13,792,937
Burnt Timber (20)	12,674,381	13,749,591
Fort Saskatchewan (21)	13,606,705	13,729,399
Wizard Lake	9,087,117	13,721,735
Bindloss (26)	13,482,224	13,589,702
Countess (16)	12,482,369	13,552,944
Leduc-Woodbend (22)	11,900,264	13,444,312
Craigend (27)	12,659,891	12,634,025
Beaverhill Lake	8,593,027	12,020,389
Olds (12)	12,882,095	11,667,330
Whitecourt	10,990,039	11,197,435
Wayne-Rosedale (3)	11,469,091	11,117,379
Bruce	734,787	10,438,670
Medicine River	8,936,117	10,370,107
Mitsue	8,533,755	10,198,170
Pend'Oreille	8,338,009	10,041,715
British Columbia		
Clarke Lake (35)	104,204,239	124,289,024
Yo Yo (31)	68,259,702	71,990,208
Beaver River (33)	68,251,540	58,151,696
Lapise Creek (30)	23,567,368	24,802,043
Sierra (31)	16,811,280	22,676,685
Rigel (34)	24,471,087	22,137,141
Jedney (30)	14,485,528	14,606,196
Nig Creek (32)	15,123,824	14,177,853
Siphon		13,315,732
Buick Creek (32)	9,767,941	12,400,690
Stoddart (34)	13,943,636	12,192,767
Northwest Territories		
Pointed Mountain (37)		34,261,563

Source: Provincial government reports.
[1] 14.65 psia. *Mcf – 1,000 cubic feet.
– Nil.



increase over 1972 withdrawals, the lowest growth rate in the past decade. Alberta continued to be the main producing province, accounting for 82 per cent of Canada's marketable gas production. British Columbia continued to supply the bulk of the remainder – about 13 per cent despite a substantial reduction in production at one of the province's principal producing fields, the Beaver River field which straddles the border between British Columbia and the Yukon Territory. Production from the Pointed Mountain field in the Northwest Territories also decreased. Both these fields are served by the Westcoast Transmission Company Limited trunkline and provided significant quantities of gas for British Columbia consumers and the export market in the United States. Recently, reservoir characteristics have developed that are impeding production and are proving difficult to remedy. The shortfall that arose because of these fields' inability to meet production expectations was confined to the export market and was alleviated to some degree by a "swapping" agreement whereby Alberta and Southern Gas Co. Ltd. agreed to make available at Kingsgate, British Columbia, surplus Alberta gas in an attempt to overcome deficiencies in export deliveries. A more permanent solution to this problem will arise when Westcoast completes a $26 million pipeline construction program to feed into their main trunkline, expanding deliverability from several shut-in northeastern British Columbia fields.

Table 2 shows the amount of gas injected into reservoirs, either as a conservation measure to increase the ultimate recovery of liquid hydrocarbons or as part of distributors' storage operations. The Kaybob South field is an example of a conservation scheme to maximize ultimate recovery of the liquid constituents of field gas. Here, gas is produced and processed to remove the liquid hydrocarbons and sulphur, after which most of the residual gas is reinjected to maintain pressure in the original producing reservoir. This operation is to ensure the maximum possible recovery of natural gas liquids before the reservoir is depleted by the sale of the gas. Similarly, natural gas may be temporarily reinjected into producing oil reservoirs thereby maintaining reservoir pressure to maximize production of crude oil where this is possible. The volumes shown as distributors' storage represent gas which is stored by gas utilities during low demand periods, usually in summer, and is later withdrawn as required to meet peak demands in winter. This helps to level out the utilities' demand on the trunk carriers over the year. In Alberta and Ontario most of the gas is stored in former producing fields which have been depleted. However, in Saskatchewan much of the storage is in large man-made subsurface caverns which have been leached from salt beds specifically to provide storage facilities near major consuming areas.

Exploration and development

Alberta. Both the number of wells and the aggregate footage drilled within the province increased in 1973. To a large degree the higher well count reflects increasing industry interest in the shallow gas-bearing horizons in southern Alberta. The fact that there are large reserves of gas in this area was well known, but development had been retarded because the formations are essentially poor gas reservoirs with a low overall yield per development well due to poor permeability and low formation pressures. However, continuing strong demand for gas with increasing well-head prices have improved the economics and prompted a revival of industry interests in the gas potential of this area. The three prime exploratory targets in southern Alberta are the Milk River, Bow Island and Medicine Hat sandstone formations of Cretaceous age and frequently more than one may be productive in a single well. Several discoveries were made in this area during the year and among the most important of these was a dual-zone gas discovery made 35 miles due north of Brooks, Alberta, by Canadian Obas Oil Limited. Commercial quantities of gas were discovered in both the Milk River and Medicine Hat formations. This find is currently being developed, and the operators have estimated the areal extent of the field to be 21 square miles. The drilling program to evaluate the British Block, which was formerly reserved for military training, got under way in October of 1973. The block, which is almost completely surrounded by gas-producing fields, is estimated to contain upwards of 4 trillion cubic feet (tcf) of gas reserves. Evaluation of the 8,000-square-mile area is being conducted by a provincial government funded drilling program under the direction of the Suffield Evaluation Committee of the Alberta government. By 1973, 53 successful gas wells had been drilled out of an ultimate planned total of 78. Preliminary reports suggest that many of the tests indicated commercial quantities of gas in more than one producing horizon. When the area has been fully evaluated there is little doubt that new-found gas in this block will add

Table 2. Pressure maintenance projects and storage of natural gas in Canada, 1972-73

	1972 Input	1973^p Input		1972 Input	1973^p Input
	(Mcf)	(Mcf)		(Mcf)	(Mcf)
Alberta			Rainbow South	706,051	2,658,817
Aerial	261,710	259,921	Red Water	335,740	651,946
Ante Creek	1,584,772	1,508,881	Ricinus	–	11,156,048
Bigstone	835,235	626,909	Rowley	424	66,416
Bonnie Glen	614,166	541,825	Swan Hills	–	42,892
Carbon	392,275	–	Swan Hills South	–	5,674,945
Carson Creek	11,872,565	4,339,392	Turner Valley	55,930	152,727
Carstairs	2,923,776	1,877,144	Waterton	13,294,717	15,772,679
Crossfield	5,910,403	1,076,590	Westerose South	5,582,935	6,374,755
Crossfield East	640,867	1,092,130	Willesden Green	1,191,835	7,742,854
Duhamel	226,521	233,770	Windfall	20,268,425	15,803,535
Gilby	87,263	30,848	Wizard Lake	10,435,068	22,414,495
Golden Spike	12,269,718	17,600,060	Total (14.65 psia)	313,549,149	358,788,494
Harmattan East	42,713,542	32,774,770	Total (14.73 psia)	311,855,984	356,851,036
Harmattan Elkton	42,753,365	44,463,225			
Joarcam	1,450,330	1,580,071	**Ontario**	76,638,840	106,412,309
Judy Creek	691,704	3,983,181			
Kaybob South	115,345,830	134,856,639	**Saskatchewan**		
Leduc-Woodbend	5,402,070	5,284,052	(14.73 psia)	6,517,666	4,659,984
Mitsue	451,427	1,123,791			
Pembina	3,639,357	2,044,287	Total Canada		
Rainbow	11,611,128	14,978,899	(14.73 psia)	395,012,490	467,923,329

Source: Provincial government reports.
^p Preliminary; – Nil.

substantially to provincial reserve totals.

In western Alberta, just north of Calgary, the Texex Crossfield 10-27 well encountered significant quantities of gas in the Mississippian Elkton formation. This test is located one mile due south of another significant Elkton discovery and, at the present time, both of these discoveries are being evaluated with additional development drilling anticipated. Another Mississippian gas discovery was reported by Gulf Oil Canada Limited when its well in the Alberta Foothills, 150 miles west of Edmonton, yielded commercial quantities of gas on test. Further testing was planned prior to an anticipated development drilling program. Elsewhere in the Foothills, offsetting wells to previous discoveries in the Quirk Creek and Ricinus areas, penetrated thick gas-bearing sections in different formations. In the vicinity of Ricinus, a step-out well to a Devonian Leduc reef discovery encountered a thick gas-bearing section. This could be an important discovery as Leduc reefs are excellent reservoirs. Further drilling is contemplated in order to determine the ultimate size of the find. At Quirk Creek, the Husky Oil Operations Ltd. well, located 2 miles west of the Quirk Creek gas field, encountered a buried plate of gas-bearing Mississippian limestone which yielded substantial flows of gas. It is still to be established if this is a major extension to the Quirk Creek field or is a separate structure.

In northwestern Alberta, Sundance Oil Company has apparently made a significant discovery of natural gas in the Fairview area. Early indications are that the productive zone contains about 5 billion cubic feet of gas per section with a large potential areal extent. Development drilling in this area could add substantially to Alberta's proven reserves.

Development drilling increased during the year and, although much of this was confined to the shallow gas trends of southern Alberta, field boundaries in other areas of Alberta were substantially expanded. Probably the most important of these was the Provost field of east-central Alberta where drilling enlarged its southwestern boundaries considerably. Other fields which were enlarged by development drilling include the Princess and Medicine Hat gasfields of southern Alberta.

British Columbia. Both the footages drilled and the number of wells completed decreased in 1973. Despite the decline in exploratory drilling, several important gas discoveries were recorded during the year, four of which may eventually prove to be major finds.

Probably the most important of these is in the Grizzly Valley Foothills area of northeast British Columbia, about 100 miles south of Fort St. John. This is a relatively new exploration area. The first multi-zone discovery was made here in 1972 when gas was found in the Monkman Pass area in the Nikanassin, Baldonnel and Halfway sandstones of Mesozoic age. Since that time, several wells have been drilled on the same trend as the discovery well, over a distance of 100 miles. To date, one major discovery has been reported and there are indications that there may be others, but many of the exploratory tests are on the confidential list and information as to their status will not be known for some time. The initial discovery was made by a team of independent oil companies headed up by Quasar Petroleum Ltd., and preliminary evaluation indicates that this could be a very large field.

Another new producing trend appears to be developing in the Cecil Lake area of northeastern British Columbia where both oil and gas discoveries have been reported during the past year. The discovery area lies just north of Fort St. John and is surrounded by oil and gas producing fields. The initial discovery well was drilled in 1971 and encountered commercial quantities of gas in both the Northpine and Halfway sandstones of Triassic age. Subsequent to this, several follow-up wells were drilled, some of which were capable of producing both oil and gas. Many of the discoveries are on separate structures, and only further development drilling will determine their importance in terms of producible reserves.

Further north, in the Kotcho Lake area, a Devonian gas discovery was drilled in 1972 and evaluated in 1973. The discovery well Kotcho b-43-J is reported to have yielded large flows of gas on test and could be a major discovery. The Kotcho gas producing area contains major proven reserves of gas in Devonian formations. Two other exploratory tests were being drilled at year-end in the vicinity of the 43-J discovery.

Another significant gas-producing trend appears to be developing in the Tattoo region of northeastern British Columbia, approximately 35 to 40 miles east of the town of Nelson Forks. Nine significant gas strikes have been made there during 1973 and early 1974. Details as to producing formations and potential productivity of these wells are still classified as confidential and have not been released.

Early in 1973 the federal government announced its intention to review areas of environmental sensitivity offshore from British Columbia and, as a preliminary step, ruled that no exploration should be undertaken in the area during 1973. There have been no exploratory wells drilled offshore from British Columbia since Shell Canada Limited completed its unsuccessful 14-well drilling program in 1969.

At the end of 1973 there were 858 gas wells in British Columbia capable of production; 325 of these were in operation.

Yukon Territory, Northwest Territories and Arctic Islands. Exploratory activity in Canada's north continued at a high level and several significant discoveries were made. One hundred and one wells were drilled in northern Canada in 1973, for a total footage of 741,217 feet compared with 70 wells and 574,102 feet in 1972. All but 6 of these wells were classed as exploratory. Of the 95 exploratory wells drilled, eight were classified as potential gas finds. The most promising northern regions in terms of discoveries have been the Mackenzie Delta and the Sverdrup basin of the Arctic archipelago.

The initial gas discovery in the Mackenzie Delta was made in 1971 on Richards Island. Since then, seven more important gas discoveries have been made in the same general area, most of them on Richards Island. Three of the discoveries were drilled in 1973 and, in addition, the Kugpik 0-13 well drilled 55 miles north of Inuvik encountered significant quantities of both oil and gas from a zone below the 7,200 foot level. Although very little information has been made available, unofficial industry analysis suggests that some of these discoveries may be major fields. This

Table 3. Canada, production of natural gas, 1972-73[1]

	1972		1973^p	
	(Mcf)	($)	(Mcf)	($)
Gross new production				
New Brunswick	97,114		81,008	
Quebec	186,849		197,337	
Ontario	12,375,129		9,441,376	
Saskatchewan	85,936,261		84,105,961	
Alberta	2,759,762,083		2,965,017,260	
British Columbia	442,510,550		479,276,186	
Northwest and Yukon Territories	15,285,439		38,318,515	
Total, Canada	3,316,153,425		3,576,437,643	
Waste and flared				
Saskatchewan	17,024,683		15,933,840	
Alberta	58,919,634		61,545,304	
British Columbia	6,070,044		5,660,235	
Northwest and Yukon Territories	890,769		1,445,515	
Total, Canada	82,905,130		84,584,894	
Reinjected				
Alberta	315,402,280		362,981,582	
British Columbia	4,308,304		4,362,741	
Northwest Territories and Yukon	496		–	
Total, Canada	319,711,080		367,344,323	
Net withdrawals				
New Brunswick	97,114	57,133	81,008	40,504
Quebec	186,849	26,362	197,337	27,903
Ontario	12,375,129	4,767,580	9,441,376	4,060,735
Saskatchewan	68,911,578	8,932,087	68,172,121	8,903,279
Alberta	2,385,440,169	338,708,715	2,540,490,374	404,192,018
British Columbia	432,132,202	43,042,713	505,850,755	61,309,111
Northwest and Yukon Territories	14,394,174	1,651,240	275,455	31,677
Total, Canada	2,913,537,215	397,185,830	3,124,508,426	478,565,227
Processing shrinkage				
Saskatchewan	2,059,645		2,016,144	
Alberta	393,382,818		420,875,323	
British Columbia	41,583,188		48,059,966	
Total, Canada	437,025,651		470,951,433	
Net new supply, Canada	2,476,511,564		2,653,556,993	

Sources: Statistics Canada, and provincial government reports.
^{p}Preliminary; – Nil; [1] 14.73 psia.

would seem to be confirmed by data recently released on the 1971 Tgalu discovery. The discovery well and two offsetting wells have been removed from confidential status and, although the true size of the field is still to be established, proven reserves are indicated to be large.

Late in 1973, the search spread to the Arctic offshore area when Imperial Oil Limited began a multi-well drilling program 10 miles from Richards Island on man-made islands in the Beaufort Sea. The first well in this program was drilled on Immerk "Island" and had to be abandoned at the 8,300 foot level because abnormally high formation pressure precluded further safe drilling. Only minor quantities of natural gas were encountered during the drilling of the well which was scheduled to go to 15,000 feet at a cost of $9 million including construction of the permanent artificial island. Shortly after this, Imperial commenced drilling the well Adgo F-38 on its other artificial island located 16 miles southwest of the Immerk well. This artificial drilling platform is nonpermanent and was constructed primarily of ice and was much less costly than the Immerk structure. The Adgo well was reported to have encountered significant thicknesses of gas-bearing sandstone at a depth of about 7,000 feet. Before fully evaluating the potentially productive zones, the well is being deepened to a target depth of 12,000 feet to test other prospective zones. The progress of this well is being closely followed by industry as the area offshore from the Mackenzie Delta is geologically reputed to have as good a potential for oil and gas as the mainland has. If exploration is as successful there as it has been on the mainland, a proven reserve base adequate enough to justify the cost of building a major pipeline to southern markets likely will be assured.

In the Arctic Islands, the tempo of exploratory success slowed somewhat in 1973 as only one significant gas discovery was made. This discovery, Dome Arctic Venture's Wallis K-62 well, on King Christian Island, encountered a thick gas and condensate bearing sandstone. This is the second major gas discovery on King Christian Island and preliminary evaluation suggests that this may be the largest discovery yet made in the Arctic Islands. Since exploration in the Arctic Islands began in earnest in 1969, six major gas discoveries have been made here, five by Panarctic Oils Ltd., the industry-government company.

Probably the most interesting exploration development in the Arctic Islands this year was the drilling of

Table 4. Canada, production, trade and total sales of natural gas, 1963-73

		Net Withdrawals	Imports	Exports	Sales in Canada
1963	Mcf	993,388,491	6,877,438	340,953,146	451,598,298
	$	124,458,230	2,356,310	75,630,344	287,584,177
1964	Mcf	1,327,664,338	8,046,365	404,143,095	504,503,380
	$	145,057,536	2,871,145	97,608,555	327,982,720
1965	Mcf	1,442,448,070	15,673,069	403,908,528	573,016,494
	$	158,938,464	5,809,335	104,279,744	369,307,232
1966	Mcf	1,341,833,195	43,550,818	426,223,806	635,514,622
	$	179,183,990	17,592,370	108,749,931	416,212,202
1967	Mcf	1,471,724,535	52,871,671	505,164,622	698,223,437
	$	197,983,450	19,914,301	123,663,828	454,722,005
1968	Mcf	1,692,300,787	88,227,825	598,143,763	765,786,814
	$	225,263,658	35,392,758	153,751,558	490,767,434
1969	Mcf	1,977,838,205	37,732,703	669,815,767	843,164,967
	$	262,332,030	16,025,449	176,187,766	537,186,938
1970	Mcf	2,277,108,791	11,877,827	768,112,547	917,440,879
	$	315,099,792	5,123,896	205,988,180	582,316,948
1971	Mcf	2,499,023,600	16,010,217	903,051,071	1,001,328,624
	$	342,548,891	7,021,000	250,719,000	641,898,026
1972	Mcf	2,913,047,178	15,759,538	1,007,053,829	1,145,797,145
	$	388,500,342	7,629,000	306,843,000	740,382,930
1973[p]	Mcf	3,124,508,426	14,699,677	1,030,912,824	1,229,409,641
	$	478,565,227	7,793,000	350,745,000	797,855,930

Source: Statistics Canada. Figures in Tables 4 and 12 differ for imports and exports because of different reporting procedures and timing.
[p]Preliminary.

a deep test on Melville Island near the crest of the structure on which the Drake Point gas field is located. The Drake Point field was the first major discovery made in the Arctic Islands and the producing horizon is relatively shallow. The purpose of the deep test was to determine if there were other productive formations underlying the established producing zone. The well, Panarctic et al Drake Point D-68 was undertaken by Panarctic and six other participating companies and was the deepest well ever drilled in the area, exceeding 17,700 feet. It was also the most expensive with total costs exceeding seven million dollars. Although there has been no official announcement of results of the test to date, unofficial reports indicate the test was successful in that other potential productive zones were found at depths below the known gas-bearing zone. In addition to increasing the reserve base of the Drake Point field, the test was obviously successful in that it has established a fund of geological information that should prove invaluable in future exploration projects in the Islands.

Saskatchewan. Although the number of wells drilled increased in Saskatchewan in 1973 footage declined slightly. Successful gas well completions fell from 86 in 1972 to 73 in 1973. All of the wells were drilled in the western part of the province with the bulk of the exploratory success confined to the southwestern corner where the productive shallow gas trends extend from Alberta. Several exploratory successes in the Milk River formation in close proximity to the Hatton and Medicine Hat fields were made during the year. Although these are low-yield finds, increased prices and the fact that the new found reserves can be moved to market through the existing gathering systems of the Medicine Hat and Hatton fields, greatly improves the economics of developing these reserves.

Eastern Canada. Offshore from the east coast, 30 wells were drilled for a total of 331,448 feet in 1973 compared with 18 wells and 191,210 feet in 1972. Drilling commenced in this region in 1966, and since then a total of 68 wells had been drilled of which four significant discoveries of oil and gas have been made. All of these were drilled in the vicinity of Sable Island, the first in 1971 on the southwestern tip of the island. This well is capable of producing oil and gas from 17 separate zones. Six miles to the southwest, a gas-condensate discovery was made a year later, and the third significant gas discovery was made 30 miles east of Sable Island when the Primrose N-50 well tested flows of gas with condensate from three separate zones. The other find was an oil discovery – the Cohasset D-42 well, located 25 miles southwest of Sable Island, penetrated three crude oil bearing zones.

Seven offset wells have been drilled around the discovery well from a drilling platform on Sable Island and six of these were successful, but with considerably reduced pay sections from that of the initial discovery. The results of the drilling to date indicate that it will be difficult, if not impossible, to develop this field on a commercial basis because of the complexity of the structure of the productive formations. The other two gas finds have not yet been fully evaluated, but preliminary data suggests that they too are not commercially viable at the present time.

Elsewhere off the east coast, the well Bjarni H-81, drilled on the Labrador Shelf, was reported to have penetrated thick hydrocarbon-bearing sandstone formations before being suspended at a depth of 8,251

Table 5. Canada, liquids and sulphur recovered from natural gas, 1963-73

	Propane	Butane	Condensate Pentanes Plus	Sulphur
	(barrels)	(barrels)	(barrels)	(long tons)
1963	4,203,558	3,242,280	21,740,013	1,281,999
1964	6,515,222	5,529,455	25,264,469	1,472,583
1965	10,168,610	6,927,505	27,867,535	1,589,586
1966	12,473,645	8,177,144	29,365,322	1,729,455
1967	14,146,829	9,327,710	30,741,400	2,168,646
1968	15,855,467	10,421,958	33,202,168	3,042,105
1969	17,807,022	11,184,685	38,534,025	3,714,312
1970	21,274,353	13,203,744	44,151,409	4,240,982
1971	24,225,504	15,447,329	46,898,136	4,555,290
1972	29,540,846	19,458,808	60,829,459	6,617,216
1973p	33,433,765	22,436,175	62,061,744	7,003,489

Sources: Statistics Canada and provincial government reports.
pPreliminary.

Table 6. Wells drilled, by province, 1972-73

	Oil		Gas		Dry[1]		Total	
	1972	1973^p	1972	1973^p	1972	1973^p	1972	1973^p
Western Canada								
Alberta	514	600	1,010	1,518	1,155	1,586	2,679	3,704
Saskatchewan	316	392	86	73	245	192	647	657
British Columbia	37	8	61	54	115	99	217	161
Manitoba	–	–	–	–	7	16	7	16
Yukon and Northwest Territories								
Arctic Islands	1	–	7	10	62	91	70	101
Westcoast offshore	–	–	–	–	–	–	–	–
Hudson Bay offshore	–	–	–	–	–	–	–	–
Subtotal	868	1,000	1,164	1,655	1,584	1,984	3,620	4,639
Eastern Canada								
Ontario	4	11	34	34	119	75	157	120
Quebec	–	–	–	–	7	3	7	3
Atlantic Provinces	–	–	–	–	2	2	2	2
Eastcoast offshore	–	–	2	1	16	29	18	30
Subtotal	4	11	36	35	144	109	184	155
Total Canada	872	1,011	1,200	1,690	1,728	2,093	3,804	4,794

Source: Canadian Petroleum Association.
[1] Includes suspended and abandoned wells.
^{p}Preliminary; – Nil.

feet and before total depth had been reached. The drillship had to be moved in order to avoid adverse seasonal weather conditions. The operating company, Eastcan Exploration Ltd., plans on re-entering and drilling the hole to projected depth during the 1974 summer drilling season.

Aggregate drilling in Ontario in 1973 increased by 8 per cent to 219,808 feet. Exploratory drilling accounted for 45 per cent of the total and declined 56,238 feet from the previous year. Two shallow test wells of a 4-well drilling program were drilled on the Hudson platform west of the southern tip of James Bay. The other two wells in this program were drilled in 1972 but all were unsuccessful.

In southern Ontario, exploratory drilling dropped by 40 per cent from the previous year's total with only 51 wells drilled. The most significant discovery was a gas bearing patch reef in Lake Erie off Kent County. These patch reefs have become a prime exploration target in recent years because of their excellent reservoir characteristics and high productivity. Development drilling increased with 73 wells drilled for 121,876 feet compared with 69 wells and 85,691 feet in 1972. Most of the gas development wells were drilled in Lake Erie.

Reserves

According to the estimates of the Canadian Petroleum Association (CPA), proved remaining marketable reserves of natural gas declined by about 500 bcf. Proven reserves at the end of 1973 totalled 52.4 tcf compared with 52.9 tcf a year earlier. Using the 1973 level of production, the life index (reserves to production ratio) for natural gas dropped to 17 years. Gross additions to reserves amounted to 1.8 tcf, including 717 billion cubic feet (bcf) attributed to new discoveries and slightly more than 1 tcf to revisions and extensions. British Columbia and Alberta additions were due to new discoveries; British Columbia contributed 88 bcf and Alberta 629 bcf. Alberta and Saskatchewan were the only two provinces that showed an increase in proven reserves at the end of 1973; Alberta's reserve position increasing by 329 bcf and Saskatchewan's by 165 bcf, all of the latter were added by revisions to previous estimates. In preparing its reserve estimates, the CPA did not take into account recent rises in the wellhead price of natural gas which would produce an upward revision of 4.5 tcf by the addition of substantial volumes of gas formerly considered to be beyond economic reach.

The estimates of gas reserves do not include any

Table 7. Footage drilled in Canada for oil and gas by province, 1972-73

	Exploratory		Development		All Wells	
	1972	1973^p	1972	1973^p	1972	1973^p
Alberta	5,122,265	5,936,914	4,939,025	6,767,198	10,061,290	12,704,112
Saskatchewan	732,410	728,946	1,108,106	1,023,110	1,840,516	1,752,056
British Columbia	700,963	566,500	445,694	301,421	1,146,657	867,921
Manitoba	16,890	44,780	1,104		17,994	44,780
Territories and Arctic Islands	568,715	664,001	5,387	77,216	574,102	741,217
Westcoast offshore	–		–		–	
Hudson Bay offshore	–		–		–	
Total western Canada	7,141,243	7,941,141	6,499,316	8,168,945	13,640,559	16,110,086
Ontario	154,170	97,932	85,691	121,876	239,861	219,808
Quebec	59,915	26,560	–	–	59,915	26,560
Atlantic provinces	25,000	22,469	–	–	25,000	22,469
Eastcoast offshore	191,210	331,448	–	–	191,210	331,448
Total eastern Canada	430,295	478,409	85,691	121,876	515,986	600,285
Total Canada	7,571,538	8,419,550	6,585,007	8,290,821	14,156,545	16,710,371

Source: Canadian Petroleum Association.
^{p}Preliminary; – Nil.

allowance for the discoveries in the Mackenzie Delta, the Arctic Islands or offshore areas.

Natural gas processing

Gas processing capacity increased only marginally in 1973 and most of the increase was due to the construction of small units. Total gas processing capacity in Canada rose by 426 MMcf/d, the smallest increase in several years.

The largest unit that came on stream during the year was Amoco Canada Petroleum Company Ltd.'s sweet gas cycling plant at Ricinus which will be extracting 7500 b/d of natural gas liquids (NGL) mix from a raw gas stream of 75 MM cf/d. Four smaller plants were also brought on stream, adding only an insignificant amount to new plant capacity. All of these plants are located in Alberta. Francana Oil & Gas Ltd. completed construction of its dehydration-compression type plant which will process gas from the Holmberg field. The plant has capacities of 12 MM cf/d of raw gas, 12 MM cf/d of residue gas and 15 b/d of pentanes plus. Western Decalta Petroleum Limited revamped its surplus gas processing plant at the Leduc field and moved it to the Rockford field where it is now processing 5 MM cf/d of raw gas to produce 4.9 MM cf/d of residue gas and 18 b/d of pentanes plus. Provident Resources Ltd. began operating its plant at Stanmore, Alberta which has a raw gas capacity of 3 MM cf/d. American Trading and Production Corporation's Oyen plant came on stream in December of 1973 with a raw gas processing capacity of 2.5 MM cf/d yielding 2.5 MM cf/d of residue gas and 2 b/d of butane.

In addition to these new plants, capacity was added by the expansion of a number of existing plants. In British Columbia, Imperial Oil Limited added NGL facilities to its Boundary Lake plant and now recovers 700 b/d of propane, 500 b/d of butane and also increased pentanes plus production to 170 b/d from 100 b/d.

In Alberta, Chevron Standard Limited added natural gas liquid processing capacity to its Kaybob South plant, and now can produce 20,000 b/d of propane-butane mix in addition to 33,840 b/d of pentanes plus. Imperial Oil completed the fourth phase in its round of expansion at the Judy Creek field increasing raw gas intake by 50 MM cf/d to 225 MM cf/d. Plant number 5 in this complex is expected to be completed in 1974 with a raw gas capacity of 40 MM cf/d. Gulf Oil Canada Limited raised the raw gas capacity of its Strachan plant to 275 MM cf/d and, at the same time, increased the deep cut facilities for propane-butane mix to 4453 b/d. Hudson's Bay Oil and Gas Company Limited increased the raw gas intake of its Brazeau River plant to 196 MM cf/d and doubled its output of pentanes plus to 2662 b/d. Shell Canada Limited expanded its Simonette gas processing plant by increasing raw gas intake to 37 MM cf/d. During the overall expansion of the plant, facilities to increase efficiency of liquids extraction were also added so that the plant will produce 745 b/d of propane-butane mix. In the Rainbow field, Imperial Oil expanded its plant to 10.5 MM cf/d of raw gas intake. Both the residue gas and the condensate byproduct are re-injected into four oil fields in the area to maintain reservoir pressure. Canadian Superior

Table 8. Canada, estimated year-end marketable reserves of natural gas, 1972-73

	1972	1973
	(millions of cubic feet)	
Alberta	41,377,769	41,706,538
British Columbia	9,145,563	8,631,565
Saskatchewan	825,270	990,778
Eastern Canada	250,382	242,312
Northwest Territories	1,336,798	886,239
Total	52,935,782	52,457,432

Source: Canadian Petroleum Association.

Oil Ltd. completed the major expansion of its Harmattan plant to produce 150 MM cf/d of sales gas from the Harmattan East field.

Future plans of Amoco Canada Petroleum Company Ltd. call for the construction of a gas plant to serve the Nipisi field. The plant will process 25 MM cf/d of raw gas to produce 17.7 MM cf/d of residue gas and 7304 b/d of NGL mix. Construction start is scheduled for 1974, with completion sometime in 1975. In British Columbia, Westcoast Transmission Company will increase the capacity of its McMahon plant at Taylor to 515 MM cf/d and, at the same time, increase NGL production by 1660 b/d. The Westcoast, Fort Nelson plant is also being enlarged; and a gathering system expansion, due to be completed in 1974, will connect the additional fields of Petitot, Cabin, Gote, and Louise. A sulphur plant is now under construction adjacent to the process plant and will begin operation in 1974, with an initial capacity of 400 lt/d.

Canadian Export Gas & Oil Ltd., has immediate plans to install a small gas processing plant on the southern edge of the Provost field in 1974. The plant will process about 5.5 MM cf/d of raw gas and recover small amounts of pentanes plus. The residue gas will be delivered to the TransCanada pipeline. Gulf Oil Canada Limited is expanding its gas processing plant in the Nevis field with completion date scheduled for 1974. Both raw gas intake and liquid byproduct production will be increased.

The slow-down in the construction of natural gas processing plants that occurred during the past year will probably be short-lived. Burgeoning demand, coupled with escalating prices for natural gas, will likely have a stimulating effect on exploration and development which in turn should revitalize the gas processing industry. Higher prices will promote substantial growth in proven reserves of natural gas by the addition of large volumes of relatively high-price gas formerly considered to be non-profitable. Higher prices will also provide incentives for explorationists to step up exploration activity in all areas of the southern plains, but primarily in the Foothills belt where operating costs are high, and the high sulphur content of the gas has proven to be a deterrent to exploration during the past three years. Recent firming of world sulphur markets and higher sulphur prices have eliminated this deterrent.

Transportation

A total of 3,411 miles of pipeline was added to gas transmission, distribution and gathering systems in Canada during 1973, compared with 2,798 miles in 1972. Total cumulative gas pipeline mileage now stands at 70,711 miles.

Gas pipeline construction increased in 1973 due essentially to looping programs; i.e., the construction of additional lines parallel to the main line, by the major gas transmission companies. Trans-Canada PipeLines Limited was the major contributor, with the addition of 497 miles of large diameter loops to its system. This consisted of 149 miles of 42-inch diameter pipe in their fourth line in Saskatchewan and Manitoba and 348 miles of 36-inch diameter pipe in their second line east of Winnipeg in Manitoba and northern Ontario. A further 37 miles of 24-inch pipeline between Toronto and Montreal were added. Additional pumping capacity was installed. Future plans call for the construction of 154 miles of 36-inch diameter parallel pipeline through northern Ontario between Orient Bay and Maple, north of Toronto. It is expected that this section will be completed before the middle of 1974.

In Alberta, The Alberta Gas Trunk Line Company Limited purchased 171 miles of the Mitsue oil pipeline. The Mitsue line, built in 1965, consists of 8- and 10-inch pipe, running from the Nipisi oil field north of Utikuma Lake to the Redwater oil field where it joins the Interprovincial Pipe Line Limited oil terminal. Mitsue Pipeline Ltd. was acquired by Rainbow Pipe Line Company Ltd. a few years ago and has been operated since then as part of the Rainbow system. The Rainbow and Mitsue pipelines although a few miles apart, run parallel to each other from Nipisi to Jarvie where they separate; the Rainbow main line going to Edmonton. Alberta Gas Trunk will convert all but 53 miles to gas transmission service, partly to carry dry residue gas from a planned gas processing plant in the Mitsue field to the compressor station at Chisholm Mills from where it will be fed into the Marten Hills lateral and transported to Edson. The converted line will also be used to supply gas to a distributing firm which is part of Alberta's rural gasification program. The Mitsue venture is somewhat similar to Alberta Gas Trunk's purchase of 300 miles of the 20-inch Peace River oil pipeline system in 1971 and its conversion to gas service for a group of Peace River area gasfields.

In British Columbia, Westcoast Transmission Com-

Table 9. Canada, natural gas processing plant capacities by fields, 1973

Main Gas Field Served	Raw Gas Capacity	Residue Gas Produced	Main Gas Field Served	Raw Gas Capacity	Residue Gas Produced
	(million cf/day)			(million cf/day)	
Alberta			Innisfail	20	13
Acheson	6	5	Joffre	8	5
Alderson (2 plants)	24	24	Judy Creek, Swan Hills (3 Plants)	256	196
Atlee, Buffalo	31	30	Jumping Pound	250	200
Alexander, Calahoo	36	35	Kaybob	95	92
Bassano	8	8	Kaybob South (3 Plants)	827	341
Bigoray	13	12	Kessler	6	5
Bigstone	48	36	Keystone	8	7
Black Butte	10	10	Lac La Biche	25	25
Birch Lake	25	25	Leduc Woodbend	38	35
Bonnie Glen	48	40	Lone Pine Creek	67	54
Boundary Lake South	16	155	Mannville	33	32
Brazeau River	196	171	Marten Hills	133	130
Brazeau South	66	60	Marten Hills South	24	24
Burnt Timber	68	57	Mikwan North	15	13
Calling Lake	15	15	Minnehik-Buck Lake	108	100
Carbon	155	150	Mitsue	21	15
Caroline (2 Plants)	53	45	Morinville, St. Albert-Big Lake	22	20
Carson Creek	100	48	Nevis, Stettler (2 Plants)	216	178
Carstairs	334	280	Okotoks	30	13
Cessford (4 Plants)	190	184	Olds	100	76
Cessford North	7	6	Oyen (2 Plants)	5	5
Chigwell (2 Plants)	7	5	Paddle River	30	28
Connorsville, Cessford	5	5	Parflesh	2	2
Countess (3 Plants)	42	40	Phoenix	3	2
Crossfield (2 Plants)	319	218	Pembina (12 Plants)	158	136
Dunvegan	207	160	Pincher Creek	105	75
East Crossfield	146	87	Prevo	5	4
East Rainbow Lake	18	11	Princess (2 Plants)	15	15
Edson	377	339	Provost (4 Plants)	127	120
Enchant	5	5	Quirk Creek	90	68
Equity, Ghost Pine	16	15	Rainbow Lake	81	reinj
Ferrier (2 Plants)	110	94	Rainier	3	3
Ferrier South	20	19	Redwater	22	8
Ferrybank	20	19	Redlaw	7	7
Figure Lake	12	12	Savana Creek	75	63
Flat Lake	25	25	Sedalia	5	5
Ghost Pine	113	111	Sibbald	6	5
Gilby (6 Plants)	136	119	Simonette	37	27
Gilby North	19	18	South Lone Pine Creek	35	26
Gold Creek	60	40	Stanmore	3	3
Golden Spike	90	reinj	Strachan D-3	275	214
Greencourt	30	28	Strachan, Ricinus West	400	242
Harmattan-Elkton (2 Plants)	486	15	Strathmore	2	2
Harmattan-Elkton South	5	4	Sturgeon Lake South	12	9
Hatton	8	7	Swalwell	4	4
Holmberg	12	12	Sylvan Lake (2 Plants)	91	82
Homeglen-Rimbey	423	357	Three Hills Creek	10	9
Hussar	120	110	Turner Valley	40	25

Table 9 (concl'd)

Main Gas Field Served	Raw Gas Capacity	Residue Gas Produced	Main Gas Field Served	Raw Gas Capacity	Residue Gas Produced
Alberta (cont'd)	(million cf/day)			(million cf/day)	
Ukalta	6	6	Coleville, Smiley	52	51
Verger	6	5	Dollard	2	2
Virginia Hills	12	10	Milton	4	4
Vulcan	25	22	Smiley	2	15
Warwick	15	15	Steelman	338	30
Waskahigan	16	14	Totnes	7	7
Waterton	468	311	West Gull Lake	15	14
Wayne-Rosedale	65	62			
Wildcat-Hills	112	95	**British Columbia**		
Willesden Green	17	15	Beaver River	240	240
Wilson Creek (2 Plants)	23	19	Boundary Lake (2 Plants)	29	27
Wimborne	60	46	Clarke Lake	1,100	910
Windfall, Pine Creek	215	132	Fort St. John	515	460
Wintering Hills	20	20			
Wood River	5	5			
Worsley	23	21	**Ontario**		
Pipeline at Ellerslie[1]	70	66	Becher	1	1
Pipeline at Empress[2] (2 Plants)	3,000	2,892	Corunna (2 Plants)	5	5
Pipeline at Cochrane[3]	1,000	970	Port Alma	16	16
Saskatchewan			**Northwest Territories**		
Cantuar	25	24	Pointed Mountain	189	189

Source: *Natural Gas Processing Plants in Canada (Operators List 7) January 1973,* Department of Energy, Mines and Resources.

[1]Plant reprocesses gas owned by Northwestern Utilities, Limited. [2]Plant reprocesses gas owned by TransCanada PipeLines Limited. [3]Plant reprocesses gas owned by exporting companies.

pany Limited completed a $55 million expansion program to its main line during 1973. The expansion included the construction of three loops of 36-inch diameter pipeline totalling some 44.5 miles in the Fort Nelson section of the main line as well as twelve loops of 36-inch pipeline totalling 401 miles in mainline loops in the more southerly section of the company line. Also included were miscellaneous pipeline facilities for the Fort St. John gathering systems and a new elemental sulphur recovery plant at Fort Nelson. The 1973 expansion will increase Westcoast's daily capacity by about 75 million cubic feet.

In 1973, two separate groups of companies were investigating the feasibility of building major natural gas transmission lines from the Canadian Arctic to southern markets in Canada and the United States. These research groups, Canadian Arctic Gas Study Limited and the Polar Gas Project are consortiums composed of several pipeline and oil companies and are also dedicated to solving the ecological and environmental problems that may be encountered in constructing and operating pipelines in permafrost areas. Because of the steady build-up of gas reserves in the Arctic Islands and the Mackenzie Delta, these companies are directly involved in studies relating to the feasibility of bringing such reserves to market; the Polar Gas Project is concerned with Artic Islands gas, while the Canadian Arctic Gas Study group is concerned with Mackenzie Valley gas.

Although there have been several estimates of the ultimate costs of these pipelines and the minimum gas reserve base necessary to justify their construction, it is generally conceded that the line from the Mackenzie Delta would cost in excess of $5.5 billion and require an ultimate minimum reserve base of 25 trillion cubic feet. It is likely that a line from the Arctic Islands would cost more, possibly as much as $7 billion and require ultimate minimum reserves of 30 trillion cubic feet.

The 26 member companies of Canadian Arctic Gas have spent about $50 million in economic, engineering and environmental studies related to the proposed line. The results of the studies showed that chilled natural gas could be transported by pipelines without damage to the permafrost. It is still anticipated that much of the gas transported by the line will come from Prudhoe Bay in Alaska because Mackenzie Valley reserves are not yet sufficient to make the line a viable proposition and the Canadian market could not absorb at once the huge deliveries of such a large line. In 1974 the company expects to file applications, with regulatory authorities both in Canada and United States,

Table 10. Gas pipeline mileage in Canada, 1969-73

	1969	1970	1971	1972	1973e
Gathering					
New Brunswick	6	6	6	6	6
Quebec	1	1	1	1	1
Ontario	1,193	1,121	1,092	1,136	1,187
Saskatchewan	805	893	875	922	990
Alberta	3,663	4,049	4,243	4,202	4,669
British Columbia	650	718	948	989	1,127
Northwest Territories and Yukon	–	2	4	–	–
Total	6,318	6,790	7,169	7,256	7,980
Transmission					
New Brunswick	13	13	13	13	13
Quebec	148	148	148	148	185
Ontario	3,612	3,612	3,711	4,351	4,699
Manitoba	1,227	1,321	1,445	1,589	1,664
Saskatchewan	4,504	4,990	5,361	5,996	6,221
Alberta	6,054	6,782	7,206	7,815	8,115
British Columbia	2,371	2,372	2,653	2,967	3,128
Total	17,929	19,238	20,537	22,879	24,025
Distribution					
New Brunswick	32	32	32	32	32
Quebec	1,572	1,568	1,638	1,693	1,748
Ontario	15,058	15,610	16,080	16,664	16,934
Manitoba	1,466	1,513	1,630	1,708	1,800
Saskatchewan	2,126	2,236	2,355	2,547	2,721
Alberta	6,721	7,553	7,841	8,657	9,198
British Columbia	5,004	5,179	5,203	5,864	6,273
Total	31,979	33,709	34,779	37,165	38,706
Total, Canada	56,226	59,737	62,485	67,300	70,711

Source: Statistics Canada.
– Nil; eEstimated by Mineral Development Sector.

seeking permission to construct the line.

The Polar Gas Project is researching the feasibility of constructing a 48-inch pipeline to deliver 4.5 bcf/d (billion cubic feet a day) from the Arctic Islands. The estimated cost of this research project is between $5 million and $6 million. The major engineering challenge of such a project is the laying of about 540 miles of pipeline underwater, at depths of up to 900 feet, between the Arctic Islands. An additional problem, the solution of which will heavily influence the design and construction of the pipeline, is the danger of ice scour – not only from drifting nearshore ice flows, but also from the bottoms of large ice packs which gouge the ocean floors at considerable depths as they drift through the channels. By the end of 1973, basic field research on this project was well advanced.

In summary, both the Polar Gas Project and the Canadian Arctic Gas Project have to deal with complex engineering and ecological problems as well as meet regulatory requirements before Arctic gas can be delivered. In addition, each likely needs the discovery of new reserves and this critical factor could largely determine which project proceeds first.

Markets and trade

Natural gas sales of all classes increased by 102 bcf to an estimated 2257 bcf, for a growth rate of 4.7 per cent over 1972 sales. Sales to Canadian customers accounted for most of this growth rate, increasing by 7.3 per cent to 1,229 bcf. Industrial sales in Canada accounted for 58 per cent of all sales in Canada in 1973. Sales in this category rose to 1,950 Mcf/d, an increase of 14.2 per cent over the previous year. Growth in commercial sales was negligible, increasing only 1.5 per cent over 1972 to 673 Mcf/d. Residential sales declined by about 1 per cent. Commercial sales accounted for 20 per cent of total sales, and residential 22 per cent. Total revenue from all sales in Canada amounted to $800 million, made up of $286 million from residential sales, $183 million from commercial sales and $330 million from industrial sales.

In 1973, Ontario accounted for the bulk of the increase in Canadian consumption, and a 10 per cent rise in industrial sales was the major factor in raising provincial consumption by 4.8 per cent to 1,586 MMcf/d. Ontario consumed 47 per cent of total gas marketed in Canada. Alberta is the second largest consuming province, and it accounted for 22.8 per cent of all gas marketed in Canada in 1973. Sales in Alberta rose by 4.8 per cent to 770 MM cf/d. Markets in British Columbia averaged 410 MM cf/d for a 26.5 per cent increase over the 1972 consumption rate. Sales of natural gas in Saskatchewan increased by 4.5 per cent, and were up marginally by 4.1 per cent in Manitoba. Quebec consumption increased by 10 per cent, but remained a relatively minor part of the total Canadian market. However, this situation could change in the near future as the result of an agreement whereby Quebec agreed to take 4.3 trillion cubic feet of gas from Alberta over a period extending from November 1, 1974 to November 1, 2000. Initial volume proposed is 40 MM cf/d for the first contract year rising to 500 MM cf/d by the sixth year. The gas is to be carried by TransCanada PipeLines which presumably will be a contract carrier marking the first major volume of gas to be carried by them under this type of agreement. The gas is to be supplied by Pan-Alberta Gas Ltd. which is jointly owned by Alberta Gas Trunk and the Alberta Energy Company Ltd. (AEC). This agreement is still subject to approval by provincial and federal regulatory authorities.

Sales in New Brunswick remained at about the same level as in the previous year. The remaining three provinces do not have natural gas service.

Export sales to the United States increased by 19 bcf to 1,028 bcf in 1973. This represents a gain of only 1.8 per cent over the previous year since, essentially, exports have reached the maximum allowed under existing permits. At year-end, three gas export applications had been filed with the National Energy Board (NEB) involving 2.2 trillion cubic feet of Alberta gas. These are: Canada-Montana Pipe Line Company's application to export 248 bcf of Alberta gas to Montana Power; Pan-Alberta Gas Ltd.'s application to export 883 bcf of Alberta gas to the California and Oregon markets; and Alberta and Southern Gas Co. Ltd.'s application to export 1.095 tcf of Alberta gas to California consumers. It is not likely that any of these applications will be acted on until after the completion of the NEB general gas export hearings scheduled for the fall of 1974. Imports from the United States, mainly into Ontario, averaged 41 MMcf/d, slightly less than in 1972.

In 1973 the Alberta government reduced the amount of gas that TransCanada had applied to remove from the province from 2590 bcf to 961 bcf. The reason the Alberta Energy Resources Conservation Board (AERCB) gave for reducing the permit volume was that the reserves in the fields under contract to TransCanada were insufficient to support the additional volumes applied for. Also, the base prices in the current gas purchase contracts of TransCanada PipeLines are substantially below the current field value, the price escalation being less than that recommended by the Board in its August 1972 report on Field Pricing of Gas in Alberta. In addition, TransCanada PipeLines contracts do not provide for redetermination of price every two years in accordance with the new natural gas policies of the Alberta government. As a result of the Board's findings, the Alberta cabinet refused to consider TransCanada's outstanding applications for permits to remove additional gas until such time as TransCanada provided data to the effect that pricing provisions in their gas purchase contracts are in accordance with the Alberta government's new natural gas policies.

In line with the policy to increase provincial revenue from oil and gas production, and following a comprehensive review of existing natural gas royalty rates during 1973, a new schedule was introduced by the Alberta government early in 1974. Under the terms of the new schedule, different royalty rates would be applied on the basis of whether the gas production is defined as "old," i.e., gas that has been discovered some time ago or "new," i.e., gas that is newly discovered. The exact point in time as to when gas is considered to be "old" or "new" is still to be determined. The royalty rate for both old and new gas will be determined by a formula and will vary with the wellhead price. For old gas the rate varies from 22 per cent at a price of 26 cents a thousand cubic feet (Mcf) to about 49 per cent at a price of $1.25 an Mcf. For new gas, the royalty rate will vary from 22 per cent at a price of 26 cents an Mcf to about 32 per cent at a price of $1.25 an Mcf. The new royalty schedule was intended not only to increase government revenue but also to encourage exploration by making it more attractive from a royalty standpoint for exploration companies to search for new gas.

The British Columbia government also acted during the past year to become directly involved in the pricing of provincial natural gas resources. As a preliminary step, the British Columbia government incorporated the British Columbia Petroleum Corpora-

Table 11. Canada, sales of natural gas by province, 1973ᵖ

	Mcf	$	Average $/Mcf	Number of Customers, Dec. 31/73
New Brunswick	47,492	157,698	3.32	840
Quebec	64,212,230	65,834,570	1.03	194,596
Ontario	579,115,457	446,451,311	0.77	943,663
Manitoba	62,372,238	40,305,559	0.65	148,146
Saskatchewan	92,917,188	44,666,072	0.48	165,859
Alberta	281,066,017	92,345,400	0.33	373,297
British Columbia	149,679,019	108,095,320	0.72	304,689
Total, Canada	1,229,409,641	797,855,930	0.65	2,131,090
Previous totals				
1969	843,164,967	537,186,938	0.64	1,836,303
1970	917,440,879	582,316,948	0.63	1,889,808
1971	1,001,328,624	641,898,026	0.64	1,958,083
1972	1,145,797,145	740,382,930	0.65	2,039,095

Source: Statistics Canada.
[p]Preliminary.

tion, and empowered it to engage in production, processing, transmission and marketing of natural gas. The royalty system was abandoned and a new system was instituted under which the province would be compensated for gas removed at a price based on current competitive energy value adjusted by proper allowance for costs incurred by industry. In effect, this meant that all the province's gas was bought directly by the Crown corporation from the producer and sold directly to the distributing companies which, essentially, relegated Westcoast Transmission Company to common carrier status.

The Crown corporation was also given the power to set both the wellhead price and wholesale price to distributing companies and immediately set the new wholesale prices of gas sold to British Columbia distributors at 58 cents a Mcf, 26 cents above the former level. The new export price at the border to the United States distributor was set under terms of the existing contract arrangement and National Energy Board policy at five per cent above domestic Canadian selling price or 61 cents, compared with the previous price of 33.5 cents. The new prices became effective in November of 1973. Shortly thereafter the British Columbia Petroleum Corporation proposed a new wellhead price schedule for natural gas in the province. The new proposal called for a six-year contract paying 18.5 cents a Mcf for old gas and 22 cents for newly discovered gas, increasing in 1979 to prices of 22.75 cents and 33 cents, respectively.

Composition and uses of natural gas

Marketed natural gas consists chiefly of methane (CH_4) but small amounts of other combustible hydrocarbons such as ethane (C_2H_6) and propane (C_3H_8) may also be present. Methane is nonpoisonous and odourless, but a characteristic odour is usually introduced into marketed natural gas as a safety measure. The heat value of natural gas averages about 1,000 British thermal units per cubic foot of gas.

Raw, natural gas, as it exists in nature, may vary widely in composition. Besides the usually predominant methane, varying proportions of ethane, propane, butane and pentanes plus may be present. Water vapour is a normal constituent. Hydrogen sulphide, although not present in some Canadian natural gas, is commonly so abundant as to be an important source of sulphur. Other nonhydrocarbon gases which may be present, usually in small amounts, are carbon dioxide, nitrogen and helium.

The most important use of natural gas is as a fuel for space and water heating. Gas is now extensively used in cooking, but is becoming common as a fuel for air conditioners, incinerators, dishwashers and laundry equipment. In industrial areas, natural gas has been a boon to such industries as automobile plants, steel plants, metal-working firms, glass factories and food-processing industries. For example, in metallurgical processing, the clean, easily controlled flame of natural gas enables the desired temperatures to be attained in rolling, shaping, drawing and tempering steel. The constituents of natural gas have become major sources of raw material for the petrochemical industry. Ethane, seldom removed from natural gas at the field processing plant in the past, is an important petrochemical feedstock that, up until now, has been recovered from pipeline gas on a limited scale subject to market forces. Ethane recovery on a large scale is

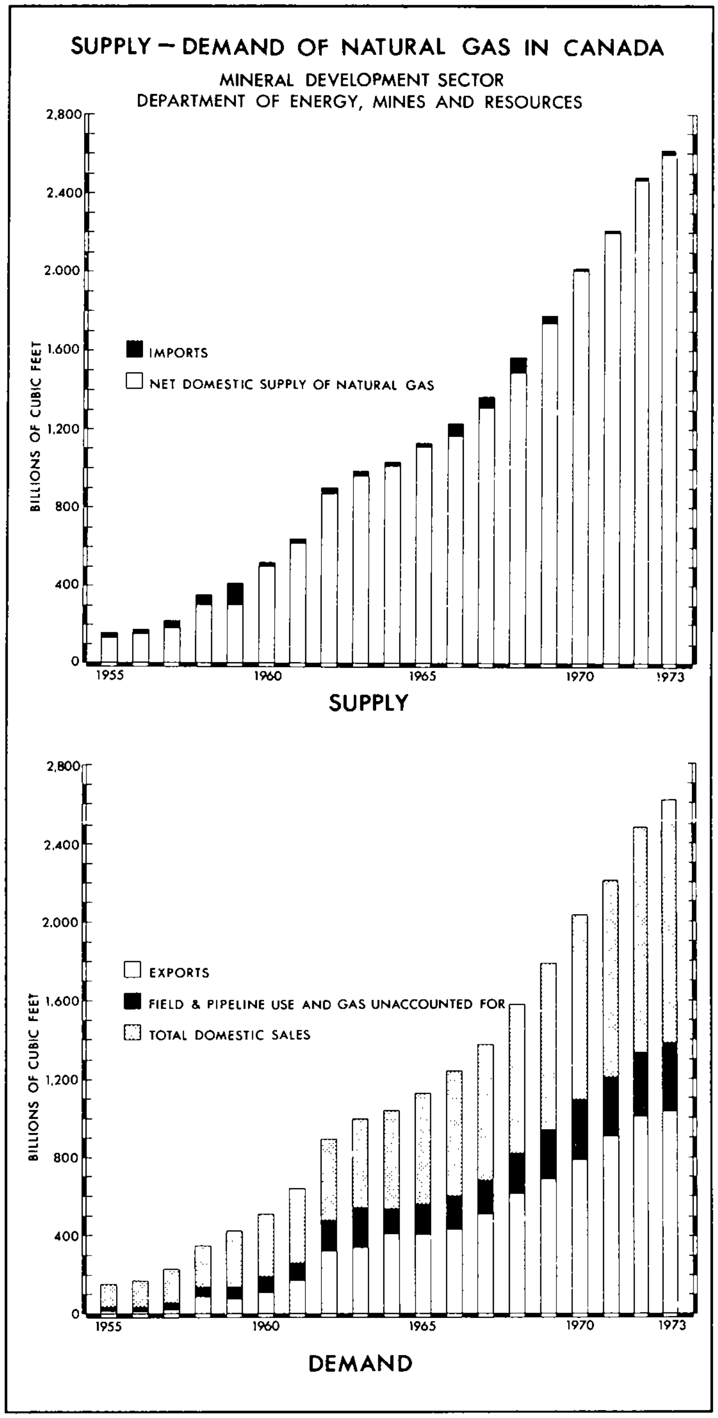

SUPPLY — DEMAND OF NATURAL GAS IN CANADA
MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES
BILLIONS OF CUBIC FEET
2,800
2,400
2,000
1,600
1,200
800
400
0
IMPORTS
NET DOMESTIC SUPPLY OF NATURAL GAS
1955
1960
1965
1970
1973
SUPPLY
BILLIONS OF CUBIC FEET
2,800
2,400
2,000
1,600
1,200
800
400
0
EXPORTS
FIELD & PIPELINE USE AND GAS UNACCOUNTED FOR
TOTAL DOMESTIC SALES
1955
1960
1965
1970
1973
DEMAND

Table 12. Canada, supply and demand of natural gas

	1972		1973p	
	MMcf	MMcf	MMcf	MMcf
Supply				
Gross new production		3,316,058		3,576,438
Field waste and flared		-82,701		-84,585
Reinjected		-319,711		-367,344
Net withdrawals		2,913,646		3,124,509
Processing shrinkage		-437,025		-470,951
Net new supply		2,476,621		2,653,558
Removed from storage	99,302		74,504	
Placed in storage	-104,284		-131,669	
Net storage		-4,982		-57,165
Total net domestic supply		2,471,639		2,596,393
Imports		15,693		14,670
Total supply		2,487,332		2,611,068
Demand				
Exports		1,009,651		1,028,029
Domestic sales				
Residential	280,811		271,797	
Industrial	623,405		711,958	
Commercial	241,581		245,654	
Total		1,145,797		1,229,409
Field and pipeline use				
In production	188,136		211,478	
Pipeline	127,864		134,652	
Other	27,255		37,652	
Line pack changes	3,655		1,253	
Total field and pipeline use		346,910		385,035
Gas unaccounted for		-15,026		-31,405
Total demand		2,487,332		2,611,068
Total domestic demand		1,477,681		1,583,039
Average daily domestic demand		4,037		4,337

Source: Statistics Canada and provincial government reports.
pPreliminary.

now predicted. With imminent prospects for major growth in the petrochemical industry, it is likely that most, if not all, of this valuable commodity will henceforth be recovered and used as a petrochemical feedstock. Natural gas supplies basic raw material for ammonia, plastics, synthetic rubber, insecticides, detergents, dyes and synthetic fibres such as nylon, orlon and terylene. Important future uses may include gas fuel-cells and power-generator systems driven by gas turbines. Canada continues to be one of the world's largest producers of elemental sulphur, a byproduct recovered in the processing of sour gas (hydrogen sulphide bearing) from fields in western Canada.

Nepheline Syenite and Feldspar

G.H.K. PEARSE

Nepheline syenite is a white to whitish-grey, medium-grained igneous rock resembling granite in texture. It consists of nepheline, potash and soda feldspar, and accessory mafic minerals such as biotite, hornblende and magnetite. Although nepheline syenite is a rock type known to occur in many parts of Canada, its industrial application is limited to those deposits in which iron-bearing accessory minerals can readily be removed; its major uses are in the glass and ceramics industries.

Nepheline syenite as an industrial raw material was first developed in Canada, which was the world's sole producer for many years. Although the U.S.S.R. began mining nepheline syenite on the Kola Peninsula during the 1930's, the deposit was worked for its phosphate content. Byproduct nepheline syenite from the Kola deposit became important as a source of aluminum and is still being used for this purpose. In addition to Canada and the U.S.S.R., only Norway produces nepheline syenite.

Canada's nepheline syenite industry began in 1932 with the staking of five claims on Blue Mountain, 25 miles northeast of Peterborough. A long period of persistent efforts in technical and market research and development was necessary before this unique industry became established. Today there are two mills in operation on Blue Mountain processing rock from three quarries.

Over the years nepheline syenite has become preferred to feldspar as a source of essential alumina and the alkalis in glass manufacture. Its use has resulted in more rapid melting of the batch at lower temperatures than with feldspar, consequently reducing fuel consumption, lengthening the life of furnace refractories and improving the yield and quality.

Industrial uses for nepheline syenite other than for glass manufacture are many; and markets are expanding rapidly in ceramics, enamels, and as a filler in paints, papers, plastics and foam rubber.

Feldspar is the name of a group of minerals consisting of aluminum silicates of potassium, sodium and calcium. Feldspar is used in glassmaking as a source of alumina and the alkalis, ceramic bodies and glazes, in cleaning compounds as a moderate abrasive, as a flux coating on welding rods, etc. High-calcium feldspars, such as labradorite, and feldspar-rich rocks like anorthosite find limited use as building stones and for other decorative purposes. Dental spar, which is used in the manufacture of artificial teeth, is a pure white feldspar free of iron and mica.

Feldspar occurs in many rock types, but commercially viable deposits are mostly restricted to coarse-grained granite pegmatites from which the mineral is generally hand-cobbed to remove quartz and other unwanted associated minerals. It is then ground to the desired size. Nearly all feldspar produced in Canada has come from pegmatites in the Precambrian rocks of southern Ontario and southwestern Quebec.

Canadian production and developments

Nepheline syenite production originates from two operations on Blue Mountain in Methuen Township, Peterborough County, Ontario. The deposit is pear-shaped, approximately five miles long and up to one and one-half miles wide. The iron content of the rock is distributed quite uniformly, but nonetheless, selective quarrying, blending of quarry material, and careful pit development are necessary to ensure a mill product capable of meeting consumer specifications. In general, the nepheline syenite zone is underlain by syenites and overlain by steeply dipping biotite schists. Nepheline syenite reserves are sufficient to satisfy demand for the foreseeable future.

Indusmin Limited, a subsidiary of Falconbridge Nickel Mines Limited, is the larger producer. The company's operation at Nephton, Ontario, was originally worked by its predecessor Canadian Nepheline, Limited. Ore is mined from two open pits, Cabin Ridge and Craig. Rock is blasted from the pit face and loaded by electrically powered shovels into trucks for haulage to an adjacent 1,000-ton-a-day mill at Nephton. The mill, built in 1956, operates three shifts a

Table 1. Canada, nepheline syenite production, exports and consumption 1972-73

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Production (shipments)	559,483	5,902,063	576,000	7,372,000
Exports				
United States	417,529	5,334,000	437,438	5,821,000
Britain	9,770	137,000	3,030	66,000
Australia	2,621	59,000	2,496	66,000
France	895	27,000	1,045	35,000
Italy	1,208	31,000	652	17,000
Spain	708	18,000	474	13,000
Dominican Republic	100	3,000	419	10,000
Puerto Rico	3,406	54,000	530	9,000
Panama	–	–	400	9,000
Other countries	2,168	59,000	1,975	53,000
Total	438,405	5,722,000	448,459	6,099,000

Consumption[1] (available data)

	1971	1972^p
	(short tons)	
Glass and glass fibre	56,896	57,071
Whiteware	10,388	12,450
Mineral wool	9,596	9,700^e
Porcelain enamel	137	250
Paints	1,668	4,861
Others[2]	4,406	11,780
Total	83,091	96,112

Source: Statistics Canada
[1]Total and breakdown from Mineral Development Sector.
[2]Includes miscellaneous chemicals, gypsum products, rubber products, cleansers and detergents and other minor uses.
^{p}Preliminary; ^{e}Estimated.

day, seven days a week producing several grades of nepheline syenite to meet a wide variety of markets. The various grades produced are based on combinations of differing mesh sizes and iron content. Iron-bearing minerals are almost totally removed by electromagnetic methods. Finished products are transported by rail to Havelock, Ontario, 18 miles south of the mill. From there, transportation is by rail to domestic and export markets. The United States accounts for about 76 per cent of total sales.

International Minerals & Chemical Corporation (Canada) Limited [IMC (Canada)] operates the other mill on the Blue Mountain deposit, about four miles east of the Indusmin operation. An 800-ton-a-day mill was constructed in mid-1956 on a part of the deposit originally staked in 1932 by the Canadian Flint and Spar Company, Limited. The mill operates three shifts daily, seven days a week and produces a variety of products based on mesh sizes and iron content suitable for many industrial uses. Rock is mined from an open pit adjacent to the mill; a certain degree of blending from various parts of the pit is required to ensure an acceptable mill feed. Ore reserves are sufficient for many years.

Production is railed to Havelock, Ontario for distribution to various markets, approximately 90 per cent being exported to the United States. IMC (Canada) produces three grades of nepheline syenite for glass, enamel, fibre and other applications.

In 1973, total nepheline syenite shipments amounted to 576,000 short tons valued at $7.4 million, a tonnage increase of 3 per cent from 1972. Revenue from sales in 1973 showed an increase of 25 per cent over 1972, largely reflecting price increases during the year.

From 1950 to 1962, annual shipments increased from 65,000 to 250,000 tons, an average growth rate of 17 per cent a year. Between 1963 and 1968 a growth rate of 9 per cent was realized. This dramatic growth was due largely to recognition by glassmakers of the superior properties, consistent quality, long-term reliable supply, and low cost of nepheline syenite compared with feldspar. Sales were especially buoyant in 1968-69 because of a tight supply situation for feldspar in the United States. Upon return to more normal feldspar supply conditions in 1970, a minor decrease in nepheline syenite shipments occurred. Notwithstanding the recovery to former growth levels in 1972, shipments have since been constrained by strikes in both the glass industry and the railways, as well as by shortages of rail cars and raw materials such as soda ash, an essential constituent in glass.

International Minerals & Chemical Corporation (Canada) Limited, the sole Canadian producer of feldspar for several years, closed down operations at its mine at Buckingham, Quebec in mid-1972. As a result of substitution by nepheline syenite, output of feldspar has declined steadily from 55,000 tons in 1947 to 10,000 tons in 1961, a level that persisted throughout the 1960's and continues to be Canada's tonnage requirement. However, during 1973, a serious shortage of potash feldspar, for which there is, as yet, no acceptable substitute in the manufacture of high voltage electrical porcelain insulators, developed in both the United States and Canada. This situation was the result of strong demand in other consuming sectors, the untimely shutdown at Buckingham, and the universal shortage of rail cars. Several local producers of high-value dental spar had delivered small tonnages to IMC (Canada's) mill at Buckingham until the recent mill closure.

Centex, a joint university-industry-government body in Manitoba, initiated an investigation in 1971 into byproduct recovery of, and possible markets for, feldspar and other minerals from mining waste in the province. Tantalum Mining Corporation of Canada Limited, mines tantalum from a pegmatite containing abundant feldspar at Bernic Lake, Manitoba and the company is actively studying recovery and market potential of a clean quartz-feldspar product.

Other domestic occurrences

Nepheline syenite is known to occur in many localities in Canada, but to date, only the Blue Mountain deposit has proven to be amenable to mining and milling economically to produce material suitable for the glass and ceramic markets. Other occurrences are either too high in iron content or are too variable in chemical composition to allow large-scale open-pit development.

An extensive body of nepheline syenite outcrops in the Bancroft area of Ontario. Small tonnages of this material were mined from 1937 to 1942, but the product proved unacceptable because of considerable variation in the nepheline content and an over-abundance of iron-bearing accessory minerals. Tontine Mining Limited (now Coldstream Mines Limited) discontinued exploration work in 1971 on a large nepheline syenite intrusive located near Port Coldwell, Ontario, after obtaining discouraging results from petrologic and metallurgical studies.

Nepheline syenite occurs in several localities in southern British Columbia, notably in the Ice River area, near Field, and in the Big Bend area on the Columbia River.

Nepheline is a common mineral constituent in the alkaline complexes of northern Ontario and southern Quebec, but none of these deposits are, as yet, of economic significance.

Feldspar is the major mineral constituent of pegmatite dykes which are widely distributed in Canada. Any large deposit near potential markets warrants investigation.

Markets

In 1973, 78 per cent of Canada's nepheline syenite output was exported. Sales to the United States increased 5 per cent from 1971 and accounted for 97.5 per cent of total exports.

Canadian offshore sales were 11,021 short tons in 1973, about half that of 1972, reflecting growing penetration of the European market by Norwegian nepheline syenite. Britain, France and Australia together accounted for just over half of Canada's sales to this market.

Domestic shipments increased 5 per cent to an estimated 127,500 tons in 1973 or approximately 20 per cent of producers' shipments. Of this, 60 per cent was used in glass and glass fibre manufacture. Consumption in whiteware manufacture continued to increase, and a substantial expansion in use as a filler in paints, plastics and other applications occurred.

For use in the glass industry, about 15 to 20 per cent by weight of the glass batch is nepheline syenite. Material with a size range of minus 30 mesh to plus 200 mesh and with an iron content of less than 0.1 per cent is required in the production of flintglass. An iron content as high as 0.6 per cent expressed as Fe_2O_3 is allowable for the manufacture of coloured glass. A typical chemical analysis for high-quality nepheline syenite produced in Canada for glass manufacture is:

Silica SiO_2	–	60.00
Alumina Al_2O_3	–	23.60
Iron Fe_2O_3	–	0.07
Lime CaO	–	0.30

Magnesia MgO	–	0.10
Potash K_2O	–	5.30
Soda Na_2O	–	10.20
Loss-on-ignition	–	0.50

A growing market is developing for finely ground material in the whiteware industry. The finer grades used for ceramic applications are produced by reducing the basic minus 30 mesh material in pebble mills. In ceramics, nepheline syenite is used as both a body and glaze ingredient. High-purity material in the minus 200 – plus 375 mesh size and with an iron content of 0.07 per cent Fe_2O_3 or less is most frequently used. Products utilizing this material include bathroom fixtures, vitreous enamels for appliances, china, ovenware, electrical porcelain and ceramic artwares.

Very finely ground material is being increasingly used as a filler in plastics, foam rubber and paints. Fine-grinding down to 10 microns is accomplished in pebble and fluid-energy mills. The very fine grain size, high reflectance and low oil absorption are important physical characteristics which make nepheline syenite an excellent filler co-material in such finished products as paints, vinyl furniture upholstery, foam rubber cushions, foam rubber carpet backings, and floor and wall tile.

A low-grade nepheline syenite is sold in bulk for use in the manufacture of fibre glass and for glazing on brick and tile. Some material with iron content is used in the manufacture of mineral wool and as an aggregate.

Substitution of alternative materials for feldspar in ceramic manufacture has been less severe than in the manufacture of glass. The principal reason is that raw material costs are low in the ceramic industry in relation to total manufacturing costs and manufacturers adopt a new raw material only after cautious trial use and extensive evaluation. Further, while the higher alumina content of nepheline syenite has been a decisive factor in the replacement of feldspar in glass manufacture, a high alumina content is less critical in ceramic manufacture. In ceramics, potash feldspar is used to bind the ceramic mix into what the industry terms a "body" and in the manufacture of electric porcelain for high voltage purposes this mineral is essential. The domestic market for feldspar appears to have bottomed at around 10,000 tons a year.

Table 2. Canada, nepheline syenite production and exports, 1964-73

	Production[1]	Exports
	(short tons)	
1964	290,300	226,971
1965	339,982	247,200
1966	366,696	263,624
1967	401,601	307,613
1968	426,595	323,182
1969	500,571	395,613
1970	486,667	387,947
1971	517,190	404,240
1972	559,483	438,405
1973^p	576,000	448,459

Source: Statistics Canada.
[1]Producers' shipments.
^{p}Preliminary.

Table 3. Canada, feldspar production and trade, 1964-73

	Production[1]	Exports	Consumption
		(short tons)	
1964	9,149	3,386	7,493
1965	10,904	3,746	8,338
1966	10,924	3,419	8,528
1967	10,394	..	8,571
1968	10,620	..	7,343
1969	12,385	..	7,635
1970	10,656	..	7,540
1971	10,774	..	8,854
1972	11,684	..	9,651
1973^p	–	..	..

Source: Statistics Canada.
[1]Producers' shipments.
^{p}Preliminary; .. Not available; – Nil.

World review

The Norsk Nefelin Division of Christiania Spigerwerk is western Europe's only producer of nepheline syenite. Operations at the plant near Hammerfest in northern Norway began in 1961 and increased steadily from an output of 23,000 metric tons in 1963 to 200,000 metric tons in 1973. The latest expansion, completed in 1973, raised capacity from 175,000 to 225,000 metric tons a year. The lenticular deposit is over one mile long and at least 750 feet deep. Unlike Canadian producers, Norsk Nefelin mines underground, drilling and blasting by conventional techniques. Nepheline syenite is supplied to the glass, ceramic and enamel industries in two main grades; glass grade is about 28 Tyler mesh and ceramic grade 200 Tyler mesh. The finer-mesh ceramic grade material is usually shipped in bags whereas the coarser glass grade is shipped in bulk to European markets. The company employs a modern fleet of coasters on

Table 4. Canada, feldspar production, 1972-73, consumption 1971-72

	1972		1973[p]	
	(short tons)	($)	(short tons)	($)
Production[1]	11,684	232,383	–	–

Consumption[2] (available data)

	1971	1972
	(short tons)	
Whiteware	7,154	8,530
Porcelain enamel	244	288
Soaps and cleaning compounds	537	542[e]
Other[3]	919	291
Total	8,854	9,651

Source: Statistics Canada.
[1]Producers' shipments.
[2]Breakdown by Mineral Development Sector.
[3]Includes artificial abrasives, electrical apparatus, glass, paper and other minor uses.
[p]Preliminary; – nil; [e]Estimated.

long-term charter, and ships finished products to storage and distribution centres in major market areas.

Nepheline syenite is an important source of alumina for aluminum production in the U.S.S.R. Very large deposits occur near Kirovsk in the Kola Peninsula and also in the Lake Baikal region of Siberia. The Kola deposits were first mined in the 1930's for phosphate. Byproduct nepheline that contains 30 per cent Al_2O_3 is recovered for use in aluminum production. In the process used to extract alumina, limestone is added to the syenite and the mix is treated to yield anhydrous alumina, soda, potash and cement. Aluminum producers elsewhere in the world, faced with rising bauxite prices and concern for raw material supply, are viewing with interest potential alternate domestic sources of alumina, such as nepheline syenite.

Feldspar still retains a major share of its traditional markets outside of North America, although Norwegian nepheline syenite is rapidly making headway in these markets. World production of feldspar declined 5 per cent to 2.5 million short tons.

Outlook

The outlook for nepheline syenite continues to be good, although current softness in the world economy will likely moderate growth in 1974 and possibly 1975. Housing starts are expected to be down as much as 30 per cent in 1974 with no significant recovery until well into 1975. This industry, of course, is a major consumer of glass, sanitaryware, paint, etc. Canadian shipments to Europe declined further under competition from Norwegian nepheline syenite. European sales account for less than 5 per cent of Canada's total sales and, therefore, will have little effect on over-all developments in the industry.

The market for micronized material used as a filler and extender in plastics, paint, rubber, paper, etc., has grown more rapidly than consumption for glassmaking and further diversification and growth of these markets is expected.

The phenomenal growth-rate enjoyed by the nepheline syenite industry during the 1950's and early 60's has moderated as markets formerly supplied by feldspar approach saturation. The near-term hiatus in growth is a temporary one, and with the recovery of the glass industry and continued expansion of other uses, a growth rate of 7 per cent a year is anticipated for the medium-term.

With increasing electrical energy requirements, the demand for essential feldspar coupled with the decline in North American production, elevates this raw material to a position of prime importance. The present slackness in the economy has eased these pressures temporarily, but rising prices and growing markets could provide an opportunity to develop a suitable Canadian deposit in the near future.

Prices and tariffs

Nepheline syenite prices vary from low-purity, crushed rock in bulk, at $5.40 a ton, to $29 a ton for high-purity products. The price of nepheline syenite

Table 5. World production of feldspar, 1972-73

	1972	1973[e]
	(short tons)	
United States	732,000	704,000
West Germany	337,000	320,000
U.S.S.R.	287,000	300,000
Italy	194,000	175,000
Norway	165,000	150,000
France	146,000	125,000
Japan	64,000	55,000
Sweden	35,000	35,000
Other countries	675,000	650,000
Total	2,635,000	2,514,000

Source: U.S. Bureau of Mines Commodity Data Summaries, January 1974.
[e]Estimated.

used in the glass industry is around $14 a ton fob plant. The largest export market is the United States where entry is duty-free.

Feldspar prices vary between $14.00 and $27.00 a ton fob mill depending on grade and grain size.

Prices

United States feldspar prices in U.S. currency as quoted in Engineering and Mining Journal of December 1973
(per short ton, fob mine or mill, carload lots, depending on grade)

	($)
North Carolina	
40 mesh, flotation	14–21
20 mesh, flotation	13
200 mesh, flotation	22.50–23.50
325 mesh, flotation	27
Georgia	
200 mesh	25.50
325 mesh	26.50
40 mesh, granular	21
Connecticut	
200 mesh	23.50
325 mesh	24.50
20 mesh, granular	16.50

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
29600–1	Feldspar, crude	free	free	free
29625–1	Feldspar, ground but not further manufactured	free	7½%	30%

United States

Item No.		On and After January 1 1970	1971	1972
522.31	Feldspar, crude	5¢ per ton	2¢ per ton	free
522.41	Feldspar, crushed ground or pulverized	5%	4%	3.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1972) TC Publication 452.

Nickel

M.J. GAUVIN

Canadian mine production of nickel increased to 268,908 tons* valued at $785.2 million from 258,987 tons valued at $717.5 million in 1972. This reversed the downtrend of the previous two years in both quantity and value. World mine production is estimated at 723,169 tons in 1973 compared with 690,542 tons in 1972.

Canada maintained its position as the leader in world nickel production in 1973, accounting for about 37 per cent of the total. The U.S.S.R., with about 18 per cent of production, and New Caledonia, with an estimated 16 per cent of world output, were the two next largest producers.

After being depressed in 1971, and part of 1972, the nickel market began to improve in the latter half of 1972 as the major economies picked up and this improvement continued throughout 1973. Consumption of nickel in the noncommunist world was about 560,000 tons; the comparable usage in 1972 was 470,000 tons. This trend is expected to continue in 1974.

The large inventories that had been accumulated by major nickel producers in the noncommunist world were gradually reduced to a normal supply position by the end of 1973.

There was no general nickel price increase during 1973. All prices were maintained during the year except for nickel oxide sinters which were increased by 3 cents a pound in July.

Canadian operations and developments

Eight companies mined nickel ores in four provinces and one territory during 1973. By far, the largest producer The International Nickel Company of Canada, Limited (Inco), which operated mines in Ontario and Manitoba. Falconbridge Nickel Mines Limited, the second largest producer, treated ores from its mines also located in the same provinces. In addition to Ontario and Manitoba, a small amount of nickel ore was mined in Quebec, British Columbia and the Yukon Territory. Inco, Falconbridge, and Sherritt Gordon Mines, Limited each have integrated mine-concentrator-smelter-refinery complexes where ore is processed to the metal stage.

Three new nickel-copper mines commenced operation in 1973. One belongs to Falconbridge, one to Inco and one is a joint Noranda Mines Limited-Inco venture. One mine closed during the year because ore reserves were depleted.

The International Nickel Company of Canada, Limited is the world's largest producer of nickel. Deliveries in 1973 of 258,515 tons of nickel accounted for over 46 per cent of consumption in the noncommunist world. The company operated twelve mines, five concentrators, two smelters and a nickel refinery in the Sudbury district, a mine and concentrator at Shebandowan, northwestern Ontario, and a nickel refinery and additives plants at Port Colborne, Ontario. In Manitoba, Inco operated three mines, one concentrator, one smelter and a nickel refinery at Thompson. At Copper Cliff (now amalgamated with Sudbury) Inco commenced production at its new nickel refinery. The new refinery is expected to reach its full designed annual capacity of 50,000 tons of nickel pellets and 12,500 tons of nickel powder in 1974. The refinery uses Inco's top-blown rotary converter and pressure carbonyl process. The refinery produces pellets of 99.97 per cent nickel and powder of 99.8 per cent purity. Inco's mine production in 1973 was greater than that of 1972 but, at the end of 1973, two mines in Ontario, the Totten and Murray, and also the Soab in Manitoba were still being maintained on a standby basis. The new 1,250-foot stack completed in 1972 to serve Inco's copper and nickel smelting operations at Sudbury operated effectively during 1973.

Falconbridge Nickel Mines Limited had record nickel deliveries of 48,704 tons during the year. Falconbridge operates eight mines, three concentrators and one smelter in the Sudbury area of Ontario. The Manibridge project, a mine and concentrator operation located near Wabowden, Manitoba, was brought into production by Falconbridge during 1971. Concentrates produced at Manibridge are smelted at Falconbridge. The Falconbridge smelter produces a nickel-copper matte which is shipped to the company's refinery in Norway. The Onaping mine provided its own ventilation and back-fill services which were formerly provided by the Hardy-Boundary mines. The Boundary mine ceased production during the year when its ore reserves were exhausted. Mining of the Hardy open pit commenced during the year. This operation is designed to recover the mine's crown pillar which will complete the mining on this property.

At Falconbridge's Manibridge operation in northern Manitoba, production continued to be restricted because of ground control problems and a shortage of skilled labour. A new tight cut-and-fill mining system initiated during the year resulted in better ground control and reduced interruptions to production.

(text continued on page 324)

*The short ton of 2,000 pounds is used throughout unless otherwise stated.

Table 1. Canada, nickel production, trade, and consumption, 1972-73

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Production[1]				
All forms				
Ontario	189,427	519,935,356	195,958	565,065,000
Manitoba	66,227	188,084,016	70,280	211,976,000
Yukon Territory	1,407	3,996,762	1,270	3,888,000
British Columbia	1,620	4,601,486	1,000	3,060,000
Quebec	306	867,485	400	1,224,000
Total	258,987	717,485,105	268,908	785,213,000
Exports				
Nickel in ores, concentrates and matte and speiss[2]				
Norway	46,917	111,756,000	45,997	124,362,000
Britain	52,200	145,780,000	37,545	112,691,000
Japan	12,127	27,525,000	16,615	41,402,000
United States	88	187,000	228	232,000
Total	111,332	285,248,000	100,385	278,687,000
Nickel in oxide				
United States	27,854	65,475,000	40,416	97,344,000
Belgium and Luxembourg	4,308	10,579,000	7,837	18,777,000
Britain	2,131	5,113,000	5,010	12,253,000
Italy	–	–	4,186	10,018,000
Sweden	729	1,852,000	2,794	6,567,000
Australia	858	2,073,000	2,628	6,408,000
Other countries	756	1,853,000	2,948	7,388,000
Total	36,636	86,945,000	65,819	158,755,000
Nickel and nickel alloy scrap				
United States	1,694	1,928,000	1,626	2,396,000
Italy	96	283,000	313	941,000
South Korea	5	9,000	222	590,000
Japan	254	578,000	142	393,000
Other countries	83	127,000	108	189,000
Total	2,132	2,925,000	2,411	4,509,000
Nickel anodes, cathodes, ingots, rods				
United States	94,760	232,053,000	82,595	211,619,000
People's Republic of China	6,188	15,927,000	24,850	73,514,000
Britain	9,392	22,723,000	15,733	39,126,000
Japan	3,363	9,228,000	5,037	15,658,000
Taiwan	888	2,415,000	2,446	7,544,000
Australia	1,042	2,812,000	1,764	5,473,000
India	638	1,686,000	1,454	4,555,000
Brazil	720	2,044,000	1,044	3,275,000
Italy	1,223	3,593,000	693	2,153,000
South Korea	76	220,000	490	1,533,000
Mexico	374	1,048,000	402	1,265,000
Argentina	323	886,000	333	1,050,000
Other countries	1,913	5,067,000	1,126	3,585,000
Total	120,900	299,702,000	137,967	370,350,000

Table 1. (cont'd)

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Exports (cont'd)				
Nickel and nickel alloy, fabricated material, nes				
United States	2,833	8,542,000	4,189	12,804,000
Britain	235	716,000	1,732	4,337,000
Italy	307	856,000	357	1,069,000
Netherlands	557	2,006,000	222	911,000
Australia	1	7,000	240	718,000
Japan	78	231,000	91	312,000
New Zealand	5	20,000	121	213,000
Other countries	551	1,732,000	344	995,000
Total	4,567	14,110,000	7,296	21,359,000
Imports				
Nickel in ores, concentrates and scrap				
French Oceania	4,730	8,919,000	2,714	5,302,000
Australia	9,859	18,435,000	2,269	4,636,000
United States	6,426	6,105,000	3,896	4,211,000
Britain	3,020	2,006,000	3,588	2,964,000
Belgium and Luxembourg	115	117,000	154	112,000
Other countries	238	294,000	103	92,000
Total	24,388	35,876,000	12,724	17,317,000
Nickel anodes, cathodes, ingots, rods				
Norway	17,770	50,446,000	13,567	43,714,000
U.S.S.R.	–	–	1,504	4,196,000
Britain	–	–	500	1,546,000
United States	156	485,000	343	969,000
Other countries	74	218,000	227	676,000
Total	18,000	51,149,000	16,141	51,101,000
Nickel alloy ingots, blocks, rods and wire bars				
United States	472	1,618,000	1,163	2,473,000
Belgium and Luxembourg	–	–	1	6,000
West Germany	–	–	...	3,000
Other countries	28	106,000	–	–
Total	500	1,724,000	1,164	2,482,000
Nickel and alloy plates, sheet strip and flat products				
United States	2,408	8,185,000	2,073	7,478,000
Britain	3	20,000	698	2,776,000
Other countries	69	239,000	43	119,000
Total	2,480	8,444,000	2,814	10,373,000

Table 1. (concl'd)

	1972		1973p	
	(short tons)	($)	(short tons)	($)
Imports (cont'd)				
Nickel and nickel alloy pipe and tubing				
United States	455	3,770,000	540	4,528,000
West Germany	86	733,000	140	838,000
Other countries	12	42,000	7	29,000
Total	553	4,545,000	687	5,395,000
Nickel and alloy fabricated material, nes				
United States	237	1,185,000	382	1,658,000
Britain	154	738,000	115	555,000
West Germany	9	39,000	15	77,000
Other countries	160	441,000	2	9,000
Total	560	2,403,000	514	2,299,000
Consumption[3]	10,187	. .	11,862	. .

Source: Statistics Canada.
[1] Refined nickel and nickel in oxides and salts produced, plus recoverable nickel in matte and concentrates exports. [2] For refining and re-export. [3] Consumption of nickel, all forms (refined metal and in oxide and salts) as reported by consumers.
p Preliminary; – Nil; nes Not elsewhere specified; . . . Less than one thousand pounds; . . Not available.

The third largest Canadian nickel producer is Sherritt Gordon Mines, Limited. Sherritt Gordon continued to operate its Lynn Lake, Manitoba, nickel-copper mine and concentrator, but the trend to decreased ore production and grade, which began a few years ago, was evident in 1973 and is likely to continue. Lynn Lake concentrates are shipped to the Sherritt Gordon hydrometallurgical refinery in Fort Saskatchewan, Alberta. Nickel production of 15,131 tons at the refinery in 1973 was 18 per cent below the level of 1972. Supplies of concentrates from Lynn Lake and matte shipments from Western Mining Corporation Limited in Australia, fell far short of the forecast quantity. The refinery is not expected to operate at capacity until some time in 1975. Contract arrangements for purchased feed and toll-refined feed assures the company of a constant flow of smelter feed for the following five years.

Renzy Mines Limited suspended operations in 1972 at its open-pit mine in Quebec when the smelter contract with Falconbridge was terminated. No alternative market was found in 1973 for the Renzy nickel-copper concentrate. Société Minière d'Exploration Somex ltée operated its small nickel-copper deposit at Lac Edouard, Quebec, throughout 1973; however, production ceased in January 1974 when fire destroyed its 250-ton-a-day concentrator.

The Langmuir mine near Timmins, Ontario, began operations in June 1973 and its nickel concentrates are shipped to Copper Cliff. It is owned 51 per cent by Noranda and 49 per cent by Inco. Kanichee Mining Incorporated completed construction of a plant at its open-pit operation at Temagami, Ontario. A small amount of tune-up work was done in the 500-ton-a-day mill in preparation for production in 1974.

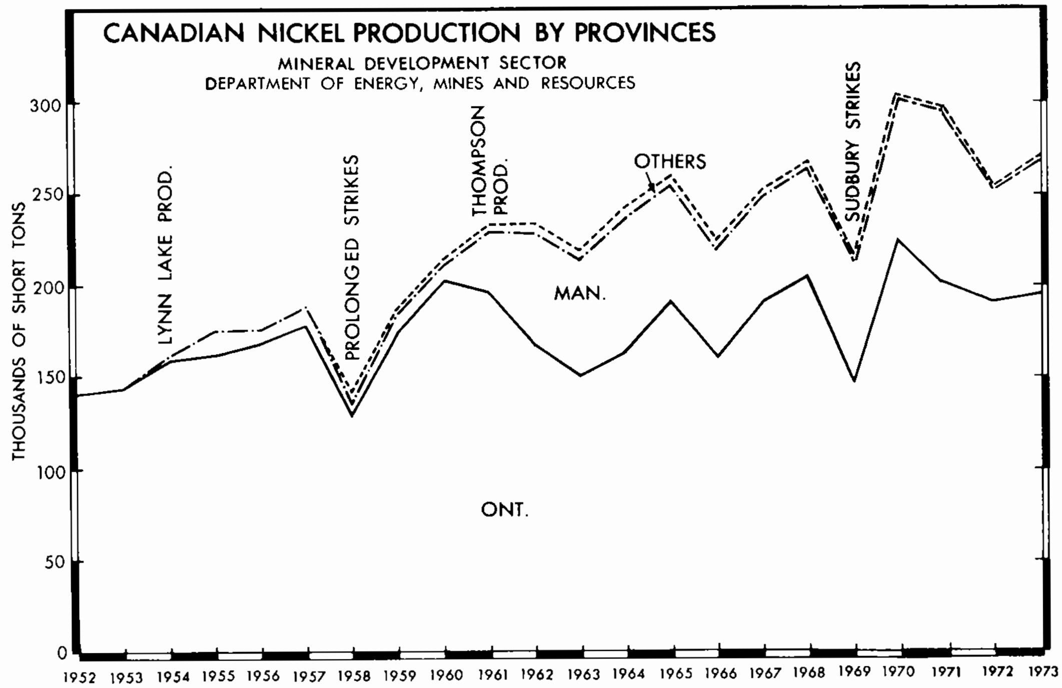


Table 2. Canada Nickel, production, trade and consumption, 1964-73

		Exports					
	Production[1]	In Matte etc.	In Oxide Sinter	Refined Metal	Total	Imports[2]	Consumption[3]
			(short tons)				
1964	228,496	74,766	35,800	128,330	238,896	10,444	6,899
1965	259,182	82,327	40,956	135,197	258,480	12,172	8,924
1966	223,610	83,586	33,631	132,712	249,929	28,916	8,608
1967	248,647	83,662	34,204	128,659	246,525	9,557	8,767
1968	264,358	95,527	42,058	127,095	264,680	11,394	11,233
1969	213,612	76,976	29,009	104,243	210,228	12,601	12,094
1970	305,881	96,659	43,895	153,203	293,757	11,826	11,794
1971	294,341	116,493	42,755	125,479	284,727	14,066	8,583
1972	258,987	111,332	36,636	120,900	268,868	18,000	10,187
1973[p]	268,908	100,385	65,819	137,967	304,171	16,141	11,862

Source: Statistics Canada.
[1] Refined metal and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates exported. [2] Refined nickel, comprising anodes, cathodes, ingots, rods and shot. [3] Consumption of nickel, all forms (refined metal, and in oxides and salts), as reported by consumers.
[p] Preliminary.

Table 3. Producing Canadian nickel mines, 1973 and (1972)

Company and Location	Mill or Mine Capacity	Grade of Ore: Nickel	Grade of Ore: Copper	Ore Produced	Contained Nickel Produced	Remarks
	(ton ore/day)	(%)	(%)	(tons)	(tons)	
Quebec						
Renzy Mines Limited, Hainault Township	1,000 (1,000)	– (0.49)	– (0.58)	– (63,630)	– (202)	Smelter contract terminated and mine closed April 4, 1972.
Société Minière d'Exploration Somex ltée, Bickerdike Township, Lac Edouard	250 (250)	1.5 (. .)	0.5 (. .)	90,000 (. .)	413 (. .)	Production ceased in January 1974 due to a fire and depletion of ore reserves.
Ontario						
Consolidated Canadian Faraday Limited, Werner Lake Division, Gordon Lake	1,200 (1,200)	– (0.78)	– (0.37)	– (56,696)	– (345)	Mine closed in August 1972 because ore reserves exhausted. Custom mills ore from Dumbarton Mines Limited.
Falconbridge Nickel Mines Limited, East, Falconbridge, Fecunis Lake, Hardy-Boundary, Longvack South, North, Onaping and Strathcona mines, mine, Falconbridge	13,600 3,000 (Falconbridge) 6,600 (Strathcona) 2,500 (Fecunis Lake) 1,500 (Hardy – not operating)	. . . .	. . . .	4,292,900 (4,199,000)	48,704[1] (44,832)[1]	Boundary mine mined out in November 1974. Hardy pit mining commenced. Hardy concentrator closed in 1972. Lockerby property being prepared for production.
The International Nickel Company of Canada, Limited, Clarabelle, Coleman, Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood-Stobie, Garson, Kirkwood, Levack, Levack West, Little Stobie, Murray, Totten, and Victoria mines, Subdury	65,000 35,000 (Clarabelle) 24,000 (Frood-Stobie) 6,000 (Levack)	. . . .	. . . .	15,966,093 (15,894,577)[3]	258,515[2] (212,540)[2]	Production from Victoria mine began in 1973. Plan to reopen Crean Hill mine in 1974.
Shebandowan mine, Shebandowan	2,500 (2,500)	. . . .	. . . . .	594,933 see above[3]	see above[2] see above[2]	Completed first full year of production in 1973.

Ontario (cont'd)						
Noranda Mines Limited, Langmuir Township	700 –	. . –	. . –	67,020 –	730 –	Concentrator started in June 1973. Ore reserves are 1.5 million tons averaging 1.72% nickel.
Texmont Mines Limited, Bartlett and Geikie Townships, Timmins	500 (500)	– (0.88)	– (–)	– (126,506)	– (756)	Mine closed December 1972 but remains unwatered ready to resume operations.
Manitoba						
Dumbarton Mines Limited, Bird River	– –	0.76 (0.86)	0.30 (0.28)	331,851 (325,766)	2,053 (2,252)	Ore trucked to the Consolidated Canadian Faraday concentrator. New F zone established.
Falconbridge Nickel Mines Limited, Manibridge mine, Wabowden	1,000 (1,000)	. . (. .)	. . (. .)	135,716 (166,399)	see above[1] see above[1]	New tight cut-and-fill mining method initiated for better ground control.
The International Nickel Company of Canada, Limited, Birchtree, Pipe, Soab and Thompson mines, Thompson	18,400 (18,400)	(. .) (. .)	(. .) (. .)	3,444,210 (3,043,648)	see above[2] see above[2]	No production from the Soab mine which is being maintained on a standby basis.
Sherritt Gordon Mines, Limited, Lynn Lake	3,500 (3,500)	0.84 (0.67)	0.39 (0.38)	675,907 (995,000)	4,270 (5,177)	Production from Lynn Lake mine continues to decrease.
British Columbia						
Giant Mascot Mines Limited, Hope	1,800 (1,800)	0.58 (0.68)	0.24 (0.38)	352,758 (389,894)	1,306 (1,966)	Continuing exploration from new ore zones. Possible suspension of operations in 1974.
Yukon Territory						
Hudson-Yukon Mining Co., Limited, Wellgreen mine, Kluane Lake	600 (600)	2.49 (2.05)	1.45 (1.35)	76,760 (112,451)	1,446 (1,840)	Mine closed in July 1973 because of discontinuity and irregularity of the orebody.

Source: Corporate annual reports and data provided by companies.
[1]Includes Manibridge. [2]Total nickel deliveries. [3]Includes Shebandowan.
. . Not available; – Nil.

Table 4. Nickel exploration projects

Company and Location	Indicated Ore	Grade of Ore	Remarks
	(tons)	(%)	
Quebec			
Dumond Nickel Corporation, Launey Township	15,500,000	0.646(Ni)	Ore reserves are for No. 1 orebody, feasibility study recommends putting the property into production at a rate of 4,500 tpy at a cost of $14 million. Agreement made with Canex Placer Limited and Timiskaming Nickel Limited for development of the orebody. Bulk samples taken for metallurgical testing.
Expo Ungava Mines Limited, Ungava	18,500,000	0.47(Ni) 0.52(Cu)	No work done on property during 1973. Located 10 miles south of property of New Quebec Raglan Mines Limited.
New Quebec Raglan Mines Limited, Ungava	16,050,000	2.58(Ni) 0.71(Cu)	No work was done on the property in 1973. The company is studying report investigating the feasibility of bringing the property into production at a rate of 1,500 tons per day.
Ontario			
Great Lakes Nickel Limited, Pardee Township	106,000,000	0.20(Ni) 0.40(Cu)	Under agreement with Boliden Aktiebolag, underground exploration, metallurgical studies and feasibility study completed to bring property into production at 1.8 million tpy.
The International Nickel Company of Canada, Limited, Sudbury, Cryderman, North Range, Victoria and Whistle mines	. .	. . (Ni) . . (Cu)	
Union Minière Explorations and Mining Corporation Limited, Pickle Crow	10,000,000	0.20(Ni) 1.60(Cu)	Exploration shaft completed to a depth of 1,780 feet. Lateral development and exploration work started on three levels.
Manitoba			
Bowden Lake Nickel Mines Limited, Wabowden,			
Bowden Lake mine	80,000,000	0.60(Ni)	Underground exploration in 1972.
Bucko Lake mine	30,000,000	0.78(Ni)	Feasibility studies continued in 1973.
Saskatchewan			
National Nickel Ltd. and Cadillac Explorations Limited, Nemeiben Lake, La Ronge	5,476,000	0.34(Ni) 0.18(Cu)	Open-pit reserves
	1,754,500	0.38(Ni) 0.70(Cu)	Underground reserves

Sources: Corporate annual reports and technical press.
. . Not available.

World developments

World mine production of nickel increased from 690,542 tons in 1972 to an estimated 723,169 tons in 1973. Most producers increased production to supply the strong demand in 1973, and which was expected to continue during 1974.

Falconbridge Dominicana, C. por A. completed its first full year of ferronickel production from laterite ores in 1973. Production in 1973 was 33,150 tons of nickel contained in ferronickel compared with 19,192 tons in 1972. Production of nickel at the Dominican Republic complex exceeded its design capacity of 31,500 tons.

In Botswana, Bamangwato Concessions Ltd. continued to prepare its Pikwe nickel-copper sulphide mine and flash smelter for early 1974 production. Nickel-copper matte from the smelter is to be toll-refined at the American Metal Climax, Inc. Port Nickel refinery in Braithwaite, Louisana, U.S.A. Annual output from the Pikwe project is expected to be 2 million tons of ore from which will be derived 50,000 tons of nickel-copper matte containing 18,700 tons of nickel and 17,000 tons of copper. The modernized Port Nickel refinery, which is designed to have an annual capacity of 40,000 tons of nickel, will produce nickel powder and briquettes, copper powder, briquettes and wire bar, and other associated byproducts.

Marinduque Mining and Industrial Corporation, in which Sherritt Gordon Mines, Limited has a 10 per cent interest, is proceeding with construction of its nickel complex in the Philippines. This will be the first commercial plant to use the Sherritt Gordon nickel laterite process. Design capacity of the project is 34,500 tons of nickel powder and briquettes, 3,300 tons of nickel in mixed sulphides and 1,650 tons of cobalt a year. Cuba has announced plans to modernize its two existing nickel plants at Moa Bay and Nicaro, thus assuring a continuing supply of about 40,000 tons of Cuban nickel a year. It has also announced plans to triple production with the addition of three new nickel plants by 1985. U.S.S.R. and COMECON countries are to provide financing for the Cuban expansion. On the island of New Caledonia the only producer, Société Le Nickel, has expanded production facilities and now has an installed annual smelter capacity of some 77,000 tons of nickel. At the end of 1973, Patino, N.V. through its subsidiary, Compagnie Française d'Entreprises Minières, Métallurgiques et d'Investissements (COFREMMI), began construction at the Poum deposit in the northern part of New Caledonia. When completed in 1976, the plant will have an annual capacity of 20,000 tons of nickel contained in ferronickel.

The International Nickel Company of Canada, Limited has two foreign laterite projects that it is planning to place in production during the second half of the decade. One of these is in Guatemala, where Inco, through Exploraciones y Explotaciones Mineras Izabal, S.A. (Exmibal) plans to start construction in 1974 on the Lake Izabal laterite deposit project. This multiphase development will include a smelter with an annual capacity of 14,000 tons of contained nickel in a sulphide matte. In Indonesia, P.T. International Nickel Indonesia expects the first stage of the development of the Malii – Soroaka deposits on Sulawesi Island, Indonesia to be completed in 1976. The company intends to ship all of the Indonesian output, some 17,500 tons of nickel a year contained in matte, to Japanese refineries. Discussions are in progress to finance a second stage which, when completed, would raise capacity to about 40,000 tons a year.

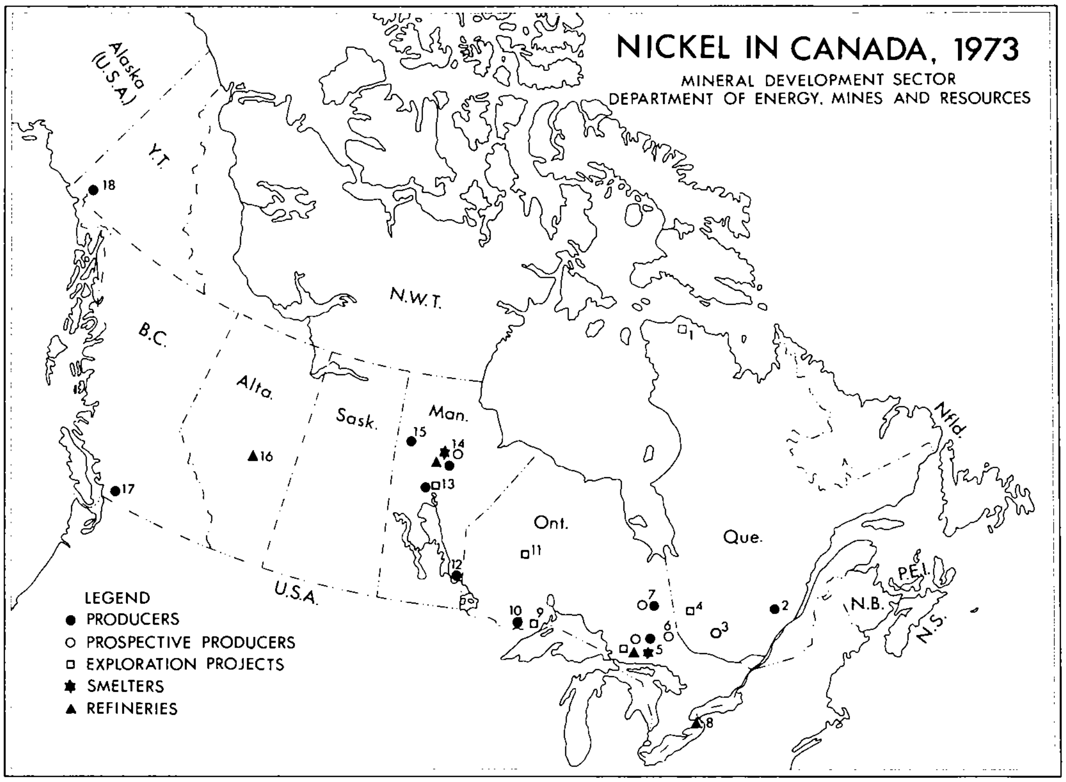
Two new sulphide mines have been slated for production in Western Australia. The Redross mine is being prepared for mining in late 1974. Ore will be toll-milled at Kalgoorlie and the concentrate is to be shipped to Sherritt Gordon's refinery in Canada. Initial production will provide 5,000 tons of nickel annually. The company is also studying the feasibility of building a smelter and refinery in Australia to treat the concentrates. Poseidon N.L. in a joint venture with Western Mining Corporation Limited is developing its Windarra orebody. A revised program calls for annual production of 12,000 tons of nickel to begin in late 1974. Western Mining will smelt the Windarra concentrate and half of the resulting matte will be purchased by Sherritt Gordon. Western Mining's new flash smelter, commissioned in 1972, has an annual capacity of 200,000 tons of nickel concentrates. Although Selection Trust Limited has not announced a production schedule for its Agnew deposit, development will likely begin soon. Ore reserves are currently reported at 33 million tons of about 2 per cent nickel. Construction at the Greenvale lateritic nickel project in Queensland, a joint venture of Freeport Minerals Company and Metals Exploration N.L., is expected to be completed in late 1974. Projected output is estimated at 23,000 tons of nickel oxide sinter 90 and 1,350 tons of cobalt metal. Ore reserves are estimated at 44 million tons of 1.57% nickel.

Uses

Nickel uses have not changed appreciably from the traditional pattern. Resistance to corrosion, high strength over a wide temperature range, pleasing appearance and suitability as an alloying agent are the chief advantages in almost all the uses of nickel.

Stainless steel is the largest single usage for nickel, followed by nickel plating and high-nickel alloys. Stainless steel use has increased in the field of rapid transit and railway car manufacture, in fertilizer and food processing machinery, in petroleum refining and in architectural applications. High-nickel alloys are used in chemical, marine, electronic, nuclear and aerospace applications.

New end-use markets which will contribute to nickel's consumption growth are gas turbine engines for surface applications, cryogenic containers, nuclear generating plants and pollution abatement equipment.



Producers

(numbers appear on accompanying map)

2. Société Minière d'Exploration Somex ltée (Lac Edouard)
5. Falconbridge Nickel Mines Limited (East, Falconbridge, Fecunis Lake, Hardy-Boundary, Longvack South, North, Onaping and Strathcona mines)
   The International Nickel Company of Canada, Limited (Clarabelle, Coleman, Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood-Stobie, Garson, Kirkwood, Levack, Levack West, Little Stobie, Totten and Victoria mines)
7. Noranda Mines Limited (Timmins)
10. The International Nickel Company of Canada, Limited (Shebandowan mine)
12. Dumbarton Mines Limited (Bird River)
13. Falconbridge Nickel Mines Limited (Manibridge mine)
14. The International Nickel Company of Canada, Limited (Birchtree, Pipe and Thompson mines)
15. Sherritt Gordon Mines, Limited (Lynn Lake)
17. Giant Mascot Mines Limited (Hope)
18. Hudson-Yukon Mining Co., Limited (Wellgreen mine)

Prospective producers

3. Renzy Mines Limited. Suspended in 1972 (Hainault Township)
5. Falconbridge Nickel Mines Limited (Fraser, Lockerby, Onex and Thayer Linsley mines)
   The International Nickel Company of Canada, Limited (Crean Hill, Murray and Totten mines – suspended in 1971-72; Levack West mine)
6. Kanichee Mining Incorporated (Temagami)
14. The International Nickel Company of Canada, Limited (Soab mine)

Nickel exploration projects

1. New Quebec Raglan Mines Limited (Ungava) Expo Ungava Mines Limited (Ungava)
4. Dumont Nickel Corporation (Launay Township)
5. The International Nickel Company of Canada, Limited (Cryderman, North Range, Victoria and Whistle mines)
9. Great Lakes Nickel Limited (Pardee Township)
11. Union Minière Explorations and Mining Corporation Limited (Pickle Crow)
13. Bowden Lake Nickel Mines Limited (Bowden Lake and Bucko Lake mines)

Smelters

5. Falconbridge Nickel Mines Limited (Falconbridge)
   The International Nickel Company of Canada, Limited (Sudbury)
14. The International Nickel Company of Canada, Limited (Thompson)

Refineries

5. The International Nickel Company of Canada, Limited (Sudbury)
8. The International Nickel Company of Canada, Limited (Port Colborne)
14. The International Nickel Company of Canada, Limited (Thompson)
16. Sherritt Gordon Mines, Limited (Fort Saskatchewan)

Outlook

The nickel market is expected to continue the strong performance recorded in 1973. Noncommunist world consumption in 1974 should exceed the record 1973 level of 1,027 million pounds. Canadian production in 1974 is expected to be higher than that of 1973, but is not expected to surpass the record production of 611 million pounds reached in 1970.

The medium-term outlook is for steady growth in nickel consumption, at a compound rate of 6 to 7 per cent a year. New nickel projects scheduled for production in the next four years are more than adequate to meet medium-term demand and there should be ample supplies of nickel during the seventies.

With the widespread acceptance of the argon-oxygen furnace in stainless steel making, less pure forms of nickel, such as ferronickel, should be consumed at an increasing rate, partly at the expense of high-purity nickel and nickel oxide sinter. Intense marketing competition can be expected for most forms of nickel and should be particularly noticeable in the stainless steel market over the next several years.

Prices

During 1973, producer prices remained unchanged from prices set in September of 1972 except for Inco's sinter 75 and sinter 90 which were each raised 3 cents to $1.40 and $1.43 a pound of contained nickel, respectively. Some nickel was delivered in 1973 at the old mid-1972 price which was as much as 20 cents a pound below current prices.

Table 5. World production of nickel, 1972-73

	1972	1973[e]
	(short tons)	
Canada[1]	258,987	268,908
U.S.S.R.	132,277	132,277
New Caledonia	115,743	119,160
Australia	39,463	39,352
Cuba	35,274	35,274
Dominican Republic	19,180	26,455
Republic of South Africa	12,897	21,385
United States	16,865	16,976
Indonesia	15,543	16,535
Greece	12,456	13,889
Rhodesia	13,228	13,227
Finland	5,732	6,283
Brazil	3,968	3,968
Other	8,929	9,480
Total	690,542	723,169

Source: World Metal Statistics, June 1974. For Canada, Statistics Canada.
[1] Production all forms.
[e] Estimated.

United States nickel prices, quoted in Metals Week during 1973, in U.S. dollars per pound

	Cathode	F Shot*	Pellets	Sinter* 75	Sinter* 90	XX* Shot	Ferronickel*
Jan. 1 to July 19	1.530	1.430	1.530	1.370	1.400	1.410	1.380
July 20 to Dec. 31	1.530	1.430	1.530	1.400	1.430	1.410	1.380

*per pound of contained nickel

Nickel prices in 1973, as quoted in the Northern Miner

	U.S. $ effective Sept., 1972
Electrolytic nickel	
The International Nickel Company of Canada, Limited	
fob Port Colborne, Ont.	1.53 per lb
Falconbridge Nickel Mines Limited	
fob Thorold, Ont.	1.53 per lb
Briquettes or powder	
Sherritt Gordon Mines, Limited	
fob Niagara Falls, Ont.	
or Ft. Saskatchewan, Alta.	1.53 per lb
	effective July 20, 1973
Nickel oxide sinter	
90% Ni content	1.43 per lb of contained nickel
75% Ni content	1.40 per lb of contained nickel

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
35500-1	Nickel, and alloys containing 60% or more nickel by weight, not otherwise provided for, viz: ingots, blocks and shot; shapes or section, billets, bars and rods, rolled, extruded or drawn (not including nickel processed for use as anodes) strip, sheet and plate (polished or not); seamless tube	free	free	free
32900-1	Nickel ores	free	free	free
33506-1	Nickelous oxide	10	15	25
35505-1	Rods, containing 90% or more nickel, when imported by manufacturers of nickel electrode wire for spark plugs, for use exclusively in manufacture of such wire for spark plugs in their own factories	free	free	10
35510-1	Metal, alloy strip or tubing, not being steel strip or tubing, containing not less than 30% by weight of nickel and 12% by weight of chromium, for use in Canadian manufactures	free	free	20
35800-1	Anodes of nickel	free	free	10
35515-1	Nickel, and alloys containing 60% by weight or more of nickel, in powder form	free	free	free

Tariffs (concl'd)

Canada

35520-1	Nickel or nickel alloys, namely: matte, sludges, spent catalysts and scrap, and concentrates other than ores	free	free	free
44643-1	Articles of iron, steel or nickel, or of which iron, steel or nickel are the component materials of chief value, of a class or kind not made in Canada, when imported by manufacturers of electric storage batteries for use exclusively in manufacture of such storage batteries, in own factories	10	10	20
37506-1	Ferronickel	free	5	5

United States

Item No.				
601.36	Nickel ore	free		
603.60	Nickel matte	free		
620.03	Nickel, unwrought	free		

		On and After January 1		
		1970	1971	1972
		(¢ per pound)		
620.04	Nickel waste and scrap (duty suspended June 30, 1973)	0.5	0.2	free
620.30	Nickel flakes	7	6	5
620.32	Nickel powders	free	free	free
620.50	Nickel electroplating anodes, wrought and cast, of nickel	7%	6%	5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. United States, Tariff Schedules of the United States Annotated (1972) TC Publication 452.

At Inco's Clarabelle Mill at Sudbury, Ontario, 528 flotation cells separate mineral particles from the rock waste through the action of chemical reagents. The panels in the foreground control this automatic operation. (Inco photo).

Petroleum

W.G. LUGG

Substantial increases in the production of crude oil and natural gas, abetted by large increases in field prices, contributed to an increase of $1 billion in revenue for an all-time high of $3.2 billion. Expenditures at $1.9 billion also gained significantly. On the other hand, the life index (reserves to production ratio) for liquid hydrocarbons dropped to 12 years as combined proven reserves of crude oil and natural gas liquids declined for the fourth consecutive year.

Exploration activity in the frontier area was maintained and several exploratory wells in the Arctic regions were successful. Although none of the oil discoveries were commercially attractive, many of the gas finds showed promise of being major discoveries. The first exploratory oil success was recorded in 1973 on the Labrador Shelf. Operating conditions are extremely difficult in this area, but this factor should be offset by the favourable geological conditions and exploration will probably increase in the future.

Events on the world petroleum scene profoundly influenced developments in Canada's oil industry in 1973 and led to a series of government actions that are likely to have a long-range effect on future marketing patterns. Supply shortages and spiralling world crude oil prices, resulting from the actions of the Organization of Petroleum Exporting Countries (OPEC), prompted the Canadian government to introduce emergency legislation designed to arrest anticipated shortfalls in supply to Canadian consumers and stabilize rapidly rising petroleum product prices.

Canadian refinery capacity was increased by 127,000 barrels a day (bbl/day) in 1973 primarily by the addition of one large new refinery in Newfoundland. Future plans for major refinery expansion in the Maritime provinces, essentially to serve anticipated demand for petroleum products in the export market will now likely be influenced by the availability and price of offshore crude oil and therefore some modification of plans could result.

Pipeline construction remained at about the same level as in 1972, and gas plant construction declined considerably from the previous year, attributable partly to the lack of discovery of new reserves and partly to the restriction on gas removal permits, which are conditional on price improvement.

Production

Production of all liquid hydrocarbons – crude oil and natural gas liquids averaged 2,116,000 bbl/day during 1973, an increase of 277,000 b/d or 15 per cent over 1972. Crude oil output alone amounted to 1,793,000 million b/d; and natural gas liquids reached 326,000 b/d comprised of 170,000 b/d of pentanes plus and condensate, and 156,000 b/d of propane and butane. Alberta's production increased by 21 per cent to 1,484,000 b/d and accounted for 82 per cent of total Canadian crude oil production. Of this amount, synthetic crude oil production from the Athabasca tar sands contributed over 50,000 b/d during 1973. Saskatchewan's crude oil production declined by 1,800 b/d to 235,000 b/d in 1973, accounting for 13 per cent of the Canadian total. British Columbia's declined by 7,000 b/d to 58,000 b/d and represented 4 per cent of total national production. Manitoba accounted for 0.7 per cent; and Ontario, the Northwest Territories and New Brunswick together, 0.3 per cent. All provinces except Alberta were producing at capacity. The Alberta Energy Resources Conservation Board (AERCB) estimated that the 1972 adjusted wellhead capacity was 1.63 million b/d which meant that about 72 per cent of the province's capability was being utilized at the end of 1972. Alberta's production capability was almost utilized to capacity in 1973.

During the year, Great Canadian Oil Sands Limited (GCOS) received permission from the AERCB to increase its allowable production of synthetic crude oil to 65,000 b/d from its present allowable rate of 45,000 b/d, bringing the yearly production level to 23.7 million barrels. The Board's approval was prompted by Alberta's declining life index of conventional crude oil, and it conceded that there would be a ready market for increased production of synthetic crude oil. Proven reserves of open-cast mineable tar sands appear adequate to support about 20 plants of 100,000 to 150,000-barrels-a-day capacity. At the present time there are two firm proposals for major open-cast bituminous sands projects in Alberta. These are the Syncrude Canada Ltd. proposal which received final approval from the Alberta government in September, 1973, and the Shell Canada Limited's project on which final approval is still pending. Construction on the proposed 125,000 b/d Syncrude project is scheduled to commence in 1974 and be completed by 1978. Under the terms of the agreement, the Alberta government will receive 50 per cent of all profits in the form of royalty payments which are estimated to amount to $1 billion over the life of the project. In addition, the provincial crown corpora-

(text continued on page 338)

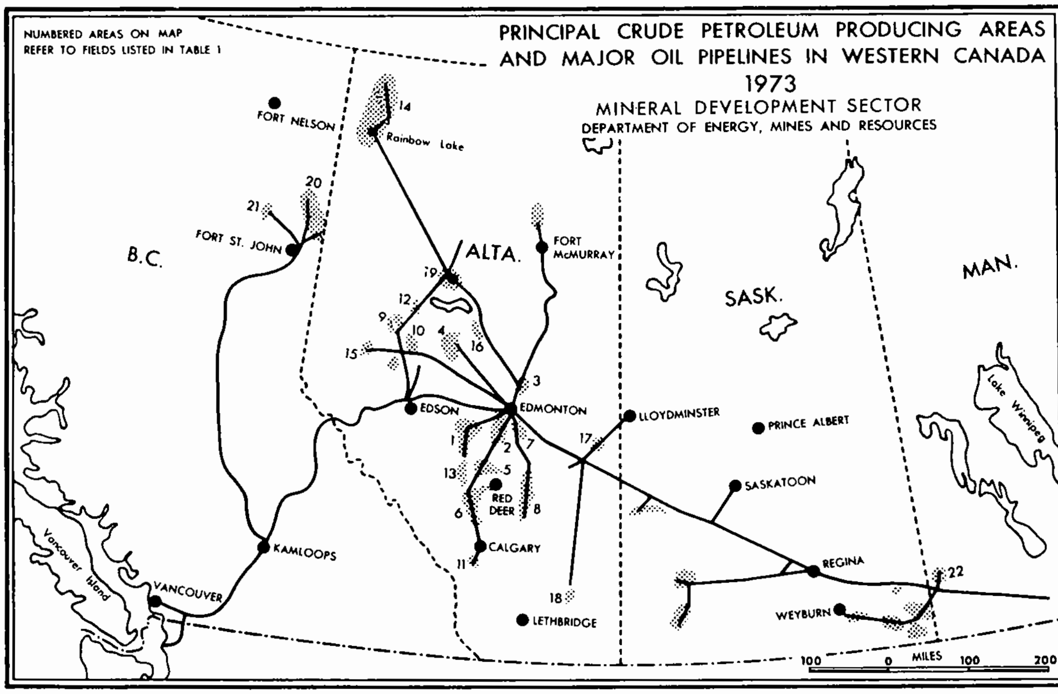


Table 1. Production of crude oil and condensate by province and field, 1972-73

(Number in parenthesis gives location of field on accompanying map)

	1972		1973^p	
	(barrels)	(bbl/day)	(barrels)	(bbl/day)
Alberta				
Swan Hills (4)	38,478,226	105,132	47,058,089	128,926
Pembina (1)	50,680,729	138,472	46,688,219	127,913
Redwater (3)	31,420,047	85,848	45,250,954	123,975
Rainbow (14)	29,380,584	80,275	35,908,669	98,380
Judy Creek	22,576,208	61,684	33,700,842	92,331
Bonnie Glen (2)	18,718,954	51,145	27,034,322	74,067
Wizard Lake (2)	17,482,568	47,767	22,931,225	62,825
Nipisi (19)	14,800,762	40,439	19,016,297	52,099
Mitsue (16)	15,480,751	42,297	18,163,616	49,763
Swan Hills South (4)	17,667,206	48,271	18,127,579	49,665
Golden Spike (2)	13,159,318	35,954	17,647,408	48,349
Fenn Big Valley (8)	9,926,906	27,123	11,266,238	30,866
Virginia Hills	7,700,961	21,041	9,864,672	27,026
Carson Creek North (4)	6,966,730	19,035	9,369,317	25,669
Leduc Woodbend (2)	7,453,623	20,365	8,981,388	24,607
Westerose (2)	5,588,629	15,269	7,462,662	20,446
Zama (14)	5,924,888	16,188	6,062,504	16,610
Kaybob (10)	5,181,156	14,156	5,900,234	16,165
Sturgeon Lake South	5,724,469	15,641	5,442,336	14,911

Table 1 (cont'd)

	1972		1973p	
	(barrels)	(bbl/day)	(barrels)	(bbl/day)
Alberta (cont'd)				
Willisdan Green (13)	5,520,209	15,082	5,384,423	14,752
Acheson (2)	4,243,502	11,594	4,800,729	13,153
Countess	2,406,433	6,575	4,796,161	13,140
Kaybob South (10)	3,136,215	8,569	4,370,904	11,975
Harmattan East (6)	3,274,400	8,946	4,315,807	11,824
Rainbow South (14)	2,938,790	8,029	3,813,472	10,448
Virgo (14)	3,160,251	8,635	3,592,584	9,843
Innisfail (6)	2,938,123	8,028	3,427,349	9,390
Joarcam (7)	2,804,369	7,663	3,370,962	9,236
Snipe Lake	3,148,130	8,601	3,162,825	8,665
Bellshill Lake	2,003,357	5,474	3,095,836	8,482
Medicine River (13)	2,547,827	6,961	2,988,744	8,188
Harmattan Elkton (6)	2,321,189	6,342	2,765,480	7,577
Provost	2,389,391	6,528	2,668,566	7,311
Wainwright (17)	2,427,875	6,633	2,427,824	6,652
Bantry (18)	2,086,656	5,701	2,381,649	6,525
Simonette (15)	3,026,657	8,270	2,351,353	6,442
Goose River	2,332,087	6,372	2,242,803	6,145
Red Earth	1,805,649	4,933	2,234,517	6,122
Clive	2,493,196	6,812	2,105,714	5,769
Gilby (5)	2,178,930	5,953	2,100,898	5,756
Sturgeon Lake	982,030	2,683	1,964,732	5,383
St. Albert – Big Lake	902,019	2,465	1,960,865	5,372
Joffre (5)	3,168,864	8,658	1,825,405	5,001
Meekwap	933,810	2,552	1,718,304	4,708
Utikuma Lake	885,617	2,419	1,678,768	4,599
Stettler	1,606,624	4,390	1,671,080	4,578
Boundry Lake South	790,722	2,160	1,639,314	4,491
Sundre	1,274,010	3,481	1,525,398	4,179
Ferrier	1,283,668	3,507	1,447,091	3,965
Excelsior	839,158	2,293	1,445,713	3,961
Taber South	1,149,252	3,140	1,422,342	3,897
West Drumheller	1,028,642	2,810	1,400,168	3,836
Grand Forks	1,500,040	4,098	1,391,209	3,812
Glen Park	907,661	2,480	1,391,061	3,811
Sylvan Lake	1,180,885	3,226	1,301,254	3,565
Hussard	1,058,628	2,893	1,299,301	3,560
Cessford	1,067,651	2,917	1,130,934	3,098
Turner Valley (11)	1,012,308	2,766	1,092,830	2,994
Chauvin South	1,115,600	3,048	1,073,036	2,940
Cyn-Pem	666,462	1,821	1,059,139	2,902
Hays	559,769	1,530	1,041,023	2,852
Other fields and pools	36,810,694	100,576	46,932,712	128,583
Total	444,220,065	1,213,716	541,686,850	1,484,074
Total Value ($)	1,272,902,634		1,890,487,106	
Saskatchewan[1]				
Total	86,787,209	237,123	85,889,079	235,312
Total Value ($)	214,056,514		283,433,960	
British Columbia				
Bound Lake (20)	9,426,811	25,756	8,643,244	23,680

Table 1 (concl'd)

	1972		1973p	
	(barrels)	(bbl/day)	(barrels)	(bbl/day)
British Columbia (cont'd)				
Peejay	3,789,160	10,353	3,118,148	8,543
Inga (21)	3,693,241	10,091	3,087,267	8,458
Milligan Creek (20)	2,443,156	6,675	2,115,934	5,797
Weasel	1,000,222	2,733	1,019,162	2,792
Other	3,583,385	9,791	3,332,512	9,130
Total	23,935,975	65,399	21,316,267	58,400
Total Value ($)	63,710,384		70,343,681	
Manitoba				
North Virden Scallion (22)	2,619,531	7,157	2,442,489	6,692
Virden-Roselea (22)	1,345,361	3,676	1,289,758	3,533
Other	1,292,047	3,530	1,351,652	3,703
Total	5,256,939	14,363	5,083,899	13,928
Total Value ($)	14,588,006		17,132,740	
Ontario				
Total	877,965	2,399	808,323	2,215
Total Value ($)	2,498,688		2,732,131	
Northwest Territories				
Total	890,067	2,432	962,733	2,638
Total Value ($)	1,059,180		1,155,280	
New Brunswick				
Total	8,714	24	9,920	27
Total Value ($)	12,200		13,888	
Canada				
Total	561,976,934	1,535,456	655,757,071	1,796,594
Total Value ($)	1,568,827,606		2,265,298,786	

Source: Provincial government reports, and Statistics Canada.
[1] Saskatchewan lists production by formation rather than by field.
pPreliminary.

tion, Alberta Energy Company Ltd. (AEC) will have an option to buy a 20 per cent interest in the Syncrude plant when it is completed. Under the terms of the Syncrude-government agreement, AEC will also own 80 per cent of a $90 million pipeline from the Syncrude plant to Edmonton and 50 per cent of a $100 million power plant to be constructed at the site.

If the Shell project is approved, construction on this 100,000 b/d plant would commence in 1976 with start-up date tentatively scheduled for 1980. In addition to its mining proposal, Shell is actively pursuing an in situ steam injection recovery research project in the Peace River area where another large bituminous sands deposit is located. If the results of this research are successful, then Shell would expand the existing facilities to a major pilot project costing about $40 million and involving about 40 production, injection and observation wells.

In the Cold Lake area, Imperial Oil Limited continued with its heavy oil recovery experimental pilot project where there is estimated to be 164 billion barrels of heavy oil in place at depths beyond the economic and physical limits of conventional mining methods. This pilot project is utilizing an in situ thermal recovery method and if successful in the Cold Lake area should also be readily adaptable to the deeper deposits of the Athabasca tar sands.

To encourage exploration, the Alberta government updated its exploratory drilling program introduced in 1972. The revised program embodies two stages – the

Table 2. Production of natural gas liquids by province, 1972-73

	1972		1973p	
	(barrels)	(bbl/day)	(barrels)	(bbl/day)
Alberta				
Propane	29,134,632	79,821	32,415,079	88,807
Butane	19,235,396	52,700	21,591,564	59,154
Pentanes Plus	58,338,020	159,830	59,326,000	162,537
Condensate	968,647	2,654	1,049,000	2,874
Total	107,676,695	295,005	114,381,643	313,372
Saskatchewan				
Propane	764,141	2,094	730,830	2,002
Butane	320,124	877	313,798	860
Pentanes Plus	400,159	1,096	235,428	645
Condensate	–	–	189,781	520
Total	1,484,424	4,067	1,469,837	4,027
British Columbia				
Propane	480,047	1,315	623,866	1,709
Butane	340,904	934	685,936	1,879
Pentanes Plus	1,018,102	2,789	1,132,701	3,103
Condensate	104,531	286	126,485	347
Total	1,943,584	5,325	2,568,988	7,038
Canada				
Propane	30,378,820	83,230	33,769,775	95,520
Butane	19,896,424	54,510	22,591,298	61,894
Pentanes Plus	59,756,281	163,716	60,694,129	166,285
Condensate	1,073,178	2,940	1,365,266	3,741
Total	111,104,703	304,396	118,420,468	327,440
Returned to formation	1,275,570	3,494	491,740	1,348
Total net production	109,829,133	300,902	117,928,728	326,092

Source: Provincial government reports.
pPreliminary; – Nil.

first being a system of credits equivalent to about 30 per cent of the cost of drilling a wildcat well and the second incentive is a five-year-tax holiday on crude oil produced from new qualifying wells.

Reserves

At the end of 1973, Canada's proven liquid hydrocarbon reserves which include conventional crude oil and natural gas liquids (propane, butane and pentane plus), amounted to 9.26 billion barrels. This is comprised of 7.67 billion barrels of crude oil and 1.59 billion barrels of natural gas liquids. These estimates do not include any volumes in the Athabasca tar sands or frontier areas. At the 1973 annual production level of 754 million barrels, the life index for conventional

Table 3. Value of natural gas liquids by province, 1972-73

	1972	1973p
	($ thousand)	
Alberta	244,591,526	331,463,000
Saskatchewan	2,397,500	2,900,000
British Columbia	3,951,049	6,764,000
Total	250,940,075	341,127,000
Volume ('000 bbls)	108,586,704	118,732,000

Source: Statistics Canada.
pPreliminary.

Table 4. Canada, crude oil production, trade and refinery receipts, 1963-73

	Production	Imports[1]	Exports[1]	Refinery Receipts[2] Domestic	Imports	Totals
			(barrels)			
1963	257,661,777	147,720,870	90,875,816	186,157,830	146,586,964	332,744,794
1964	274,626,385	143,530,957	101,258,926	199,456,597	143,946,481	343,403,078
1965	296,418,914	144,184,281	108,010,297	208,581,343	144,000,656	352,581,999
1966	320,542,794	146,076,898	123,691,342	220,196,625	158,546,823	378,743,448
1967	351,292,332	170,784,980	150,344,567	224,569,817	163,148,797	387,718,614
1968	379,396,276	177,738,586	167,487,968	236,178,376	177,293,134	413,471,510
1969	410,989,930	193,124,846	197,340,741	242,034,744	190,479,081	432,513,825
1970	461,180,059	207,633,062	240,893,633	258,966,344	208,339,853	467,306,197
1971	492,739,049	244,971,778	270,770,498	263,239,168	244,224,822	507,463,990
1972	561,976,934	288,754,232	341,252,881	273,238,175	288,754,232	561,992,367
1973p	655,757,071	327,563,814	420,059,984	300,123,924	311,292,150	611,416,074

Source: Statistics Canada.
[1] Trade of Canada (SC) data. [2] Includes condensate and pentanes plus.
p Preliminary.

Table 5. Canada, year-end reserves of crude oil, 1972-73

Province or Region	1973	% of Total 1972	% of Total 1973	Net Change 1973 over 1972
	('000 bbls)			
Alberta	6,784,268	88.6	88.4	-319,113
Saskatchewan	588,739	7.5	7.7	-5,466
British Columbia	205,106	2.7	2.7	-14,622
Northwest Territories	41,895	0.5	0.5	-1,038
Manitoba	43,646	0.6	0.6	-5,174
Eastern Canada	10,496	0.1	0.1	-578
Total	7,674,150	100.0	100.0	-345,991

Source: Canadian Petroleum Association.

crude oil and natural gas liquids dropped, for the fourth consecutive year, to 12.3 years as production outstripped newly discovered oil by 454 million barrels. Reserves added in 1973 totalled 283 million barrels, and of this amount 237 million barrels were attributable to revisions, 34 million barrels to extensions of established fields and 12 million barrels to new discoveries.

The reserve position of all provinces declined; the most notable reduction occurring in Alberta where total reserves dropped by 416 million barrels. The Canadian Petroleum Association (CPA) estimated Alberta's remaining recoverable reserves of crude oil at 6.8 billion barrels and natural gas liquids at 1.5 billion barrels. Together this accounted for about 90 per cent of Canada's proven reserves. Saskatchewan's reserves of liquid hydrocarbons declined from 603 million barrels to 597 million barrels in 1973. Oil discoveries in the frontier regions of the north and the Atlantic offshore regions are not included in these estimates because a lack of data precluded any meaningful estimate. However, these discoveries, regardless of their current economic status, are not large and would not have a significant impact on known reserve totals if they were added.

According to an appraisal of Alberta's oil sands completed this year by the Alberta Energy Resources Conservation Board (AERCB), there is an ultimate in place reserve of crude bitumen of 1,000 billion barrels of which 250 billion barrels are recoverable by all

Table 6. Canada, reserves of liquid hydrocarbons at the end of 1973

	Natural Gas Liquids	Crude Oil Plus Natural Gas Liquids	% of Total
	('000 bbls)	('000 bbls)	
Alberta	1,547,112	8,331,380	90.0
Saskatchewan	7,787	596,526	6.4
British Columbia	39,812	244,918	2.6
Other Areas	–	96,037	1.0
Total	1,594,711	9,268,861	100.0

Source: Canadian Petroleum Association.
– Nil.

known methods of technology. The bulk of the recoverable reserves are located in the Athabasca deposit with the remainder distributed between the Cold Lake, Peace River, Wabasca and Buffalo Head Hills deposits. Of the 250 billion barrels of recoverable synthetic crude oil, only 26.5 billion barrels are amenable to open-cast mining methods and all of this is located in the Athabasca deposit. The remaining 223.5 billion barrels are expected to be eventually recovered by in situ recovery techniques which are still in the experimental stage of development.

Exploration and development

Alberta. Encouraged by substantial increases in field prices for both oil and gas and provincial incentive programs exploratory effort increased substantially in Alberta in 1973. Drilling statistics show that development drilling increased 36 per cent to 6.73 million feet and exploratory drilling increased 16 per cent to 5.97 million feet. Despite the increased activity, no large oil discoveries were made in 1973. All discoveries were in the small field category and no new oil exploratory trends were outlined.

In west central Alberta, about 50 miles west of the Swan Hills field, the Cego et al Sunset well yielded a substantial flow of oil on test from the Devonian Swan Hills formation. Further drilling is scheduled to evaluate this discovery. Another oil discovery was recorded in the Valhalla region of northwestern Alberta, about six miles north of the Knopcik gas field. It was reported to have flowed significant quantities of oil from an unidentified formation. Farther north, and within the boundaries of the Virgo Devonian field, two separate discoveries were drilled late in the year. The producing zones in this field are Keg River limestone reefs of limited areal extent, but high productivity. As in previous years, several small discoveries were made in the central and southern regions of the province. In terms of reserves, however, these new fields contributed little to the provincial total.

Most of the oil field development drilling in the province was concentrated in two fields – the Twining field of Mississippian age and Red Earth basal Paleozoic age pool where field boundaries were enlarged. The Twining field has become a major field. It has been developed from a relatively insignificant field in 1971 to one in which current reserve estimates place original oil in place at 329 million barrels and the field boundaries are still being expanded by drilling. A considerable amount of infill drilling was carried out in the Willesden Green and Lloydminster fields and marginal drilling was conducted around the periphery of the Pembina field. However, with the exception of the Twining field, there were no major extensions to existing fields by development drilling this year. The large increase in development drilling footage in 1973 was due to gas rather than oil-field development.

In the field of enhanced recovery programs, Imperial Oil Limited received tentative permission from the AERCB to institute a waterflood pressure maintenance scheme in the Redwater Devonian D3 field. When fully operational, this will be one of Alberta's largest waterflood projects designed to put 100,000 barrels of water a day into the producing reservoir. The Redwater field is one of Canada's oldest and most productive fields. The waterflood will have no effect on the field's ultimate recovery because there is a strong natural water drive, but the program is intended to maintain production rates at over 100,000 b/d from the field to meet current strong demand. In the Rainbow Lake field, which is made up of numerous smaller pools, Mobil Oil Canada, Ltd. received AERCB permission to add three more pools to its present two-pool waterflood scheme. All of these pools are isolated Keg River reef buildups, and a reservoir study verified that all five pools were in pressure communication through a common aquifer. Original oil in place in the five pools is estimated to be 14.4 million barrels and, with the extension of the waterflood, the ultimate recovery factor will be increased to 60 per cent or 8.6 million barrels.

Saskatchewan and Manitoba. Drilling footage in Saskatchewan declined slightly in 1973 although the number of completions increased. Total footage drilled amounted to 1.75 million feet compared with 1.81 million in 1972. In Manitoba, drilling completions totalled 16 for 1973 compared with only 6 in 1972. This is directly attributable to a multi-well drilling program operated by Asamera Oil Corporation Ltd. with the assistance of the Manitoba government. By year-end, Asamera had completed 16 wells of its 25-well program with no commercial successes.

In Saskatchewan, 286 exploratory wells were drilled during 1973 for a combined footage of 752,681 feet, an increase of 2 per cent over 1972. However, there were no oil discoveries of any significance reported. Development drilling in Saskatchewan amounted to 999,746 feet, representing a 1 per cent decline over 1972. Much of this was confined to the Cretaceous heavy oilfields in the Lloydminster area of northwestern Saskatchewan. Important infill drilling also occurred in the established Mississippian oilfields located in the southeastern corner of the province.

British Columbia. Both exploratory and development drilling decreased in 1973. Exploratory drilling amounted to 566,500 feet, 134,463 feet less than in 1972. Development drilling decreased by 140,566 feet to 301,421 feet. The only significant oil discovery made in British Columbia in 1973 was completed in the Cecil Lake area, just north of the town of Fort St. John. This sector has yielded both oil and gas discoveries during 1973 and is adjacent to several other gas and oil producing regions. The initial discovery was a gas well and, subsequent to this, two oil discoveries were recorded in the North Pine sandstone formation of Triassic age. In addition, another oil discovery was recorded in the Belloy sandstone of Permian age in the same general area. The well is capable of producing at a rate of 400 barrels per day. A successful follow-up well to this discovery was drilled later in the year, and further development drilling is planned.

Successful development drilling in British Columbia was essentially confined to the Inga and Wolf fields which produce from Triassic reservoirs.

Yukon Territory, Northwest Territories and Arctic Islands. In northern Canada, there were 101 wells drilled in 1973 for a total footage of 741,217 feet compared with 71 wells and 574,102 feet in 1972. All but six of the 101 wells were classed as exploratory and, of these, seven were classed as natural gas finds, five being located in the Mackenzie delta and the remainder in the Arctic Islands. One oil discovery was drilled in the Mackenzie delta in 1973.

Large scale exploratory effort in the Mackenzie delta began in 1969. Since that time there have been two oil discoveries, seven gas-condensate discoveries and two oil and gas discoveries. At least three of the gas discoveries are likely to be in the major field category. The first oil discovery in the general region of the Mackenzie was made in 1970 at Atkinson Point in the Northwest Territories, 50 miles northeast of Tuktoyaktuk. Further drilling proved that this field was not large.

Table 7. Canada, wells completed and footage drilled

	1955		1960		1972		1973	
	(no.)	(ft)	(no.)	(ft)	(no.)	(ft)	(no.)	(ft)
Western Canada								
Westcoast offshore	–	–	–	–	–	–	–	–
New Field Wildcats	–	–	–	–	–	–	–	–
Hudson Bay offshore								
New Field Wildcats	–	–	–	–	–	–	–	–
British Columbia								
New Field Wildcats	34	194,014	60	365,818	22	178,206	13	115,204
Other Exploratory	2	13,020	11	55.749	102	522,757	87	451,296
Development	–	–	–	331,740	93	441,987	65	301,421
	36	207,034	143	753,307	217	1,142,950	165	867,921
Alberta								
New Field Wildcats	307	1,773,980	338	2,078,876	405	2,001,701	424	1,937,315
Other Exploratory	105	436,941	223	1,171,079	795	3,120,564	1,253	4,036,298
Development	1,208	6,219,810	1,131	7,125,856	1,519	4,929,202	2,099	6,730,499
	1,620	8,430,731	1,692	10,375,811	2,719	10,051,467	3,776	12,704,112
Saskatchewan								
New Field Wildcats	312	1,182,727	113	468,507	132	364,916	130	346,848
Other Exploratory	50	179,511	28	99,203	117	367,494	156	405,833
Development	550	1,873,040	461	1,795,968	385	1,083,027	380	999,375
	912	3,235,278	602	2,363,678	634	1,815,437	666	1,752,056
Manitoba	59	174,313	10	30,505	6	16,890	16	44,780
New Field Wildcats								
Other Exploratory	10	23,743	3	6,370	–		–	–
Development	292	647,379	54	110,073	–	–	–	–
	361	845,435	67	146,948	6	16,890	16	44,780
Territories and Arctic Islands								
New Field Wildcats	9	12,666	32	105,969	65	511,485	78	633,779
Other Exploratory	–	–	–		5	57,230	17	49,205
Development	–	–	–		1	5,387	6	58,233
	9	12,666	32	105,969	71	574,102	101	741,217

Table 7 (concl'd)

	1955		1960		1972		1973	
	(no.)	(ft)	(no.)	(ft)	(no.)	(ft)	(no.)	(ft)
Total Western Canada								
New Field Wildcats	718	3,337,300	553	3,049,675	630	3,073,198	661	3,077,926
Other Exploratory	167	653,215	265	1,332,401	1,019	4,068,045	1,513	4,942,632
Development	2,050	8,740,229	1,718	9,363,637	1,998	6,459,603	2,550	8,089,899
	2,935	12,730,744	2,536	13,745,713	3,647	13,600,846	4,724	16,110,086
Eastern Canada								
Eastcoast Offshore	–	–	–	–	18	191,210	27	300,764
New Field Wildcats	–	–	–	–	–	–	3	30,684
Other Exploratory								
					18	191,210	30	331,448
Ontario								
New Field Wildcats	64	112,246	39	68,393	79	139,172	39	73,854
Other Exploratory	57	92,536	55	109,839	9	14,998	19	27,563
Development	266	271,191	213	228,190	47	77,852	69	118,391
	387	475,973	307	406,422	135	232,022	127	219,808
Quebec								
New Field Wildcats	9	10,226	5	4,287	7	59,915	3	26,560
Other Exploratory	–	–	–	–	–	–	–	–
Development	–	–	1	240	–	–	–	–
	9	10,226	6	4,527	7	59,915	3	26,560
Newfoundland								
New Field Wildcats	–	–	–	–	–	–	1	7,581
Other Exploratory	–	–	–	–	–	–	–	–
Development	–	–	–	–	–	–	–	–
	–	–	–	–			1	7,581
Nova Scotia								
New Field Wildcats	–	–	1	9,840	–	–	1	14,888
Other Exploratory	–	–	–	–	–	–	–	–
Development	–	–	–	–	–	–	–	–
	–	–	1	9,840	–	–	1	14,888
Prince Edward Island								
New Field Wildcats	–	–	–	–	2	25,000	–	–
Other Exploratory	–	–	–	–	–	–	–	–
Development	–	–	–	–	–	–	–	–
	–	–	–	–	2	25,000	–	–
Total Eastern Canada								
New Field Wildcats	75	127,267	47	95,543	106	415,297	71	423,647
Other Exploratory	57	92,536	55	109,839	9	14,998	22	58,247
Development	273	292,334	214	228,430	47	77,852	69	118,391
	405	512,137	316	433,812	162	508,147	162	600,285
Total Canada								
New Field Wildcats	793	3,464,567	600	3,145,218	736	3,488,495	732	3,501,573
Other Exploratory	224	745,751	320	1,442,240	1,028	4,083,043	1,535	5,000,879
Development	2,323	9,032,563	1,932	9,592,067	2,045	6,537,455	2,619	8,208,290
	3,340	13,242,881	2,852	14,179,525	3,809	14,108,993	4,886	16,710,371

Source: Canadian Petroleum Association.
– Nil.

Table 8. Wells drilled by province, 1972-73

	Oil		Gas		Dry[1]		Total	
	1972	1973^p	1972^p	1973^p	1972	1973^p	1972	1973^p
Western Canada								
Alberta	514	600	1,010	1,518	1,155	1,586	2,679	3,704
Saskatchewan	316	392	86	73	245	192	647	657
British Columbia	37	8	61	54	115	99	217	161
Manitoba	–	–	–	–	7	16	7	16
Yukon and Northwest Territories								
Arctic Islands	1	–	7	10	62	91	70	101
Westcoast Offshore	–	–	–	–	–	–	–	–
Hudson Bay Offshore	–	–	–	–	–	–	–	–
Sub-total	868	1,000	1,164	1,655	1,584	1,984	3,620	4,639
Eastern Canada								
Ontario	4	11	34	34	119	75	157	120
Quebec	–	–	–	–	7	3	7	3
Atlantic Provinces	–	–	–	–	2	2	2	2
Eastcoast Offshore	–	–	2	1	16	29	18	30
Sub-total	4	11	36	35	144	109	184	155
Total Canada	872	1,011	1,200	1,690	1,728	2,093	3,804	4,794

Source: Canadian Petroleum Association.
^{p}Preliminary; – Nil.
[1] Includes suspended and abandoned wells.

Table 9. Oil wells in western Canada at the end of 1972-73

	Producing Wells		Wells Capable of Production	
	1972	1973	1972	1973
Alberta	9,689	10,028	14,168	14,368
Saskatchewan	6,390	6,521	7,421	7,653
Manitoba	638	659	891	882
British Columbia	566	542	685	693
Northwest Territories and Arctic Islands	44	43	64	65
Total	17,327	17,793	23,229	23,661

Source: Provincial and federal government reports.

In 1971, another oil discovery was made 30 miles southwest of the Atkinson Point well when the Mayogiak P-17 well yielded significant quantities of oil and gas on test. Subsequently a step-out well was drilled to this discovery but was unsuccessful. The first oil discovery on Richards Island, at the mouth of the Mackenzie, was recorded by Imperial Oil in 1972 when its Ivik J-26 well penetrated several productive horizons which yielded substantial flows of oil and gas. The size and extent of this find is still to be determined.

Early in 1973, the Kugpik 0-13 well, on the southwestern corner of Richards Island, tested large quantities of both oil and gas from a zone below the 7,200-foot level. This find is important in that it not only extended the delta play to the southwest but also because it revealed the hydrocarbon potential of a different geological horizon to that of previous discoveries. The full potential of this discovery will only be known when further drilling is done.

The search for oil and gas spread to the Arctic offshore areas in 1973 when Imperial Oil Limited launched a multi-well drilling program from two manmade islands just off the coast of Richards Island in the Beaufort Sea. The first well in this program was drilled on Immerk "island" and had to be abandoned at the 8,300-foot level because abnormally high-formation pressures precluded further safe drilling. Only minor natural gas shows were encountered in the well which was scheduled to go to 15,000 feet at a cost of $9 million including construction of the artificial island. Shortly after this, Imperial commenced drilling the well Adgo F-28 on its other artificial island located about 20 miles southwest of the Immerk test.

This well was more successful and was reported to have penetrated significant thicknesses of gas-bearing sandstone at a depth of about 7,000 feet. Before fully evaluating the productive formations, the well is being deepened to a target depth of 12,000 feet to test other prospective hydrocarbon-bearing zones. The progress of this well is being closely followed by industry as the area offshore from the Mackenzie delta is believed to have excellent potential for oil and gas accumulations. If offshore exploration continues to be as successful as it has been on the adjacent mainland, the hopes of a proven reserve base adequate enough to justify the building of a major pipeline to southern markets may become a reality.

Table 10. Mileage in Canada of pipelines for crude oil, natural gas liquids and products

Year-end	Miles	Year-end	Miles[1]
1958	7,143	1966	12,995
1959	7,808	1967	14,155
1960	8,436	1968	14,832
1961	9,554	1969	17,075
1962	10,037	1970	17,062
1963	10,607	1971	17,837
1964	11,744	1972	18,310
1965	12,315	1973[e]	18,750

Source: Statistics Canada.
[1] Includes producers' gathering lines for 1969 to 1973.
[e] Estimate.

Table 11. Deliveries of crude oil and propane by company and destination, 1972-73

Company and Destination	1972	1973
	(millions of barrels)	
Interprovincial Pipe Line Limited		
Western Canada	42.4	53.7
United States	214.2	278.3
Ontario	151.6	170.8
Total	408.2	502.8
Trans Mountain Pipe Line Company Ltd.		
British Columbia	39.8	44.2
State of Washington	101.2	93.9
Westridge terminal	3.5	6.3
Total	144.5	144.4

Source: Company annual reports.

In the Arctic Islands, where exploration began in earnest in 1969, there have been six major gas discoveries – five of them by Panarctic Oils Ltd., the industry-government company. In addition, there have been two oil discoveries, both of which have little commercial significance at the present time. The first oil discovery was made on the Fosheim Peninsula of Ellesmere Island in 1972, and the second this year on Cameron Island by the well Panarctic Tenneco et al Bent Horn N-72. This well was reported to have tested significant quantities of high gravity crude oil from a Paleozoic formation below the 10,000-foot level. Although the discovery is not considered to be commercial, it is significant in that it constitutes the first recovery of crude oil from older Paleozoic rocks in the Arctic Islands thereby broadening the horizon to future exploratory effort.

Eastern Canada. Aggregate drilling in Ontario declined in 1973 by 6 per cent to 219,808 feet. Exploratory drilling accounted for 46 per cent of the total, down 35 per cent from the previous year. Two shallow test wells of a 4-well drilling program were drilled on the Hudson platform west of the southern tip of James Bay. The other two wells in this program were drilled in 1972, but all were unsuccessful. In southern Ontario, there were no noteworthy discoveries made this year despite the upsurge in exploratory drilling.

In the Gulf of St. Lawrence, two deep exploratory wells were drilled in 1973 and both were dry and abandoned. The wells were drilled on either side and offshore from the Magdalen Islands, an area which is noted for the occurrence of numerous large salt diapirs in the subsurface.

In the offshore east area, more than 400 million acres have been taken under permit by more than 50 companies since 1960. Drilling commenced in 1966, and since then a total of 66 exploratory wells had been completed by the end of 1973 and, of these, four were significant discoveries. All discoveries were in the vicinity of Sable Island, the first one being on the southwestern tip of the Island in 1971. This well, when tested, yielded substantial quantities of oil and gas from 17 separate zones. Since that discovery, seven more were drilled on the same structures and six of these were successful but with considerably reduced pay sections. Results of this drilling show that the geological structure is extremely complex and casts some doubt on the commercial viability of the field.

Six miles to the southwest of Sable Island, a gas-condensate discovery was made in 1972, and the third significant discovery was made 30 miles east of Sable Island when the Primrose N-50 well tested flows of gas with condensate from three separate zones. In mid-1973, another oil discovery was made 25 miles southwest of Sable Island when the Cohasset D-42 well yielded low sulphur crude oil on test from three separate zones. These three discoveries are currently being evaluated, but it will probably be some time before their commercial significance will be fully known.

Elsewhere off the east coast, the well Bjarni H-81, drilled on the Labrador shelf, was reported to have encountered hydrocarbon shows before being suspended at a depth of 8,251 feet and before projected total depth had been reached. The company considered it advisable to move the drillship in order to avoid anticipated adverse seasonal weather conditions. However, the company plans on re-entering and fully evaluating the hole during the 1974 summer drilling season. Unofficial reports indicate that this may be a significant discovery as the structure on which the well is located is known to be a large one. A significant discovery here could possibly revitalize lagging industry interest in the costly search for oil and gas off Canada's east coast where results have been generally disappointing to date.

Transportation

Oil and product pipeline construction declined in 1972 as only 440 miles of new pipeline were put into operation. The bulk of this was large-diameter pipe attributable to extensive looping programs (the construction of additional lines parallel to the main line) by major oil transmission companies.

Interprovincial Pipe Line Limited was the major contributor with the addition of 170 miles of large-diameter loops to its main trunkline. This consisted of 142 miles of 48-inch-diameter pipe in Alberta, Saskatchewan and Manitoba, 28 miles of 20-inch-diameter pipe in Ontario, some pipeline modification and the installation of additional pumping facilities on the main line between Alberta and Ontario. The addition of the 48-inch line is the continuation of the on-going construction of a fourth line in Interprovincial's trunk system from Edmonton to Superior. This looping program, which began in 1972, increased the overall capacity of the system by 120,000 b/d to 1,555,000 b/d out of Cromer, Manitoba at the end of 1973.

In eastern Alberta, Bow River Pipe Lines Ltd., added 88 miles of 10- and 12-inch-diameter pipe parallel to their main line. This line connects the fields of southeastern Alberta with the Interprovincial trunkline at Hardisty, Alberta.

In Ontario, Sun-Canadian Pipe Line Company Limited, added 75 miles of 12-inch-diameter pipe parallel to its products pipeline between Sarnia and Toronto. The addition of this line is part of a two-year program which will result in near completion of looping the entire 198-mile line in the province.

The bulk of the remaining oil pipeline construction in Canada was confined to the addition of loops to existing feeder line systems and the installation of approximately 100 miles of oil-gathering line in producing fields.

In anticipation of future development of oil and gas reserves in Arctic areas, three large northern pipeline research institutions were formed during the past three years. They are consortiums composed of several pipeline and oil companies dedicated to solving the ecological, environmental and operational problems that may be encountered by constructing and operating pipelines in far northern areas. Two of the research groups, Canadian Arctic Gas Study Limited and the Polar Gas Project are directly involved in studies relating to the feasibility of bringing Mackenzie River delta and Arctic Islands gas to southern markets. The third, Mackenzie Valley Pipe Line Research Limited, has been involved in research on northern oil pipeline construction with the principal subject of investigation being the response of permafrost to a warm-oil pipeline. The Mackenzie Valley study was completed in 1973, and the findings were set out in a report which concluded that it was technically feasible to construct and operate the line without major or irreparable damage to the Arctic environment. The study was based on the premise that the Alaskan North Slope fields would provide the bulk of the crude oil flowing through the line. However, recent actions by the United States government strongly indicate that an all-Alaskan route will be selected to transport Alaskan production to United States markets and it is likely construction of this line will begin in 1974. Consequently, the company is now concentrating studies on an all-Canadian pipeline out of the Mackenzie delta to Edmonton as an alternative. This project would be contingent on the establishment of an adequate oil reserve based on the Canadian Arctic mainland – something that appears to be not close at hand.

Because of cut-backs in shipments of crude oil from Arab states, and to avoid possible shortages of petroleum products in those areas of eastern Canada which depend on this crude oil for refinery feedstock, in January, 1974, the federal government initiated the reactivation of a section of the Trans-Northern product pipeline in order to bring petroleum products from the Toronto area to Ottawa. This section had been inactive for several years but when fully operative is capable of transporting up to 50,000 b/d of refined petroleum products – principally light heating oil and gasoline.

In line with long-term objectives to self-sufficiency in crude oil and refinery production, the government announced its intention to supply the Montreal refining centre with western Canadian crude oil. As the first step in this program, the federal government decided that Interprovincial's crude oil pipeline system would be extended from the Sarnia terminus to Montreal. When completed, the proposed 30-inch-diameter line will be capable of transporting 600,000 b/d. The initial throughput of 250,000 b/d will only serve about half of the Montreal refinery requirements. Government and industry officials favour a southern route via either TransCanada PipeLines Limited's gas pipeline route or Trans Northern's right-of-way. Construction of the 520-mile, $150 million line could begin as early as 1974, and the facility be on stream by the end of 1975, but a later date is expected. To ensure self-sufficiency in crude oil, it has been proposed that an all-Canadian pipeline system be constructed from Interprovincial's Winnipeg terminal to Montreal via a route north of the Great Lakes with eventual expansion to east coast refineries. The construction of this line would depend on the adequacy of future supply from western Canada or offshore from eastern Canada.

Pipeline tariffs of the major trunklines such as Interprovincial and Trans Mountain Pipe Line Company Ltd. remained unchanged in 1973. Bow River Pipe Line Limited reduced the pipeline tariff on its crude oil gathering system in southeastern Alberta from 9 to 7 cents a barrel.

Petroleum refining

Canadian refinery capacity increased by 127,000 b/d in 1973, due primarily to the addition of the large new refinery at Come By Chance, Newfoundland. At the end of 1973, crude oil refining capacity of Canada's 41 operating refineries totalled 1,857,300 b/d. This represents a gain of 7.2 per cent over 1972 in the industry's capability to refine crude oil, and is 2.7 per cent more than the overall increase in demand for petroleum products during the year.

In the Atlantic provinces, Newfoundland Refining Company Limited's 100,000 b/d refinery went on stream late in 1973, but is not expected to reach full capacity until mid-1974, when its platforming, hydrocracking and hydrofining units will come on stream. The plant has been designed with a flexibility to meet the changing product market, but initial emphasis will be placed on production of fuel oils, jet fuel and gasoline. Feedstock will be Kuwait and Iranian light crude oil supplied by British Petroleum Company Limited under a 10-year contract, and products are expected to be marketed in Europe, eastern Canada and the United States. The present all-weather dock is capable of accommodating tankers up to 350,000 dwt carrying up to 2 million barrels of crude oil. Elsewhere in the Maritimes, Texaco Canada Limited expanded the crude oil capacity of its Halifax refinery by 1,500 b/d to 17,500 b/d.

At the present time there are several proposals for the construction of major new refineries in the Maritimes where there are good, deep-water harbour sites. These proposed refineries have been planned to mainly serve the export markets, particularly the growing market for low sulphur fuel oil in the northwestern United States, where there are few, if any, good, deep-water harbours. Among the most important of these plans are two large refineries proposed by Shaheen Natural Resources Company Inc., New York, the company which built the Come By Chance refinery. One plant is a 200,000 b/d facility to be located across the Canso Strait from Gulf Oil Canada Limited's two-year old, Point Tupper refinery; the other refinery would be built at Come By Chance close to the present plant and would have a capacity of 300,000 b/d, the largest ever built in Canada. Whether these, or others which have been talked about for the east coast to become a reality, will likely depend to a large extent on developments concerned with the price and availability of crude oil from the principal foreign supply countries.

Table 12. Crude oil refining capacity by regions

	1972		1973	
	(bbl/day)	(%)	(bbl/day)	(%)
Atlantic provinces	312,500	18.1	414,000	22.3
Quebec	587,500	34.0	608,500	32.7
Ontario	410,800	23.7	413,700	22.3
Prairies and Northwest Territories	290,200	16.8	290,800	15.7
British Columbia	129,300	7.4	130,300	7.0
Total	173,300	100.0	1,857,300	100.0

Source: Department of Energy, Mines and Resources, *Petroleum Refineries in Canada* (Operators List 5), January 1974.

In Quebec, refinery expansions consisted of a 12,000 b/d capacity increase by Petrofina Canada Ltd. and minor additions to capacities at both the Imperial Oil and Texaco refineries in Montreal East. In Ontario, refinery growth was confined to a 2,000 b/d crude oil capacity increase by Texaco Canada Limited at its Port Credit plant and a minor expansion of crude oil capacity at Imperial Oil's Sarnia refinery. BP Canada Limited's 40,000 b/d expansion of its Oakville refinery is expected to be completed early in 1974. Sun Oil Company Limited is well advanced on the expansion of its Sarnia refinery which will more than double capacity to 80,000 b/d by 1974. In addition, current plans call for construction to start on Texaco Canada's planned 95,000 b/d refinery at Nanticoke on Lake Erie early in 1974, with completion scheduled for 1976.

In the Prairie provinces, construction was well advanced on Imperial Oil Limited's 140,000 b/d Strathcona refinery on the site of its existing plant east of Edmonton. Completion is scheduled for the end of 1974. The Strathcona refinery will be the hub of a new petroleum product supply system which Imperial is building in the Prairie provinces. A pipeline system will link the new plant with other terminals at major Prairie centres, and when the Strathcona refinery is completed, Imperial's existing smaller refineries at Regina, Calgary and Winnipeg will be converted to petroleum product distribution terminals. The net result will be an overall increase in capacity of 26,000 b/d. Expansion to other refineries in the Prairie provinces was negligible.

In British Columbia, Imperial Oil has embarked on a three-year modernization and environmental control program on its Port Moody refinery. Main emphasis of the program is on environmental improvement imple-

Table 13. Canada, crude oil received at refineries, 1972 and 1973[p]

Location of Refineries		Canada	Middle East	Trinidad	Venezuela	Africa	Colombia	Other	Total Received
				Country of Origin					
					(barrels)				
Atlantic provinces	1972	--	47,552,806	–	33,144,106	49,932	–	16,438,472	97,185,316
	1973	230,825	54,115,846	–	39,069,549	–	–	16,850,054	110,266,274
Quebec	1972	–	51,843,338	1,308,823	108,862,414	21,306,862	4,450,655	3,372,433	191,144,525
	1973	5,315,499	70,009,491	–	105,362,587	18,835,661	3,839,175	2,719,334	206,081,747
Ontario	1972	137,477,565	–	–	424,391	–	–	–	137,901,956
	1973	148,886,750	–	–	490,453	–	–	–	149,377,203
Prairies	1972	87,280,302	–	–	–	–	–	–	87,280,302
	1973	93,325,241	–	–	–	–	–	–	93,325,241
British Columbia	1972	47,567,342	–	–	–	–	–	–	47,567,342
	1973	51,420,427	–	–	–	–	–	–	51,420,427
Northwest Territories and Yukon	1972	912,926	–	–	–	–	–	–	912,926
	1973	945,182	–	–	–	–	–	–	945,182
Total	1972	273,238,135	99,396,144	1,308,823	142,430,911	21,356,794	4,450,655	19,810,905	561,992,367
	1973	300,123,924	124,125,337	–	144,922,589	18,835,661	3,839,175	19,569,388	611,416,074

Source: Statistics Canada.
[p]Preliminary.

menting the latest technology. Also in British Columbia, Chevron Canada Ltd. has received approval to double the capacity of its Burrard Inlet refinery to 45,000 b/d.

On a company basis, Imperial Oil Enterprises Ltd. remained the largest refiner in Canada. The company's nine refineries comprise 25 per cent of Canadian refinery capacity. Gulf Oil Canada Limited's eight plants constitute 18 per cent of Canadian refinery capacity, and Shell Canada Limited, third largest refiner, operates six refineries which account for 15 per cent of the total.

Marketing and trade

Receipts of crude oil and equivalent at Canadian refineries totalled 1.68 million barrels daily in 1973, 8 per cent more than in 1972. Deliveries of crude oil to refineries in western Canada and Ontario were increased by 8 per cent for an average delivery of 807,000 barrels of Canadian oil daily. On the other hand, imports of crude oil by Canadian refineries in Quebec and the Maritime provinces rose by only 7 per cent and amounted to 853,000 b/d. The slow-down in the rate of use of imported crude oil was due mainly to the partial embargo on exports of crude oil to Canada levied by the Arab producing states late in the year. To compensate for this shortfall, refiners located east of the Ottawa Valley were partly supplied with crude oil from western Canada on a contingency basis. Much of this crude oil was shipped to Quebec and Maritime refining centres either by tanker via the Great Lakes and St. Lawrence Seaway or by tanker from west coast ports via the Panama Canal. By year-end western Canada was supplying about 100,000 b/d of crude oil to those areas in eastern Canada which in the past had exclusively been served by offshore crude oil.

Venezuela continued to be the largest exporter of crude oil to Canada. The volume of its exports increased from 389,000 b/d in 1972 to 397,000 b/d in 1973. Despite the Arab producing countries, principally Abu Dhabi's and Saudi Arabia's limited embargo on shipments to Canada in the latter stages of the year, exports from Middle East countries expanded from 272,000 b/d in 1972 to 340,000 b/d in 1973. However, all of the increase resulted from increased supplies from Iran. In 1973, Middle East sources of imported oil were Iran, Saudi Arabia, Iraq, Kuwait, Quatar, Bahrain and the Trucial States. Nigeria continued to provide substantial amounts of crude oil to Canadian refineries, although import volumes from this country declined by 7,000 b/d to 52,000 b/d. Imports from Colombia declined slightly to 10,500 b/d.

Exports to the United States of crude oil and equivalent increased by 23 per cent to 1,151,000 barrels daily in 1973. Canadian exports to the United States west coast region (District 5) via Trans Mountain Pipe Line Company Ltd. averaged 257,000 b/d, a decrease of 19,000 b/d from the 1972 average. Exports to markets in the northern states east of the Rocky Mountains (Districts 1-4), primarily via Interprovincial's main line, increased by 235,000 b/d to 894,000 b/d. Although the increase in supply of Canadian crude oil to United States refiners was substantial in 1973, it was still well below their actual demand, particularly in the latter part of the year. The gap between growing domestic requirements of petroleum in the United States and the ability of its producing industry to meet these requirements is steadily widening. As a result, United States refiners have increasingly depended on imported oil to bridge this gap. When the Arab embargo on oil shipments to the United States was enforced, shortfalls in supply quickly developed, and United States refiners attempted to make up these shortfalls by increasing producing industry partly because of limited excess transportation capacity, but also because the Canadian producing industry was hard pressed to meet increased domestic requirements precipitated by the same Arab embargo on shipments of oil to Canadian refiners.

Exports of products exceeded imports in 1973. Exports increased by 18 per cent to 213,000 b/d and all went to United States, principally the northeastern region which had to rely on petroleum products from other regions because no refineries are located there. Imports of products decreased by 15 per cent to 121,000 b/d. The trend to decreasing imports of petroleum products, particularly heavy fuel oil, began two years ago when refinery capacity in eastern Canada was substantially increased by the addition of the St. Romuald and Point Tupper refineries. Newfoundland Refining Company Limited's 100,000 b/d refinery at Come By Chance, Newfoundland commenced operating too late in the year to have any large impact on product imports. When fully operative, sufficient domestic deliveries are expected to occur which will further reduce aggregate product imports into Canada, although the refinery was designed primarily to serve the export market.

The rapid rise in world crude oil prices and the induced supply shortages following the Middle East conflict prompted the Canadian government to introduce a series of emergency measures which were designed to partially insulate the Canadian consumer from the effects of these forces. The most immediate of these was to impose export restrictions on propane, butane and heavy fuel oils in addition to those that had been imposed earlier in the year on gasoline and home heating oil. In September, the federal government asked oil companies not to raise the prices for crude oil and petroleum products until January 30, 1974. In order to ensure that exported Canadian crude oil was priced at market values comparable to other imported and domestically produced crude oils in the United States, the federal government levied a tax on exported crude oil, beginning in October, 1973. Initially the tax was set at 40 cents a barrel but was set at higher levels as the foreign reference prices escalated

Table 14. Consumption of petroleum products by province 1973[p]

	Motor Gasoline	Kerosene Stove Oil, Tractor Fuel	Diesel Fuel Oil	Light Fuel Oils No. 2 and 3	Heavy Fuel Oils No. 4, 5 and 6
	(thousands of barrels)				
Newfoundland	3,491,885	1,601,251	3,121,872	3,727,118	3,958,529
Maritimes	14,139,391	2,770,239	4,518,084	13,195,323	25,333,917
Quebec	48,913,822	5,578,029	12,178,576	37,051,525	43,484,600
Ontario	73,681,348	2,629,921	14,015,038	37,317,111	27,290,050
Manitoba	9,519,642	1,091,757	4,060,919	1,808,117	912,040
Saskatchewan	11,220,986	1,112,207	4,542,085	1,594,679	528,917
Alberta	19,643,360	517,232	7,460,139	925,907	793,373
British Columbia	20,953,241	1,723,753	10,559,250	6,544,091	9,256,448
Northwest Territories and Yukon	537,305	352,444	1,402,919	673,234	163,920
Total	202,100,980	17,376,833	61,858,882	102,837,105	111,721,794

Source: Statistics Canada.
[p]Preliminary.

upwards. By January 1, 1974 it had been set at $2.20 a barrel and one month later it was further increased to $6.40 a barrel. Also in January, the federal government froze all domestic product prices both east and west of the Ottawa Valley line and decided to compensate companies from federal funds for losses incurred in importing foreign crude oil and petroleum products.

Early in 1974, the wellhead price of western Canadian crude oil, which had been frozen at $4.00 a barrel, was being renegotiated by the federal and provincial governments with a view to raising this price to a level considered to be fair and equitable to all concerned. The consensus was that a price of about $6.50 per barrel would meet these requirements and, if agreed on, would mean a fairly substantial rise in petroleum product prices west of the Ottawa Valley line and minor price hikes east of the line where prices were already substantially above the national average. The effects of these government actions were twofold – consumers in Canada did not have to pay the large increase in petroleum product prices they would have if the price of domestic crude oil had been allowed to rise with world prices; and the prices of petroleum products nationally were essentially equalized regardless of the source of refinery feedstock and discounting differences in transportation charges.

Late in the year, the Alberta government was in the process of establishing a petroleum marketing commission which would have the power to set the posted price of Alberta crude oil, take in kind the government's share of oil production, and market most of Alberta's current 1.8 million b/d output of crude oil and natural gas liquids. The three-man marketing commission will likely form the cornerstone of pending Alberta legislation dealing with the petroleum and natural gas industry, particularly in respect to new royalty schedules. The terms of the new legislation are said not to include natural gas or synthetic crude oil from the Athabasca tar sands. Policy for these two commodities will presumably wait until their provincial supply-demand significance and other factors pertaining to the tar sands have been fully assessed.

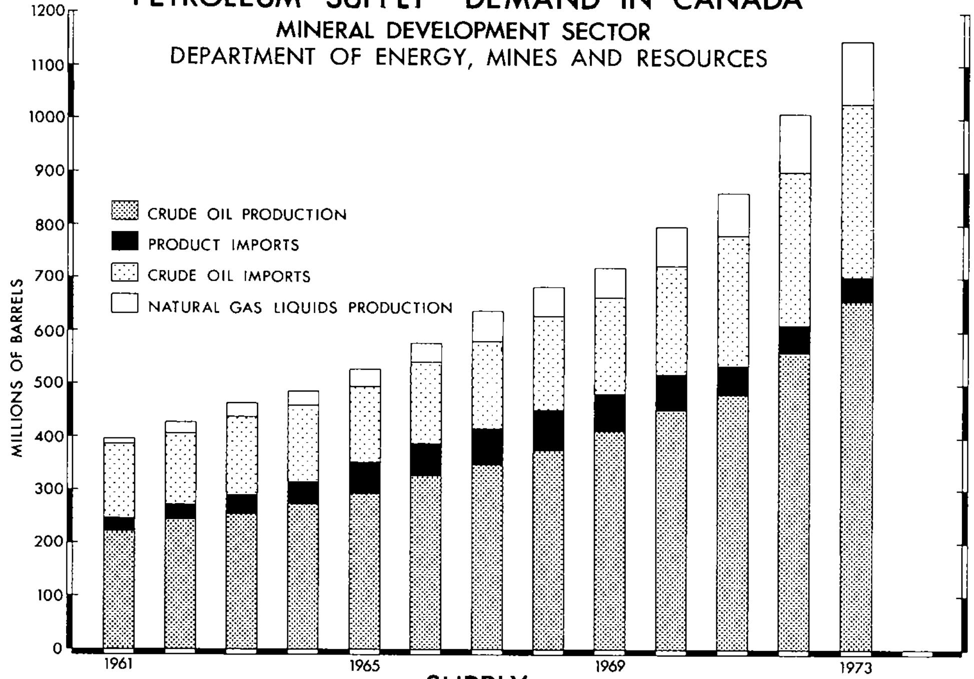
During the year, the Saskatchewan government enacted the Oil and Gas Conservation Stabilization and Development Act. The terms of the Act provide the province with a broad range of powers to deal with the exploration, producing and marketing phases of Saskatchewan's oil and gas industry, including the right to: take over all freehold oil and gas rights held by about 24 companies or groups of companies, with only those companies holding two sections or less exempted; set wholesale petroleum prices; control crude oil production; establish a new mineral income tax and royalty surcharge and provide incentives to increase oil and gas exploration. The principal thrust of the bill is to enable the province to assert its right to control the price and distribution of Saskatchewan oil. This measure closely follows the legislation enacted by the Saskatchewan government which incorporated Saskatchewan Oil and Gas Corporation (Saskoil). The new company is a provincial Crown corporation that will operate essentially as an integrated oil company with the power to explore, develop, produce, process, refine, manage, utilize, conserve, transport, purchase or sell petroleum, natural gas or any of its associated products.

In British Columbia, on the recommendations of the British Columbia Energy Commission, a five-member board was set up by the British Columbia government to study various aspects of the province's oil and gas industry, the provincial government incor-

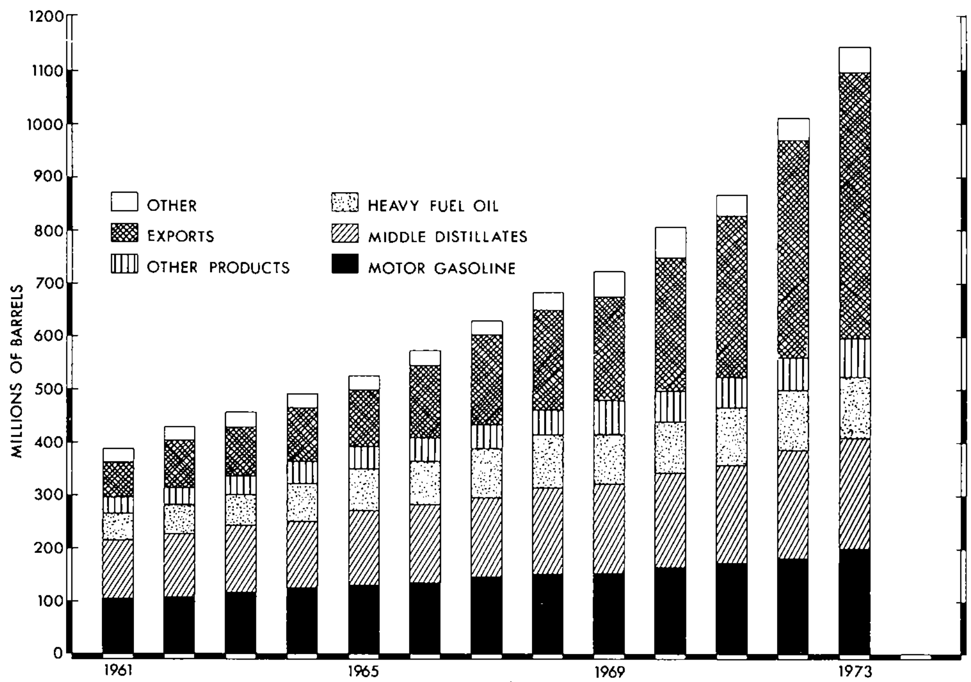
(text continued on page 352)

PETROLEUM SUPPLY - DEMAND IN CANADA

MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES



SUPPLY



DEMAND

SOURCE: STATISTICS CANADA

porated the British Columbia Petroleum Corporation. This Crown corporation was given the authority to enter almost any segment of the petroleum industry, but the major priority of the new corporation will be to control the pricing and marketing of natural gas. Its broadly based terms of operations include the power to buy, sell and otherwise deal in petroleum and natural gas; acquire or sell pipelines and related facilities; and explore for, develop and produce oil and gas.

Table 15. Canada, exports and imports of refined petroleum products, 1972-73

	Exports		Imports	
	1972	1973^p	1972	1973^p
	(millions of barrels)			
Propane and butane	31.38	36.20	0.08	0.27
Aviation gasoline	–	–	0.15	0.11
Motor gasoline	0.73	3.31	3.06	0.22
Aviation turbo fuel	1.11	1.67	2.21	2.46
Kerosene, stove oil and tractor fuel	0.12	0.08	1.87	0.98
Diesel fuel oil	0.10	0.52	2.65	1.13
Light fuel oils #2 and 3	2.03	1.27	9.40	4.87
Heavy fuel oils #4, 5 and 6	26.20	31.65	26.36	28.48
Asphalt	0.04	0.01	0.40	0.10
Petroleum coke	–	–	2.94	3.37
Lubricating oils	–	–	1.46	1.58
Other products	3.77	3.03	1.29	0.62
Total, all products	65.44	77.74	51.87	44.19

Source: Statistics Canada.
^{p}Preliminary; – Nil.

Outlook

Rapidly changing circumstances in the world petroleum scene makes it difficult to predict what might happen in the several sectors of the industry with any degree of assurance. Certainly, the demand for Canadian crude oil (at home and abroad) will remain strong. The controlled price of western Canadian crude oil in the Montreal refining area is at least competitive with imported crude oil; therefore, the constraints of transportation facilities to this area will dictate what will occur at least until the Interprovincial pipeline system is extended to the Montreal area. As this region absorbs more western Canadian crude oil it follows that there will be a concomitant decrease in exports to the United States as current Canadian productive capacity is now close to maximum output.

The anticipated substantial wellhead price increases for western Canadian crude oil will be followed by sharp increases in the consumer prices of petroleum products west of the Ottawa Valley where domestic crude oil is used for refinery feedstock. East of the line, where offshore crude oil is the main refinery supply source, product prices are already above the national average and, therefore, the levelling of prices nationally will result in a smaller price raise.

Exploratory activity in the Arctic areas, where success ratios have been good, particularly in respect

Table 16. Canada, supply and demand of oils, 1972-73

	1972^p	1973^p
	(thousands of barrels)	
Supply		
Production		
Crude oil and condensate	562,453	655,757
Other natural gas liquids	108,756	116,563
Net production	671,209	772,320
Imports		
Crude oil	288,754	327,564
Products	51,871	44,194
Total imports	340,625	371,758
Changes in stocks		
Crude and natural gas liquids	−6,211	−8,616
Refined petroleum products	+3,765	−7,754
Total change	−2,466	−16,370
Oils not accounted for	+167	+2,465
Total supply	1,009,535	1,130,173
Demand		
Exports		
Crude oil	341,253	420,060
Products	65,436	77,741
Total	406,689	497,801
Domestic sales		
Motor gasoline	184,409	202,101
Middle distillates	202,890	203,033
Heavy fuel oil	110,544	111,721
Other products	64,184	71,151
Total sales	562,027	588,006
Uses and Losses		
Refining	41,413	42,975
Field plant and pipeline	−594	1,391
Total	40,819	44,366
Total demand	1,009,535	1,130,173

Sources: Statistics Canada and provincial government reports.
^{p}Preliminary; ^{r}Revised.

to gas exploration, can be expected to be at least maintained at a similar level to that of the past two years. Offshore from eastern Canada where drilling costs are high and results have been disappointing, it is likely that exploratory activity will decline in the short-term and, unless the success ratio improves, this decline will probably accelerate in the longer-term. Future exploratory activity on the Labrador Shelf may rejuvenate industry interest. This area, which parallels the Labrador coast, has thick sequences of young sediments, a combination which most exploration petroleum geologists consider essential ingredients for large offshore oil and gas accumulations. It is for this reason that the final evaluation of the Bjarni discovery assumes special status during the coming year. This is a physically difficult area to operate in because of seasonal iceberg and weather problems and the attendant costs of both exploration and any future development requires that any discovery to be developed will have to be large. The geology is favourable and only drilling can prove the potential.

On the basis of domestic production capability versus domestic demand, Canada is now self-sufficient in petroleum and will likely remain so, at least until the end of the decade. The Canadian producing industry is, therefore, theoretically capable of filling the anticipated future demand of refiners located east of the Ottawa Valley but only at the expense of the export market in the United States. Beyond 1980, and unless the declining trend in Canada's proven crude oil reserves can be reversed, maximum conventional crude oil production will be hard-pressed to meet domestic requirements even if exports are to be phased out. Production of synthetic crude oil from the Athabasca tar sands holds promise of meeting the shortfall, but operations there are large undertakings both physically and financially so that there are limits to what this source can supply in the short term. In the longer-term, however, it will likely constitute a growing proportion of domestic supply.

Phosphate

A. F. KILLIN

There is no commercial production of phosphate rock in Canada. Large quantities are imported, mostly from the United States, for use in the manufacture of agricultural and industrial phosphate products sold in domestic and export markets. The United States is the principal market for Canadian exports of phosphorus and phosphate fertilizers.

About four fifths of the world's phosphate rock consumption is for agriculture, largely fertilizers. World demand for phosphate rock expanded at unprecedented rates from 1963 to 1967 to meet the needs of a rapidly developing phosphate fertilizer industry, but eased considerably between 1968 and 1971. A worldwide food shortage that started to assume serious proportions in 1970-71 has increased and has been accompanied by an accelerating world demand for fertilizers, including phosphates. In Canada, phosphate fertilizer demand soared from 1965 to 1968, but dropped sharply in 1969 and 1970 reflecting a levelling in farm incomes. Domestic production of phosphate fertilizers has increased in response to the world demand for food, but the increase has been inhibited by the lack of availability of phosphate rock.

Phosphate rock

Phosphate is a term applied to a rock, mineral, or salt containing one or more phosphorus compounds. Phosphate rock, or phosphorite, contains one or more suitable phosphate minerals, usually calcium phosphate, in sufficient quantity for use, either directly or after beneficiation, in the manufacture of phosphate products. Sedimentary phosphate rock is the most widely used phosphate raw material; apatite, which occurs in many igneous and metamorphic rocks and can be represented by the formula $Ca_5(PO_4)_3(F, Cl, OH)$, is second in importance. Other sources of phosphate include guano and a basic slag byproduct of some steel mills. Phosphate rock can be decomposed by three methods: acid treatment; thermal reduction; or thermal treatment without reduction. Canadian phosphate producers use the first two methods.

Phosphate rock is graded either on the basis of its P_2O_5 equivalent (phosphorus pentoxide) or $Ca_3P_2O_5$ content (tricalcium phosphate or bone phosphate of lime – BPL). For comparative purposes, 0.458 P_2O_5 equals 1.0 BPL, and one unit of P_2O_5 contains 43.6 per cent phosphorus.

Occurrences in Canada

There are numerous occurrences of low-grade phosphate rock in Canada. They are of limited extent and fall into three main categories: apatite deposits within Precambrian metamorphic rocks in eastern Ontario and southwestern Quebec; apatite deposits in some carbonate-alkaline complexes in Ontario and Quebec; and Late Paleozoic-Early Mesozoic sedimentary phosphate rock deposits in the southern Rocky Mountains.

The Precambrian metamorphic apatite deposits of Ontario and Quebec occur in pyroxenites as small, irregular, scattered pockets and veins with phlogopite mica and pink calcite. Most of the outcrops are in the Rideau Lakes region of eastern Ontario and the Lièvre River area of southwestern Quebec, where many deposits were worked extensively between 1869 and 1900, before low-cost Florida rock entered world markets. Among the more important alkaline-complex apatite occurrences are: The Nemegos deposits, some 150 miles northwest of Sudbury; the Oka deposit, 20 miles west of Montreal; and some deposits north of Arvida.

Sedimentary phosphate beds are fairly common in the Rocky Mountains. Most of the exposures occur along the Alberta-British Columbia border between the International Boundary and Banff. Beds at the base of the Fernie shale have received considerable attention during recent years.

Canadian phosphate industry

Elemental phosphorus. Elemental phosphorus is produced in Canada by the thermal reduction method which involves the smelting of phosphate rock with carbon (coke) and a siliceous flux. Coproducts of the process are ferrophosphorus, carbon monoxide and calcium silicate slag. About nine tons of phosphate rock grading 66-68 per cent BPL are required to manufacture one ton of phosphorus. Although elemental phosphorus can be used for making fertilizers, it is generally used in the manufacture of chemicals, insecticides, detergents and other industrial compounds.

Phosphate fertilizers. Phosphate fertilizers are normally produced by decomposing phosphate rock with a strong mineral acid. In Canada, only the two most common acidulents, sulphuric acid and phosphoric

Table 1. Canada, phosphate rock imports and consumption, 1972-73

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Imports				
United States	3,001,933	17,997,000	3,671,229	23,705,000
Netherlands Antilles	6,499	243,000	6,327	204,000
Romania	–	–	1,061	5,000
Total	3,008,432	18,240,000	3,678,617	23,914,000
	1971		1972	
Consumption[1] (available data)				
Fertilizers, stock and poultry feed	1,780,830		2,102,529	
Chemicals	232,513		244,656	
Other[2]	17,946		14,825	
Total	2,031,289		2,362,010	

Source: Statistics Canada.
[1] Breakdown by Mineral Development Sector. [2] Includes amounts for refractories, food processing, medicinals and pharmaceuticals.
^{p}Preliminary; – Nil.

Table 2. Canada, phosphate rock imports and consumption, 1964-73

	Imports	Consumption
	(short tons)	
1964	1,406,424	1,448,571
1965	1,695,296	1,606,915
1966	2,181,341	1,735,488
1967	2,279,767	2,275,095
1968	2,349,980	2,234,259
1969	2,201,331	1,822,069
1970	2,470,050	1,896,684
1971	2,844,453	2,031,289
1972	3,008,432	2,362,010
1973^p	3,678,617	..

Source: Statistics Canada.
^{p}Preliminary; .. Not available.

acid, are used in commercial practice; the former is by far the most common.

When phosphate rock is treated with sulphuric acid, either single superphosphate or phosphoric acid (correctly named orthophosphoric acid, H_3PO_4) is produced. For the former, the rock is treated with sufficient acid to convert the tricalcium phosphate into water-soluble monocalcium phosphate; the coproduct of the reaction, calcium sulphate, remains in the mixture. Normal raw material requirements to pro-

Table 3. World production of phosphate rock, 1971-73

	1971	1972	1973^e
	('000 metric tons)		
United States	34,397	36,905	38,629
U.S.S.R.	19,011	19,722	21,250
Morocco	12,013	14,468	16,564
Tunisia	3,162	3,297	3,474
China, People's Rep.	2,200	2,600	3,000
Togo	1,715	1,928	2,272
Senegal	1,546	1,419	1,693
Islands in the Indian and Pacific Oceans	3,626	2,991	4,605
South Africa	1,233	1,252	1,333
Israel	980	832	858
Jordan	569	694	1,106
Algeria	496	471	641
Egypt, Arab Republic	558	497	510
Viet-Nam, North	550	280	700
Other countries	1,185	1,463	2,141
Total	83,241	88,819	98,776

Source: International Superphosphate and Compound Manufacturer's Association (London).
^{e}Estimated.

Table 4. Canada, phosphorus and phosphate fertilizer plants, 1973

Company	Plant Location	Annual Capacity	Principal End Products	Basis for H_2SO_4 Supply for Fertilizer Plants
		(st)		
Elemental phosphorus				
Erco Industries Limited[1]	Varennes, Que.	20,000	el ph	
	Long Harbour, Nfld.	80,000	el ph	
Total, elemental phosphorus		100,000		
Phosphate fertilizer		(P_2O_5 eq.)		
Canada Wire and Cable Limited[2]	Belledune, N.B.	125,000	am ph	SO_2 smelter gas
Canadian Industries Limited	Beloeil, Que.	28,000	ss	sulphur
	Hamilton, Ont.[3]		ss	sulphur
	Courtright, Ont.	80,000	am ph	SO_2 pyrrhotite, Copper Cliff
Cominco Ltd.	Kimberley, B.C.	128,000	am ph	SO_2 smelter gas
	Trail, B.C.	86,000	am ph	SO_2 smelter gas
Erco Industries Limited[1]	Port Maitland, Ont.[4]	190,000	H_3PO_4, ss ts, ca ph	sulphur
Green Valley Fertilizer & Chemical Co. Ltd.	North Surrey, B.C.	1,000	ss	SO_2 smelter gas, Trail
Imperial Oil Limited	Redwater, Alta.	140,000	am ph	sulphur
Northwest Nitro-Chemicals Ltd.	Medicine Hat, Alta.	60,000	am ph	sulphur
St. Lawrence Fertilizers Ltd.	Valleyfield, Que.	56,000	ts, am ph	SO_2 smelter gas
Sherritt Gordon Mines, Limited	Fort Saskatchewan, Alta.	45,000	am ph	sulphur
Simplot Chemical Company Ltd.	Brandon, Man.	..	am ph	
Western Co-operative Fertilizers Limited	Calgary, Alta.	65,000	am ph	sulphur
Total, phosphate fertilizer		1,004,000		

el ph Elemental phosphorus; P_2O_5 eq. Phosphorus pentoxide equivalent; am ph Ammonium phosphates; ss Single superphosphate; tx Triple superphosphate; ca ph Food supplement calcium phosphate. . . Not applicable, H_3PO_4 is made elsewhere.
[1]Electric Reduction Company of Canada, Ltd. changed its name to Erco Industries Limited, effective January 1, 1973.
[2]Noranda Mines Limited acquired full ownership of Belledune Fertilizer, effective April 1, 1972, name changed to Canada Wire and Cable Limited, June 5, 1972.
[3]CIL's Hamilton Works was closed early in 1972.
[4]Operates at less than annual capacity because of environmental restrictions.

duce one ton of superphosphate, grading 20 per cent P_2O_5 equivalent, are 0.64 ton of phosphate rock (70-72 per cent BPL) and 0.47 ton of sulphuric acid (100 per cent basis).

To produce phosphoric acid, larger quantities of sulphuric acid are added to maintain a fluid slurry that facilitates removal of calcium sulphate by filtering. Filtered acid, containing 30 to 32 per cent P_2O_5 equivalent, may be used either directly in the manufacture of phosphate fertilizers or concentrated by evaporation to as high as 54 per cent P_2O_5 equivalent prior to further use or sale as merchant acid. Typical raw material requirements for one ton of P_2O_5 equivalent produced are 3.1 tons of phosphate rock (74-75 per cent BPL) and 2.6 tons of sulphuric acid (100 per cent basis). Also, for every ton of P_2O_5 equivalent produced, about 4.5 tons of waste calcium sulphate are generated.

Most of the acid is then neutralized with ammonia to form ammonium phosphate fertilizers. Common grades are 16-20-0 (16 per cent N, 20 per cent P_2O_5 equivalent, and 0 per cent K_2O equivalent), 11-40-0 and 18-46-0. At some plants, phosphoric acid is used to acidulate phosphate rock, in which case the end product is triple superphosphate, normally grading 46 per cent P_2O_5 equivalent.

There are ten phosphoric acid plants in Canada with a combined annual productive capacity of 940,000 tons of P_2O_5 equivalent. The balance of Canada's P_2O_5 productive capacity, amounting to 64,000 tons annually, consists of plants that are

Table 5. Canada, phosphate fertilizer production, years ended June 30, 1964-73

	short tons P_2O_5 equivalent
1964	353,547
1965	374,159
1966	461,608
1967	533,460
1968	538,796
1969	523,934
1970	496,380
1971	619,669
1972	745,667[r]
1973[p]	813,972

Source: Statistics Canada.
[p]Preliminary; [r]Revised.

Table 6. Canada, trade in selected phosphate products, 1972-73

	1972		1973[p]	
	(short tons)	($)	(short tons)	($)
Imports				
Calcium phosphate				
United States	27,010	2,833,000	24,782	2,898,000
Total	27,010 -	2,833,000	24,782	2,898,000
Fertilizers				
Normal superphosphate, 22% P_2O_5 or less,				
United States	642	20,000	4,949	155,000
Triple superphosphate, over 22% P_2O_5				
United States	45,855	1,898,000	19,689	1,063,000
France	9	1,000	6	7,000
Total	45,864	1,899,000	19,695	1,070,000
Phosphatic fertilizers, nes				
United States	60,878	3,741,000	40,075	3,451,000
Britain	689	201,000	554	159,000
Belgium-Luxembourg	13	3,000	515	96,000
Netherlands	79	13,000	40	6,000
Total	61,659	3,958,000	41,184	3,712,000
Chemicals				
Potassium phosphates				
United States	2,307	653,000	2,465	695,000
Total	2,307	653,000	2,465	695,000
Sodium phosphate tribasic				
United States	1,451	201,000	1,118	187,000
France	75	10,000	97	15,000

Table 6 (concl'd)

	1972		1973^p	
Imports (cont'd)	(short tons)	($)	(short tons)	($)
Belgium-Luxembourg	205	21,000	60	8,000
Germany West	–	–	3	3,000
People's Republic of China	6	...	–	–
Total	1,737	232,000	1,278	213,000
Sodium phosphate, nes				
United States	5,413	1,196,000	3,300	899,000
Germany West	94	28,000	63	25,000
Britain	5	3,000	–	–
Total	5,512	1,227,000	3,363	924,000
Exports				
Nitrogen-phosphate fertilizers, nes				
United States	614,216	37,689,000	495,363	33,760,000
Lebanon	16,212	690,000	79,653	4,626,000
Pakistan			40,649	4,071,000
India	51,424	2,960,000	45,569	3,054,000
Britain	2,701	171,000	2,986	301,000
Ireland	–	–	3,090	252,000
Japan	–	–	2,611	225,000
Yugoslavia	–	–	4,516	192,000
Nicaragua	–	–	1,878	148,000
Ivory Coast	–	–	2,854	121,000
Bermuda	–	–	61	3,000
Belgium and Luxembourg	11,576	492,000	–	–
New Zealand	5,612	330,000	–	–
Brazil	2,235	133,000	–	–
Total	703,976	42,465,000	679,230	46,753,000

Source: Statistics Canada.
– Nil; nes Not elsewhere specified; . . . Less than one thousand dollars.
^p Preliminary.

capable of producing single and/or triple superphosphate. Early in 1972, Canadian Industries Limited closed its superphosphate plant at Hamilton, Ontario; the plant had been operating since 1931.

Production, trade and consumption. Nearly all Canada's trade in phosphate fertilizers is with the United States, mostly in areas where plants are close to farming communities in the neighbouring country. Under foreign aid programs, shipments are occasionally made to southeast Asian countries.

Preliminary figures indicate that imports of phosphate rock rose 22 per cent over 1972 to a total of 3,678,617 tons; phosphate fertilizer production rose 9 per cent to 813,972 tons (P_2O_5 equivalent); and consumption of phosphate fertilizer (P_2O_5 equivalent) rose 22 per cent to 457,784 tons. Exports of fertilizer were up 10 per cent to 331,522 tons during the 1972/73 fertilizer year.

Outlook

Food specialists and agriculture experts predict that the world shortage of protein will persist beyond 1980. Two alternatives are open to the industrialized economy nations, i.e. supply the rest of the world with more food, or supply the lesser developed nations with fertilizer and equipment and thus equip them to grow their own food. Either way there will be a continuing and increasing demand for fertilizer, and Canadian manufacturers should be able to participate in this expanding market because of the availability of sulphur for the manufacture of acid and natural gas for ammonia used in the production of ammonium phosphate fertilizers.

Table 7. Canada, phosphate fertilizer consumption and trade, years ended June 30, 1964-73

	Consumption	Imports[1]	Exports
	(short tons P_2O_5 equivalent)		
1964	264,245	86,279	102,842
1965	293,758	66,604	97,207
1966	367,591	65,498	126,524
1967	412,214	73,936	138,133
1968	440,093	43,726	165,048
1969	347,813	24,054	161,051
1970	309,400	11,293	218,501
1971	359,781	11,421	338,779
1972	375,684	21,863	300,705
1973[p]	457,784	8,463	331,522

Source: Statistics Canada.
[1]Excludes nutrient content of mixtures and of orthosphoric acid.
[p]Preliminary.

Prices and tariffs

Prices of the three basic raw materials, phosphate rock, sulphur and natural gas, used in the manufacture of phosphate fertilizer have been rising since 1972. Farm prices have also risen and the increased cost of fertilizer is being passed directly to the farmer and indirectly to the ultimate consumer. Phosphate rock prices rose very sharply effective January 1, 1974 when the two major producers, Morocco and United States raised their prices as follows:

Morocco		Florida	
U.S. $ per tonne fas		U.S. $ per ton fob	
80% TPL	$50.00	77/76% TPL	$30.00
77%	$47.25	75/74%	$27.50
75%	$42.00	73/72%	$25.50
72%	$40.00	72/70%	$24.00
70%	$37.50	70/68%	$22.00
		68/66%	$20.00
		66/64%	$18.00

Source: British Sulphur Corporation Limited – Phosphorus and Potassium Number 68 – November/December 1973, p. 3

These prices were declared effective January 1, 1974 and are to be in effect for six months.

Phosphate rock prices are based upon the BPL content. Maximum limits of moisture, iron and alumina are specified and bonuses are paid and penalties assessed for variations above and below the base grade. Although much phosphate rock is supplied on a contract basis, price quotations serve as a reliable guide. Prices for phosphate fertilizers are usually based on the unit content or minimum analysis of the P_2O_5 equivalent, commonly expressed as an available phosphoric acid (apa).

The December 31, 1973 issue of Chemical Marketing Reporter listed the following prices:

	($)
Phosphate rock, Florida land pebble, run-of-mine, unground, bulk, carlots fob mines, per short ton	
(% BPL)	
66-68	9-15
68-70	10-16
70-72	10.50-18
74-75	13-21
76-77	16-23
Defluorinated phosphate, feed grade, 100-lb bags, carlots, fob Coronet, Fla., freight equalized, 18 per cent P, per short ton	72.25
Phosphoric acid, agricultural grade, fob works, per unit-ton*, 52-54 per cent apa	1.95
Superphosphate, run-of-pile, pulverized, bulk, carlots, fob works, per unit-ton, under 22 per cent apa	.80-.95

*A unit-ton is 2,000 pounds of 1 per cent of the basic constituent or other standard of the material. The percentage figure of the basic constituent multiplied by the price shown in OPD gives the price of 2,000 pounds of the material.

Phosphate rock and phosphate fertilizer materials enter Canada and the United States duty free.

Platinum Metals

J.J. HOGAN

The platinum group metals (platinoids) consist of platinum, palladium, rhodium, iridium, ruthenium and osmium. The major producers, ranked in decreasing order of production volume, are the U.S.S.R., Republic of South Africa and Canada. Minor producers are Colombia, the United States, Japan and the Philippines.

The platinum group metals are found in nature associated with basic and ultrabasic rocks and in placer deposits, although production from placers is of minor importance. A large quantity of platinum metals comes from mines worked principally for platinum metals, mainly in South Africa; a substantial amount is also recovered as a byproduct from the treatment of nickel-copper ores.

Most producers increased capacity rapidly during the 1960's. South African producers expanded their facilities because of a short supply situation during the sixties and an anticipated growth in demand in the seventies. Canadian capacity increased because platinoids are a byproduct of nickel-copper refining and Canadian nickel-copper processing facilities have undergone major expansion during the past few years.

There was a strong demand for platinum metals in 1973, based largely on the forthcoming use of these metals in catalytic converters, which will be required on most automobiles manufactured for the United States market in order to meet exhaust emission standards. To meet this greater demand, South African producers were expanding their capacity, although supplies were adequate to meet current market needs. Substantial stocks existed in consumer inventories, mainly in the United States but also in Japan and Europe.

Canadian production of platinum metals in 1973 was 288,000 ounces* valued at $34,274,000 compared with 406,048 ounces in 1972 valued at $34,656,545. Platinum metal output in Canada was directly related to nickel production which increased by about 4 per cent in 1973 over that of 1972. The large drop in the production of platinum metals was caused by the build up of these metals in the metallurgical circuit as a result of changes in the recovery process at one of the producers, and was of a temporary nature.

World mine production of the platinum group metals in 1973 was estimated at 5,049,000 ounces, an increase of 9.3 per cent over the 4,620,479 ounces produced in 1972. The two largest producers, the U.S.S.R. and the Republic of South Africa, accounted for over 93 per cent of world production.

Canadian operations and developments

The platinum metals produced in Canada were recovered as a byproduct from the treatment of the nickel-copper sulphide ores, principally those of Sudbury, Ontario and the Thompson-Wabowden region of Manitoba. The platinum metals concentrate in a nickel-copper alloy and sulphide matte produced during the smelting process. Following further processing of the smelter products and, finally, electrolysis, the platinum metals collect in the electrolytic tanks as sludge. The sludge from the operation of The International Nickel Company of Canada Limited (Inco) is shipped to its refinery at Acton, England for the extraction and refining of the platinum metals. Falconbridge Nickel Mines Limited ships nickel-copper matte from its Falconbridge, Ontario plant to its refinery in Kristiansand, Norway. The sludge collected from this operation is shipped to Engelhard Minerals & Chemicals Corporation at Newark, New Jersey for recovery of the contained platinum metals. The nickel refining process used by Sherritt Gordon Mines, Limited does not lend itself to economic recovery of platinum metals. In Canada, the metal ratios of the platinum group metals are approximately 46 per cent platinum, 40 per cent palladium and 14 per cent other platinum metals. Osmium is not produced in Canada.

In the Sudbury area of Ontario, Inco, the largest nickel producer, operated ten nickel-copper mines, three concentrators and a nickel-copper smelter in 1973. The company officially opened its new carbonyl nickel refinery at Copper Cliff, Ontario in 1973, and platinum metals were a byproduct of this operation. Elsewhere in Ontario, Inco operated a nickel refinery at Port Colborne and a mine-concentrator complex at Shebandowan near Thunder Bay. Falconbridge Nickel operated eight nickel-copper mines, three concentrators and one smelter in the Sudbury area.

Two small nickel mines came into production in 1973 in Ontario. The 700-ton-a-day capacity Langmuir mine, near Timmins, began shipping concentrates to Copper Cliff during the third quarter. A 500-ton-a-day producer, Kanichee Mining Incorporated, near

*The term "ounce" refers to "troy ounce."

Table 1. Canada, platinum metals production and trade, 1972-73

	1972		1973p	
	(troy ounces)	($)	(troy ounces)	($)
Production[1]				
Platinum, palladium, rhodium, ruthenium, iridium	406,048	34,656,545	288,000	34,274,000
Exports				
Platinum metals in ores and concentrates				
Britain	541,193	28,561,000	432,312	31,267,000
Norway	14,985	1,439,000	14,623	1,864,000
United States	101	4,000	203	18,000
Total	556,279	30,004,000	447,138	33,149,000
Platinum metals				
Britain	1,180	125,000	4,667	758,000
United States	18,343	1,103,000	8,668	659,000
Dominican Republic	–	–	45	5,000
Other countries	13	2,000	79	8,000
Total	19,536	1,230,000	13,459	1,430,000
Platinum metals in scrap				
United States	22,954	1,965,000	26,130	2,731,000
Britain	16,079	1,951,000	5,516	838,000
Total	39,033	3,916,000	31,646	3,569,000
Re-export[2]				
Platinum metals, refined and semiprocessed	33,376	4,542,000	49,762	5,248,000
Imports				
Platinum lumps, ingots, powder and sponge				
Britain	5,202	671,000	8,119	1,339,000
Switzerland	–	–	50	8,000
United States	–	–	2	–
Total	5,202	671,000	8,171	1,347,000
Other platinum group metals in lumps, ingots, powder and sponge				
Britain	26,306	1,534,000	26,500	2,259,000
South Africa	15,300	628,000	11,101	895,000
United States	911	25,000	13,357	816,000
Japan	–	–	4,823	338,000
Total	42,517	2,187,000	55,781	4,308,000
Total platinum and platinum group metals				
Britain	31,508	2,205,000	34,619	3,598,000
South Africa	15,300	628,000	11,101	895,000
United States	911	25,000	13,359	816,000
Japan	–	–	4,823	338,000
Switzerland	–	–	50	8,000
Total	47,719	2,858,000	63,952	5,655,000
Platinum crucibles[3]				
United States	29,835	4,685,000	25,265	4,072,000
Britain	4	. . .	–	–
Total	29,839	4,685,000	25,265	4,072,000

	1972		1973^p	
	(troy ounces)	($)	(troy ounces)	($)
Platinum metals, fabricated materials, not elsewhere specified				
Britain	29,941	2,918,000	23,575	3,532,000
United States	11,592	270,000	5,227	422,000
Total	41,533	3,188,000	28,802	3,954,000

Source: Statistics Canada.
[1]Platinum metals, content of concentrates, residues and matte shipped for export. [2]Platinum metals, refined and semiprocessed, imported and re-exported after undergoing no change or alteration. [3]Includes spinnerets and bushings.
[p]Preliminary; – Nil; . . . Less than one thousand dollars.

Table 2. Canada, platinum metals, production and trade, 1964-73

	Production[1]		Exports				Imports[4]	
			Domestic[2]		Re-export[3]			
	(ounces)	($)	(ounces)	($)	(ounces)	($)	(ounces)	($)
1964	376,238	25,404,117	408,792	20,812,514	581,779	20,888,749	221,557	17,369,291
1965	463,127	36,109,799	551,022	30,103,254	321,950	11,389,395	233,603	13,461,546
1966	396,059	32,370,064	441,625	25,800,000	199,152	11,779,822	197,853	14,930,000
1967	401,263	34,668,915	475,855	29,829,000	164,033	9,087,955	212,889	13,161,000
1968	485,891	46,199,718	584,942	38,068,000	83,228	8,254,753	207,961	17,077,000
1969	310,404	30,881,016	463,500	35,306,000	52,694	5,247,240	118,946	9,300,000
1970	482,428	43,556,597	650,066	43,174,000	20,399	2,365,735	60,745	3,123,000
1971	475,169	39,821,616	224,796	23,917,000	35,523	3,185,000	53,608	3,298,000
1972	406,048	34,656,545	614,848	35,150,000	33,376	4,542,000	47,719	2,858,000
1973^p	288,000	34,274,000	492,243	38,148,000	49,762	5,248,000	63,952	5,655,000

Source: Statistics Canada.
[1]Platinum metals, content of concentrates, residues and matte shipped for export. [2]Platinum metals in ores and concentrates and platinum metals, refined. [3]Platinum metals, refined and semiprocessed, imported and re-exported after undergoing no change or alteration. [4]Imports, mainly from Britain, of refined and semiprocessed platinum metals, derived from Canadian concentrates and residues, a large part of which is re-exported.
[p]Preliminary.

Temagami, started operations in the fourth quarter. Concentrates will be shipped to Falconbridge Nickel Mines Limited's smelter in 1974.

Three companies mined nickel-copper ores in Manitoba. Inco operated three mines and a concentrator-smelter-refining complex in the Thompson region. At Wabowden, Falconbridge Nickel operated a mine and concentrator and shipped the concentrates to its smelter at Falconbridge. Ore from Dumbarton Mines Limited in the Bird River area, was custom treated at the Werner Lake concentrator of Consolidated Canadian Faraday Limited in Ontario. The nickel-copper concentrate produced was shipped to the Falconbridge smelter.

In the Yukon Territory, the Wellgreen mine of Hudson-Yukon Mining Co., Limited, a 600-ton-a-day operation, near Kluane Lake, was closed in July. It had operated for about a year and produced a small amount of platinum metals in nickel-copper concentrates that were shipped to Japan.

World developments

Republic of South Africa. Producers of platinum metals in the Republic of South Africa, the largest supplier of platinum metals in the noncommunist world, were expanding production to meet the anticipated increase in general industrial use and to satisfy commitments made to the automotive industry of the United States, as well as to be in a position to fill any additional demands.

The Republic of South Africa is the only country that mines platinum-bearing ores primarily for the recovery of platinum metals. The deposits, which occur in the Merensky Reef horizon near Rustenberg, also contain some gold, copper and nickel. Platinum metals output contains approximately 70 per cent platinum, 25 per cent palladium and 5 per cent minor platinum-group metals. Small amounts of osmium and iridium were recovered as a byproduct from the treatment of gold ores.

Rustenberg Platinum Mines Limited, the largest platinum metals producer in the noncommunist world announced in 1972 that its production capacity was to be increased to 1,525,000 ounces a year by 1976. The company operated three mines in the Transvaal district, one in the Rustenberg section and two in the Union section. Production at these properties will be increased to 1,300,000 ounces. A new mine, Amandelbult, was being prepared for production at an initial annual capacity of 225,000 ounces. This operation will give the company flexibility to adjust to possible fluctuations in future demands. The refining of all material was handled by Matthey Rustenberg Refineries (Proprietary) Limited which was jointly owned by Johnson, Matthey & Co., Limited and Rustenberg. Processing operations were carried out in the Republic of South Africa and in Britain. Refining capacity was also being expanded to handle the increased mine output.

Impala Platinum Limited operated a mine-concentrator-refinery complex near Rustenberg. Capacity of the operation was 350,000 ounces of platinum metals a year, but after signing a ten-year contract in 1972 with General Motors Corporation to supply 300,000 ounces of platinum and 120,000 ounces of palladium a year over the life of the contract, the decision was made to increase yearly output to 650,000 ounces of platinum metals. In July 1973, the company announced that production capacity was to be increased to 950,000 ounces by the end of 1974.

The Middlehaal mine-concentrator-smelter complex of Western Platinum Limited, jointly owned by Lonrho Limited, Falconbridge Nickel and Superior Oil Company, operated a plant at a rated capacity of 150,000 ounces of platinum metals a year. Production began in 1971 and by 1973 had reached the rated capacity of the concentrator. To recover platinum, palladium and gold from the operation, a refinery with a rated capacity of 150,000 ounces a year was being built at Brakpan in the Transvaal. Residues containing other platinum group metals will be stockpiled for treatment at a later date.

Atok Platinum Mines (Proprietary) Limited, near Pieterburg, Transvaal announced that mine output would be increased to 35,000 ounces of platinum metals a year by 1975. The company reports that the orebody contains sufficient tonnage to support a large-scale mining operation but expansion would be undertaken only under an assured market position.

U.S.S.R. In the U.S.S.R., platinum metals were derived mainly as a byproduct from mining nickel ores in the Norilsk region of Siberia and the Kola Peninsula of northwest Russia. Small amounts of platinum were recovered from placer deposits in the Southern Urals. Output in 1973 was estimated at 2.5 million ounces of platinum metals, compared with an estimated production of 2.35 million ounces in 1972. Russia was carrying out a major expansion program at its nickel mines in the Norilsk district. The first phase of this program, the preparation of a new mine for production and the construction of a nickel smelter to treat the increased production, was expected to be completed in 1975. The second phase, which involves bringing another mine into production, was expected to be completed by 1980. Increased production of platinum group metals should follow increased nickel production. Palladium accounted for approximately 60 per cent of platinum group metals production and platinum about 30 per cent.

United States. Mine production of platinum metals in the United States was derived from placer deposits in the Goodnews Bay area of Alaska and as a byproduct of gold and copper refining. Some exploratory work was done on platinum occurrences in Montana.

Colombia. Production in Colombia was estimated at 26,000 ounces in 1973 and was obtained from placers in the Choco district.

Table 3. World mine production of platinum group metals

	1971	1972	1973^e
		(troy ounces)	
U.S.S.R.	2,300,000	2,350,000	2,500,000
Republic of South Africa	1,253,200	1,803,000	2,200,000
Canada	475,169	406,048	288,000
Colombia	25,610	26,000	26,000
United States	18,029	17,112	17,000
Other countries	12,102	18,319	18,000
Total	4,084,110	4,620,479	5,049,000

Source: Canadian production Statistics Canada. For other world producers, U.S. Bureau of Mines, *Minerals Yearbook 1972* for 1971 and 1972; U.S. Bureau of Mines Commodity Data Summaries, January 1974, for 1973.
1973.
^{e}Estimated.

Uses

The industrial uses of platinum group metals are based on special properties, the principal ones being catalytic activity, resistance to corrosion and to oxidation at elevated temperatures, good electrical properties, high melting point, high strength and good ductility and aesthetic qualities. Platinum and palladium are the major platinum metals. The others, iridium, osmium, rhodium and ruthenium, are mainly used as alloying elements with platinum and palladium, but small amounts are also used in special applications.

Platinum metal catalysts find wide application in the petrochemical, chemical and pharmaceutical industries. A major new use for platinum and palladium is in catalytic converters that are to be installed on automotive vehicles manufactured for sale in the United States to meet the exhaust emission standards established by the Environmental Protection Agency (EPA) to reduce air pollution. It has been estimated that each converter will contain about 0.05 ounce of the platinum metals, the ratio being about 70 per cent platinum and 30 per cent palladium. Platinum and palladium catalysts are currently used on a limited scale in emission control systems where clean exhausts are required, and in catalytic incineration systems for fume abatement.

The catalytic action of platinum metals is utilized in the petroleum industry for the production of high-octane gasolines. The platinum-catalytic exhaust control system requires lead-free gasoline because lead fouls the catalyst and reduces its effectiveness. To obtain a satisfactory octane rating in low-lead and unleaded gasoline requires further reforming and thereby will increase the demand for platinum alloy catalyst used in the process. A plantinum-rhenium catalyst is also used for reforming, but its use is restricted because the potential supply of rhenium is small.

A platinum-rhodium alloy is used in bushings in the manufacturing of fibre glass, in spinnerets in the production of synthetic fibres, in electric furnaces and in thermocouples.

Platinum metals have many other applications, such as in the computer field, for electrical and laboratory equipment and in the dental, jewelry and glass-making industries. Another application is in the cathodic protection of ships' hulls. A major use of palladium is in electrical contacts for telephone equipment. Because of its resistance to corrosion at high temperatures, iridium crucibles are used for the growing of laser crystals and synthetic gems.

Outlook

The short- and medium-term outlook for platinum metals is that supply will be adequate to meet demand. The automotive manufacturing firms in the United States have generally made commitments for the use of platinum metals for their exhaust emission control devices. It has been estimated that initially about 450,000-500,000 ounces of platinum and palladium a year will be required to meet this requirement. To satisfy this increased demand the producers in the Republic of South Africa are increasing their output and, by 1975, total rated plant capacity will be 2,660,000 ounces a year. Production of platinum metals in Canada and the U.S.S.R. is largely based on nickel output, and the supply to the market from these sources depends entirely on nickel production, and production of platinum metals from these countries does not react to supply-demand forces. In the Republic of South Africa the platinum-producing mines are worked primarily for their platinum metal content and the producers therefore can more readily adjust their output upwards or downwards to meet market requirements.

A number of automobile manufacturers in 1972 signed five- to ten-year agreements with the Republic of South Africa producers for the purchase of platinum and palladium for use in catalytic converters. Rustenberg altered the agreement with Engelhard and the Ford motor Company and will now supply 380,000 ounces of platinum and 120,000 ounces of palladium yearly for the period from 1975 to 77; and 360,000 ounces of platinum and 144,000 ounces of palladium yearly during 1978 to 79. Also, Rustenberg has signed an agreement with Toyota Motor Co. Ltd. of Japan to supply its platinum-palladium requirements for automobiles to be sold in the United States. Western Platinum has signed a five-year contract to supply Mitsubishi Corporation of Japan with 65,000-75,000 ounces of platinum a year and about one third of this amount of palladium. Johnson Matthey Chemicals Limited, which obtains its platinum metals from Rustenberg, has signed a three-year contract to supply Volkswagen AG with 50 per cent of its platinum requirements. General Motors has a contract with Impala for the purchase of 300,000 ounces of platinum and 120,000 ounces of palladium annually during the period from 1974 to 83.

In April 1973, the EPA granted automobile manufacturers a one-year extension for implementing the federal 1975 exhaust emission control standards on all automobiles manufactured for sale in the United States, with the exception of those for sale in California, but established modified interim standards. Automobiles manufactured for sale in California were required to meet the original emission control standards. General Motors has indicated it may install platinum-palladium catalytic converters on most of its U.S. models to ensure compliance with these interim standards. Ford also indicated that some of its automobiles manufactured in 1975 will be fitted with converters. Other manufacturers expect to use the converters on cars manufactured for the Californian market. The EPA extension will have a moderate effect on delaying the projected platinum metals consumption in catalytic converters but the medium-term outlook appears to be encouraging.

In July, the Canadian government announced new exhaust emission control standards for 1975 model cars in Canada that are less stringent than those adopted by the United States. Canadian standards will require a reduction of carbon monoxide emissions to 25 grams per vehicle-mile (gpm), hydrocarbon emissions to 2 gpm and nitric oxides emissions to 3.1 gpm. Catalytic converters will not be required to meet this standard but any cars manufactured in Canada for sale in the U.S. will require converters to meet the U.S. requirements.

Platinum metals recovered from secondary sources will play an important role in supplying the world demand, especially when catalytic converters are recycled.

Research is being done on the development of cheaper substitutes for use in converters and any success in this field would have a depressing effect on the long-term demand for platinum metals. Also, considerable research is being done to develop an engine that can meet the emission standards without a catalytic converter.

Prices

On February 14, 1973, the major producers of platinum group metals increased the price of most of the metals to compensate for the 10 per cent devaluation of the U.S. dollar. On June 6, South African producers raised the price of platinum metals to reflect the 5 per cent revaluation of the Rand announced on June 4. Towards the end of June, U.S. prices were lowered to those that existed before June 6, because of the U.S. price freeze order. On August 8, the U.S. palladium price was increased by approximately 12 per cent to $84 an ounce under Phase IV of the price and wage controls program of the United States government's Cost of Living Council. Under the same price and wage control program, the U.S. platinum price was increased on September 21, by about 5 per cent to $U.S. 150 an ounce. Price control restrictions in the United States were removed on December 6, and were followed by increases in the prices of iridium and rhodium. In 1973, U.S. prices for platinum and palladium increased by approximately 17 and 24 per cent, respectively, over the corresponding prices at the end of 1972, and the price of osmium remained unchanged. After an increase of 20 per cent in February, there was no further change in the U.S. price of ruthenium. A strong demand for iridium and rhodium resulted in a sharp rise in the price of these metals, iridium increasing from $U.S. 150 to $285 an ounce and rhodium from $195 to $270. The dealer prices for both these metals were substantially higher than the producer price, and year-end quotes were $525 for iridium and $425 an ounce for rhodium.

U.S. prices of platinum group metals, 1973

	Producers	Dealers
	(U.S. $ per troy ounce)	
Iridium		
January 1 – February 13	150-195	275-300
February 14 – June 5	220-225	260-300
June 6 – July 25	250-255	250-320
July 26 – September 20	220-225	450-500
September 21 – December 5	250-255	490-525
December 6 – December 16	250-255	520-570
December 17 – December 28	285-290	525-570
Osmium		
January 1 – June 6	200-225	150-175
June 7 – December 28	200-225	140-165
Palladium		
January 1 – February 13	68-70	62-69
February 14 – June 5	75-77	63-78
June 6 – June 27	80-82	78-82
June 28 – August 12	75-77	79-85
August 13 – December 28	84-86	80-85
Platinum		
January 1 – February 13	130-135	138-145
February 14 – February 21	150-155	140-156
February 22 – March 7	150-155	168-176
March 8 – June 5	150-155	137-160
June 6 – June 27	158-163	150-158
June 28 – July 18	150-155	154-161
July 19 – August 8	150-155	167-179
August 9 – September 20	150-155	160-167
September 21 – October 17	158-163	162-169
October 18 – October 31	158-163	165-178
November 1 – December 28	158-163	157-164
Rhodium		
January 1 – February 13	195-200	195-198
February 14 – June 5	220-225	212-218
June 6 – June 27	235-240	230-235
June 28 – September 19	220-225	230-235
September 20	220-225	255-260
September 21 – September 26	235-240	255-260
September 27 – December 16	235-240	375-450
December 17 – December 28	270-275	425-450
Ruthenium		
January 1 – February 13	50-55	58-60
February 14 – December 28	60-65	50-60

Source: Based upon *Metals Week*.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential*
36300-1	Platinum wire and platinum bars, strips, sheets or plates; platinum, palladium, iridium, osmium, ruthenium and rhodium, in lumps, ingots, powder, sponge or scrap	free	free	free	free
48900-1	Crucibles of platinum, rhodium and iridium and covers therefore	free	free	free	free

*General Preferential Tariff rate from July 1, 1974 to June 30, 1984

United States

Item No.		Rate of Duty
601.39	Precious metals ores	free
605.02	Platinum metals, unwrought, not less than 90% platinum	free
		On and After Jan. 1, 1972
605.03	Other platinum metals, unwrought	20
605.05	Alloys of platinum, semimanufactured, gold-plated	25
605.06	Alloys of platinum, semimanufactured, silver-plated	12
605.08	Other platinum metals, semimanufactured, including alloys of platinum	20
605.60	Platinum leaf	20

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division Ottawa; Tariff Schedules of the United States, Annotated (1972) TC Publication 452.

Potash

J.Y. TREMBLAY

World production of potash (K_2O equivalent)* increased 6 per cent in 1973 over 1972 but, owing to accelerated demand, was unable to meet world requirements and as a consequence inventories declined. Even though world production capacity was rated at 30 million tons in 1973, only 21 million tons were produced; this was due to a rapid turn-around from oversupply to scarcity, coupled with unpreparedness of spare capacity and lags in transportation.

Production and developments in Canada

Production in the Canadian industry, responding to increased demand, was 8 per cent higher than in 1972. In 1973, sales exceeded production, and inventories were reduced to about 10 per cent of annual production.

According to Saskatchewan Department of Mineral Resources figures, 1973 potash production was increased by about 350,000 tons K_2O over 1972 production. Preliminary data from Statistics Canada also show an increase in shipments of 15 per cent over the year, to a value of $151,123,000. Mine and plant capacity utilization averaged 56 per cent throughout the year. Also, a prolonged Canadian railway strike reduced potash deliveries in late summer and early fall.

Although almost 75 per cent of total Canadian exports of potash went to the United States in 1973, some important sales were made offshore by Canpotex Limited, the offshore sales agent for Canadian potash. In October and December, Canpotex sold a total of 320,000 metric tons of potash to the People's Republic of China. Other important offshore sales include 450,000 metric tons to India and 650,000 tons a year to Japan for five years. A number of new offshore markets were penetrated; among these were South Africa, Pakistan, Cuba, Chile and Bangladesh.

Shamrock Chemicals Limited started a 240-ton-a-day potassium sulphate plant at Port Stanley, Ontario in 1972 but, because of environmental problems, the plant was inoperative during most of 1973.

The Potash Company of America (PCA) was granted an exploration lease by the New Brunswick government to explore a potash occurrence near Sussex with an option to develop a mine if feasible. To date, the company has completed eleven drill holes and is preparing to carry out further exploration. The geographical location of this deposit would allow penetration of the east coast markets of North America.

Government action

Production allowables set by the Saskatchewan government under the prorationing plan were raised three times during 1973 as forecasted demand for potash was revised upwards.

The provincial government has expressed dissatisfaction at Canada's share of world markets which is about 20 per cent while production capacity in Canada is 29 per cent of world total. The government feels that the industry should be more aggressive in its marketing policies without necessarily resorting to price-cutting. As of October 1, 1973 the prorationing fee was raised from 60 cents a ton of potash produced to $1.20; the increased fee should yield a total of about $10 million a year to Saskatchewan. Mine owners will, in future, be required to file precise financial details of their operations with the Saskatchewan government, and the provincial authorities have announced that until a sound plan for provincial government participation in the industry has been implemented no new mining or milling capacity will be authorized.

Table 1. Potash production allowables

Fertilizer Year	Date of Allowables Schedule	Total Allowables S. Tons K_2O	Industry % Capacity[1]
1971-72	Sept/71	4,008,200	48.2
1971-72	Mar/72	4,008,200	48.2
1972-73	Jun/72	4,316,153	52
1973-74	Jun/73	4,910,686	59
1973-74	Oct/73	5,221,786	63
1973-74	Nov/73	5,705,008	68.5

Source: Saskatchewan Department of Mineral Resources.
[1] Based on a total capacity of 8,324,200 s. tons K_2O.

*K_2O equivalent x 1.64 equals muriate of potash (KCl product). Unless otherwise noted, potash tonnages are in short tons of K_2O equivalent.

Table 2. Canada, potash production, shipments and trade, 1972-73

	1972		1973p	
	(short tons)	($)	(short tons)	($)
Production, potassium chloride				
Gross weight[1]	7,082,000	. .	8,625,000	. .
K_2O equivalent	4,329,457	. .	4,684,179	. .
Shipments				
K_2O equivalent	3,852,120	135,512,850	4,432,000	151,123,000
Imports, fertilizer potash				
Potassium chloride				
United States	69,120	1,699,000	103	38,000
West Germany	15	5,000	6	2,000
Total	69,135	1,704,000	109	40,000
Potassium sulphate				
United States	20,517	862,000	25,190	1,107,000
Potash fertilizer, nes				
United States	28,833	628,000	49,416	1,131,000
Potash chemicals				
Potassium carbonate	1,211	217,000	1,165	212,000
Potassium hydroxide	1,812	365,000	1,918	349,000
Potassium nitrate	6,105	656,000	3,077	487,000
Potassium phosphate	2,307	653,000	2,465	695,000
Potassium bitartrate	69	48,000	120	88,000
Potassium silicates	916	174,000	1,041	167,000
Total, potash chemicals	12,420	2,113,000	9,786	1,998,000
Exports, fertilizer potash				
Potassium chloride				
United States	4,666,454	107,291,000	5,751,988	133,542,000
Japan	627,068	15,027,000	663,808	16,028,000
Belgium-Luxembourg	201,570	4,741,000	390,708	8,096,000
India	191,903	4,641,000	237,763	6,509,000
Korea, South	146,547	3,388,000	218,366	5,600,000
Brazil	156,427	4,039,000	149,208	3,035,000
Singapore	47,659	1,206,000	87,641	1,929,000
Australia	95,395	2,140,000	75,942	1,697,000
People's R. China	15,631	482,000	58,652	1,368,000
New Zealand	62,958	1,568,000	34,982	1,220,000
Italy	17,546	370,000	34,556	1,160,000
Taiwan	32,749	995,000	35,882	903,000
Bangladesh	–	–	21,952	863,000
Other Countries	76,019	1,595,000	97,274	1,956,000
Total	6,337,926	147,483,000	7,858,722	183,906,000

Source: Statistics Canada; Saskatchewan Department of Mineral Resources for K_2O production figures.
[1] Based on a conversion factor of K_2O x 1.64 for standard, special standard, granular and coarse grades, and K_2O x 1.60 for soluble and chemical grades.
p Preliminary; – Nil; . . Not available.

The $2 million claim for damages and the suit to have the prorationing regulations declared ultra vires filed by Central Canada Potash Co. Limited against the Saskatchewan government in December 1972 are still pending. The federal government joined Central Canada Potash as plaintiff in seeking a court declaration that the Potash Conservation Regulations of 1969 are ultra vires.

On the American scene, final antidumping revocations concerning Kalium Chemicals Limited, PCA, International Minerals & Chemical Corporation (IMC) and CF Industries Inc. were obtained in May from the U.S. Treasury Department. It is expected that Cominco Ltd. will also apply for revocation of dumping levies.

Transportation

The rail freight from the mines in Saskatchewan to the port of Vancouver is $9.18 a short ton of KCl. On January first, loading charges for potash at Vancouver were increased from $1.14 a short ton to $1.50. The chartering of vessels for wheat movement and the oil crisis have pushed ocean freight rates up. Following the award of a major potash contract in South Korea, Canadian shippers had to pay rates of $14 a ton in November 1973; more than three times the rate charged in July 1972. The rate from Vancouver to the east coast of India was $28 a ton in September, compared with $22.50 in April; on the spot market, this rate moved sharply from $28 to $39 a ton in the space of

Table 3. Canada, potash production and sales by grade[1] and destination, 1972-73

	1973							
	Standard	Special Std.	Coarse	Granular	Soluble	Chemical	Total	1972
	(short tons of K_2O equivalent)							
Production	1,181,779	287,292	1,617,827	1,039,940	477,861	79,480	4,684,179	4,329,457
Sales								
Domestic	22,835	–	175,456	10,259	3,644	236	212,430	219,769
United States	657,489	7,710	1,546,229	1,022,234	372,705	76,645	3,683,012	2,797,018
Offshore								
Australia	5,607	–	21,935	26,992	–	–	54,534	54,934
Bangladesh	–	–	6,544	3,938	–	–	10,482	–
Belgium	68,208	154,527	7,576	19,711	–	–	250,022	135,787
Brazil	1,911	–	73,781	–	–	–	75,692	88,079
Chile	17,571	–	–	–	–	–	17,571	–
China	27,432	–	–	–	–	–	27,432	18,025
Cuba	2,751	–	–	–	–	–	2,751	–
England	–	–	–	–	–	998	998	700
France	13,555	4,910	24	5,963	9,269	–	23,853	13,450
India	191,286	–	4,847	–	1,403	–	197,536	135,511
Indonesia	16,731	–	–	–	–	–	16,731	4,684
Italy	10,758	–	–	–	10,909	–	21,667	10,949
Japan	57,031	182,383	28,595	350	137,710	126	406,195	396,218
Korea, South	134,311	–	–	–	3,402	–	137,713	74,037
Malaysia	30,166	267	518	496	–	–	31,447	34,235
Netherlands	3,255	–	–	–	–	–	3,255	–
New Zealand	47,195	–	–	–	–	–	47,195	38,044
Pakistan	–	–	–	2,010	–	–	2,010	–
Philippines	17,308	–	7,676	–	–	–	24,984	36,396
Singapore	6,182	–	–	343	–	–	6,525	12,570
South Africa	–	–	3,060	–	–	–	3,060	–
Taiwan	20,077	–	–	–	–	–	20,077	18,397
Thailand	–	–	–	–	–	–	–	67
Offshore Total	671,335	332,267	154,508	59,803	162,693	1,124	1,381,730	1,072,083
Total sales	1,351,659	339,977	1,876,193	1,092,296	539,042	78,005	5,277,172	4,088,870

Source: Saskatchewan Department of Mineral Resources, Monthly Potash Report.
[1]Common specifications are: standard -28 to +65 mesh, special standard -35 to +200 mesh, coarse -8 to +28 mesh, granular -6 to +20 mesh, each grading a minimum of 60 per cent K_2O equivalent; soluble and chemical grade a minimum of 62 per cent K_2O equivalent.
– Nil.

six weeks as charters had to compete with booming exports of sulphur, grain and timber.

Prices

The floor price set under the Saskatchewan prorationing plan has remained unchanged at 33.75 Canadian cents a short-ton unit K_2O since it was introduced in 1970.

Posted prices

Grade and %K_2O min.	Jan.	Feb.-June	July-Aug.	Sept.-Jan./74	Feb.-June/74
	(cents/short-ton unit)				
Standards 60-62	33.75	35.	34.	47.	52.
Coarse 60-62	39.	42.	37.	50.	55.
Granular 60-62	40.	43.	39.	52.	57.
Soluble 62	36.	38.	35.	50.	55.

The prices shown above are for muriate of potash, in bulk, carload lots, fob mine Saskatchewan, a unit (20 lb.) K_2O; they indicate a certain degree of price-cutting in the last part of the year but prices have broken away from the floor-price level. Canpotex concluded a number of major sales in the $45-$50-a-ton range fob Vancouver late this year, compared with $35 a ton in January, reflecting a heavy demand for the product.

Realized prices based on monthly potash report[1]

Grade	Jan./73	Feb.-June/73	July-Aug./73	Sept.-Dec./73
	(cents/short-ton unit)			
Standard	34.8	35.4	36.3	35.9
Coarse	35.2	36.9	36.4	38.7
Granular	34.9	37.7	36.9	40.1
Soluble	35.6	35.0	35.6	38.7

[1] 1973 calendar year.

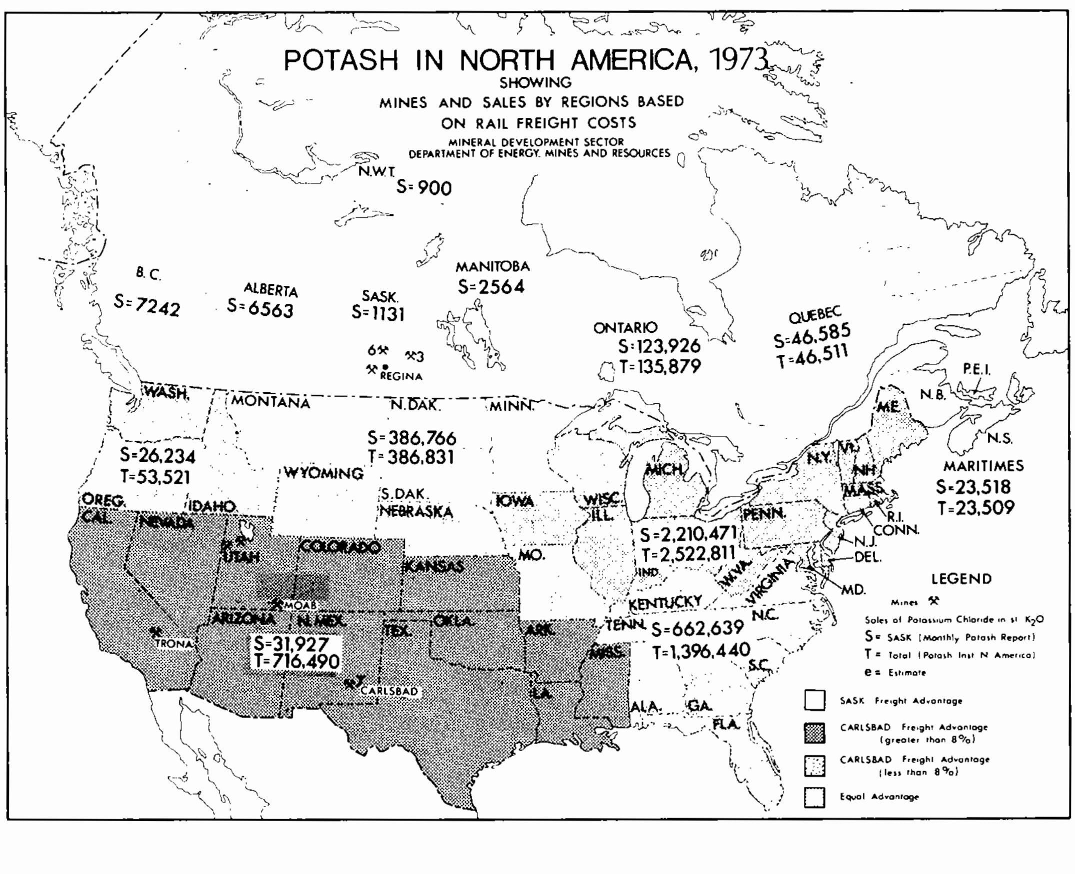


Table 4. Canada, potash production and trade, years ended June 30, 1964-73

	Production	Imports[1]	Exports
	(short tons K_2O equivalent)		
1964	747,257	58,115	638,749
1965	1,176,408	49,780	983,556
1966	1,927,843	34,522	1,676,174
1967	2,204,231	38,090	2,004,504
1968	2,971,206	32,900	2,723,471
1969	3,085,995	24,600	2,620,672
1970	3,930,662	27,020	3,648,384
1971[r]	3,422,430	28,010	3,319,284
1972	4,151,105	52,052	3,974,278
1973	3,994,685	69,009	3,889,330

Source: Statistics Canada, Fertilizer Trade.
[1]Includes potassium chloride, potassium sulphate and sulphate of potash magnesia, except that contained in mixed fertilizers.
[r]Revised.

World review

Manufacturers of fertilizer products confirmed that potash was in relatively tight supply during 1973 although no shortage existed. The industry as a whole appears to be ill-equipped to meet sudden pressures upon its supply capability. A number of smaller potash mines have been shut down, and industrial problems in certain countries have held production to a 2½ per cent annual growth rate. Substantial increases in output have been achieved by the U.S.S.R., France and Canada who, together with smaller producers, added about 1.2 million metric tons of K_2O to world supply, most of this tonnage coming from existing mines. Five new mines started operations in 1973 and, together with expansions at existing mines, represented a combined nominal capacity of 2.4 million metric tpy of K_2O; however, the additional output from the new facilities amounted to only 0.5 million metric tons of K_2O in 1973 since about 25 per cent of the new capacity went into replacing production from mines that had shut down. Eastern Europe produces 39 per cent of world potash, the U.S.S.R. being the largest potash producing country in the world.

The total amount of potash traded throughout the world in the 1972/73 fertilizer year reached 8.14 million metric tons of K_2O, an increase of 700,000 tons over the previous year. The bulk of the growth of exports came mainly from West Germany and the United States.

Table 5. Canada, summary of potash mines and production allowables for fertilizer year 1973-74[1]

Company	Production Capacity		Production[2] Allowable
	KCl	K_2O eq.	
	(Short tons yearly)		(St. K_2O eq.)
International Minerals & Chemical Corporation (Canada) Limited	3,820,000	2,330,000	1,792,954
Kalium Chemicals Limited	1,500,000	937,500	598,404
Potash Company of America	760,000	460,000	300,428
APM Operators Ltd.	1,500,000	912,700	580,835
Alwinsal Potash of Canada Limited	1,000,000	600,000	401,863
Duval Corporation of Canada	1,200,000	732,000	490,024
Cominco Ltd.	1,200,000	720,000	473,784
Central Canada Potash Co. Limited	1,500,000	900,000	550,724
Hudson Bay Mining and Smelting Co., Limited	1,200,000	732,000	515,992
Total	13,680,000	8,324,200	5,705,008

[1]All mines are in Saskatchewan; fertilizer year refers to 12 months July 1, 1973 to June 30, 1974.
[2]Production allowable figures according to Schedule 1, November 1, 1973; Saskatchewan Department of Mineral Resources.

Europe. Most of the European potash industry has been going through a rationalization program over recent years and, in 1973, two new mines started production; one in England and the other in East Germany.

Western Europe. In West Germany, potash production was increased by 100,000 metric tons, and the closure of the Buggingen mine in April reduced the number of active mines to ten without affecting total capacity.

Italian potash capacity is about 5 million tons a year. This country is a major producer of potassium sulphate, and a new plant was brought on stream at Pasquasia in September with a nominal capacity of 125,000 tons K_2O a year; aside from this new plant in Sicily, no large expansions are foreseen. Italy is increasing in importance as a market for potassium chloride.

The United Kingdom will be entering the producers' market when the potash mine at Boulby comes on stream at the end of 1974, with an annual capacity of 1 million tons of KCl. The opening of the Boulby mine will bring the number of potash producing countries in the world to eleven and will lower the U.K.'s import requirements considerably. The British domestic market represents 800,000 tons a year; one third of which comes from East Germany, the remainder being from West Germany, the U.S.S.R., Canada and France. For many years prior to the European Economic Community's enlargement, the majority of Canadian exports entered the United Kingdom duty free under the British Preferential Tariff, but Canada lost its preferred access to British markets.

Table 6. Canada, consumption of potash fertilizers, years ended June 30, 1964-73

	In Materials	In Mixtures	Total
	(short tons of K_2O equivalent)		
1964	14,087	106,609	120,696
1965	18,264	117,142	135,405
1966	20,644	135,695	156,339
1967	27,806	150,336	178,142
1968	34,771	148,329	183,100
1969	40,967	144,560	185,527
1970	40,475	152,004	192,479
1971	46,831	156,362	203,193
1972[r]	48,340	226,057	274,397
1973	45,974	164,246	210,220

Source: Statistics Canada.
[r]Revised.

In Spain, the present level of potash capacity is about 750,000 tons a year of K_2O, but expansion plans at Catalonia will increase this level to 1.3 million tpy by 1975; most of this increase in production will go towards satisfying domestic demand.

The French potash industry suffered a substantial loss of production because of a miners' strike in 1972. The 420,000 metric tons K_2O of additional output in 1973 can be attributed partly to a recovery from this loss and partly to expansions in Alsace. French potash production was restricted to 2 million metric tons K_2O in 1973 due to environmental constraints. France also has a potash operation in the Congo.

Eastern Europe. Very large expansions took place in the Russian potash industry in the 1960's but, in 1973, numerous delays occurred in the schedules for completing new mining operations. By 1975, production is expected to have increased to 8.2 million tons K_2O a year. About two thirds of the exports currently go to East European markets, mostly to Poland, and about 20 per cent to western Europe.

In East Germany, the present level of production is 2.5 million metric tons K_2O a year and expansions are focussed on export markets. At Zielitz, one of the largest European potash mines was finally brought on stream in 1973 and output should be 200,000 metric tons K_2O in 1973; full nominal capacity of 900,000 tons K_2O a year should be achieved after 1975. The old Stassfurt mine was officially shut down.

United States. The United States is one of the five largest producers of potash in the world, but domestic production now supplies less than half the country's needs. Moreover, there is an underlying downward trend in production as the better reserves in New Mexico become exhausted, and the closure of the Teledyne mine in May 1973, while unimportant in terms of tonnage, was a significant indicator of this trend. Any loss in output from the U.S. is expected to be taken up by producers in Saskatchewan. However, in the present tight supply situation for potassium sulphate, the reserves of langbeinite ore in the Carlsbad area are attracting interest. Norandex Inc., a U.S. subsidiary of Noranda Mines Limited, has applied to the authorities of New Mexico for permission to begin test drilling on a property near Carlsbad. The reconstructed solution mine of Texasgulf Inc. in Utah appears to have been producing satisfactorily since it was started up in 1972.

Middle East. In Israel, the potash capacity has been 1 million tpy of sylvite with only one producer; The Dead Sea Works. In 1973, planning for a production level of 1.3 million tpy KCl has been started. Most of the Israeli potash exports go to North America and Asia.

Oceania. Australian potash production, which is small, started this year from the Lake Macleod evaporite deposit; the deposit has been producing common salt since 1968, but this year a potash refinery was added to the complex. The plant produces 45,000 tons a year K_2O equivalent in the form of langbeinite, a potassium magnesium sulphate with a content of 22 per cent K_2O. A solution mining method is used along with concentration by solar evaporation. Lake Macleod will be the first indigenous source of potash for Australia. The operator, Texada Mines Ltd. is expected to concentrate on export markets in Japan and New Zealand, aiming at consumers requiring a chloride-free potash fertilizer.

Africa. The Congolese operation is controlled by the French potash industry and has an annual capacity of 500,000 metric tons K_2O. Production in 1973 reached only 266,000 tons because of operational difficulties.

Table 7. Canada, potash deliveries by product and area, 1972-73

		Agriculture						
		Potassium Chloride						
		Standard	Coarse	Granular	Soluble	Potassium Sulphate	Total Agriculture	Industrial
		(short tons of K_2O equivalent)						
Atlantic Provinces	1972	–	18,874	1,227	–	1,112	21,213	–
	1973	3,012	20,497	–	–	671	24,180	–
Quebec	1972	14,983	55,468	896	–	4,205	75,552	334
	1973	9,039	37,360	112	–	2,156	48,667	326
Ontario	1972	11,185	112,563	3,546	142	10,679	138,115	4,804
	1973	16,041	118,346	1,330	162	10,981	146,860	4,558
Prairie Provinces	1972	6,679	1,762	3,208	3,028	145	14,822	5,007
	1973	583	2,454	3,823	724	19	7,603	2,671
British Columbia	1972	123	2,102	1,046	90	335	3,696	121
	1973	298	1,854	2,924	39	212	5,327	144
Northwest Territories	1972	–	–	–	–	–	–	–
	1973	–	–	–	–	–	–	901
Totals	1972	32,970	190,769	9,923	3,260	16,476	253,398	10,266
	1973	28,973	180,511	8,189	925	14,039	232,637	8,600

Source: Potash Institute of North America.
– Nil.

Table 8. World potash production, sales and inventories, 1971-73

	1971[r]		1972[r]		1973[p]	
	Production	Sales	Production	Sales	Production	Sales[1]
	('000 metric tons K_2O equivalent)					
U.S.S.R.	4,807	4,680[e]	5,433	5,300[e]	5,900	5,235[e]
Canada	3,573	3,606	3,928	3,703	4,249	4,785
Germany, East	2,443	2,452	2,458	2,460[e]	2,550	2,460
Germany, West	2,443	2,363	2,449	2,474	2,548	2,592
United States	2,347	2,385	2,412	2,347	2,360	2,487
France	1,850	1,850[e]	1,610	1,650[e]	2,031	. .
Israel	568	560	579	546	570	546
Spain	505	506	533	534	473	538
Congo	258	252	284	273	266	. .
Italy	150[e]	150[e]	150	150[e]	133	180[e]
Others	21	–	24	–	30	–
Total	18,965	18,804	19,860	19,437	21,110	. .

Year-end producer inventories

	1971	1972	1973
U.S.S.R.	1,000	1,100	. .
Canada	683	1,040	. .
United States	388	425	272
East Germany[e]	225	200	. .
West Germany[e]	80	80	. .
France	96	80	. .
Israel	60	60	. .
Others[e]	80	80	. .
Total	2,612	3,065	. .

Sources: Saskatchewan Department of Mineral Resources, U.S. Bureau of Mines and the *Journal of World Phosphorus and Potassium.*
[p]Preliminary; [e]Estimated; [r]Revised; . . Not available.
[1]Sales figures are for fertilizer year July 1972-June 1973, except U.S.S.R., Canada and East Germany. 2,056 represents the estimated combination of sales by France and Congo.

Outlook

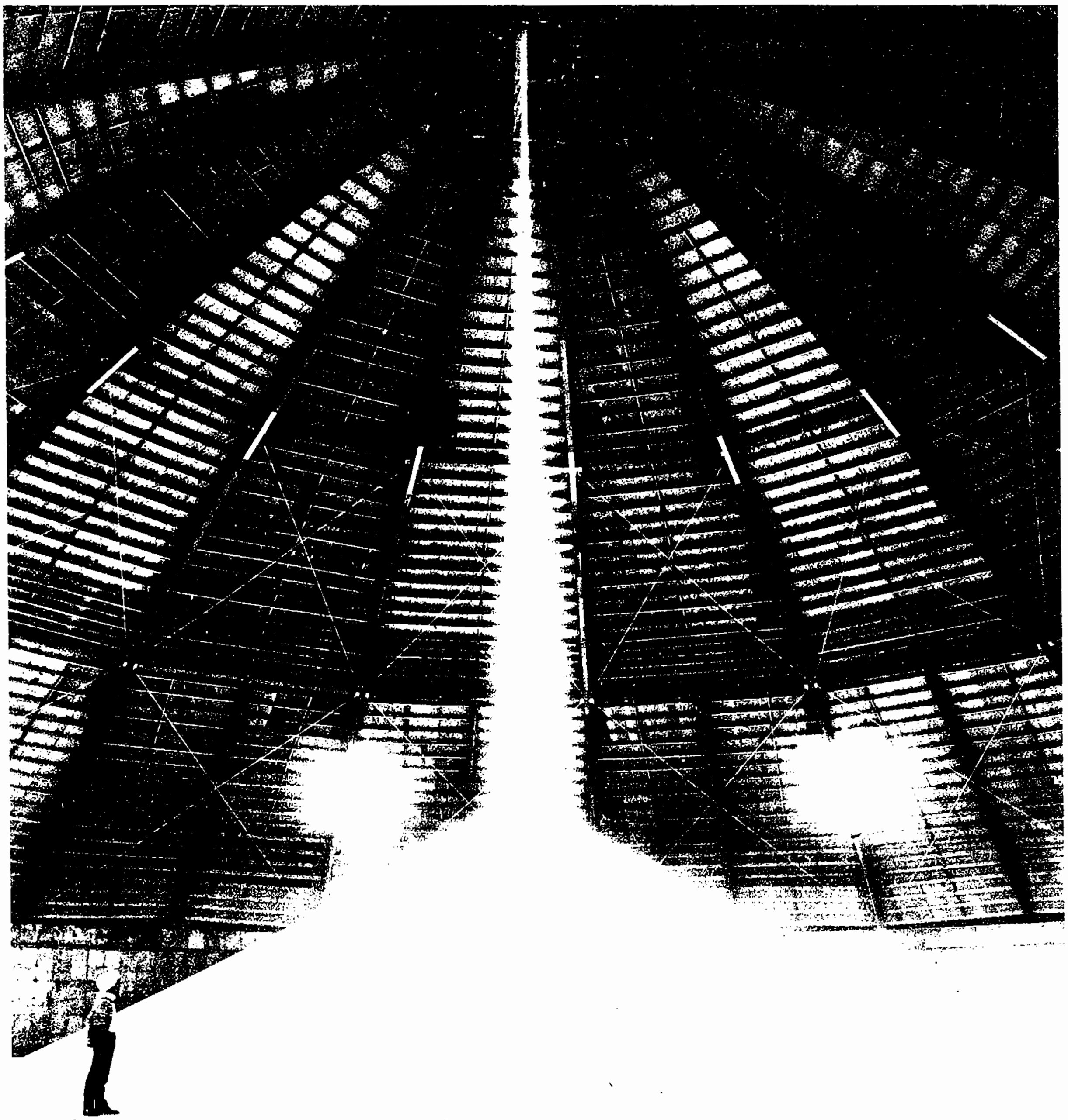
With potash in tight supply for the last two years, there is a growing interest in additional sources of supply. Substantial reserves of unemployed capacity equivalent to 3 million tons K_2O a year exist in Canada and several projects have been delayed to the extent that their effect on supply will not be felt before 1974-75. It must be anticipated that the new mines brought on stream in 1973 will make a greater impact on world supply over the next two years. The current shortages of nitrogen and phosphates may have a moderating effect on increased potash sales, the other two nutrients along with potash being required for the manufacture of mixed fertilizers. Potash demand is likely to increase at a rate of 5 per cent a year. Competition from Russia and East Germany is expected to be small as each is busy satisfying domestic demand.

The Canadian industry holds the key to world potash availability, and investments are now underway to raise effective capacity in Canada. It is expected that Canadian mines will operate at over 60 per cent of capacity in the next year. Steady increase in utilization of production capacity of the potash mines in Saskatchewan is expected.

Table 9. Canada, potash sales by destination

	1972	1973
	(short tons K_2O equivalent)	
Canada		
Alberta	15,315	6,563
British Columbia	16,910	7,243
Manitoba	1,662	2,564
New Brunswick	6,532	12,297
Nova Scotia	2,428	3,397
Ontario	128,661	123,926
Prince Edward Island	1,538	7,823
Quebec	43,630	46,586
Saskatchewan	594	1,131
Northwest Territories	2,130	900
Total Canada	219,400	212,430
United States		
Alabama	56,788	54,384
Arizona	–	126
Arkansas	580	1,146
California	91	–
Colorado	1,349	1,539
Connecticut	2,521	4,351
Delaware	35,736	35,618
Florida	53,924	76,229
Georgia	77,468	108,961
Hawaii	1,734	6,188
Idaho	4,414	2,235
Illinois	443,371	639,598
Indiana	291,147	461,343
Iowa	320,947	380,132
Kansas	2,001	4,904
Kentucky	59,505	69,976
Louisiana	950	3,534
Maine	12,289	12,177
Maryland	43,608	49,778
Massachussetts	2,567	3,990
Michigan	138,015	145,312
Minnesota	303,738	346,154
Mississippi	16,668	17,726
Missouri	41,092	64,750
Montana	55,178	5,284
Nebraska	20,624	29,395
New Hampshire	120	352
New Jersey	13,542	16,200
New Mexico	208	120
New York	140,518	145,090
North Carolina	48,131	70,584
North Dakota	11,790	21,307
Ohio	239,718	358,787
Oklahoma	(512)	92
Oregon	5,339	4,902
Pennsylvania	46,032	63,636
Rhode Island	1,736	2,251
South Carolina	50,520	70,182
South Dakota	8,600	14,021
Tennessee	27,026	41,197
Texas	12,523	2,638
Utah	30	104
Vermont	5,447	5,597
Virginia	54,529	75,471
Washington	12,298	19,097
West Virginia	2,626	3,469
Wisconsin	198,680	241,576
Wyoming	794	1,509
Others	–	–
Total United States	2,790,745	3,683,012
Offshore		
Australia	54,934	54,533
Bangladesh	–	10,482
Belgium	135,787	250,022
Brazil	88,079	75,692
Chile	–	17,571
China	18,025	27,432
Cuba	–	2,751
England	700	998
France	13,450	23,853
Holland	–	3,255
India	135,511	197,537
Indonesia	4,684	16,731
Italy	10,949	21,667
Japan	396,218	406,195
Korea, South	74,037	137,714
Malaysia	34,235	31,447
New Zealand	38,044	47,194
Pakistan		2,010
Philippines	36,396	24,984
Singapore	12,570	6,525
South Africa	–	3,060
Taiwan	18,397	20,077
Thailand	67	–
Total offshore	1,072,083	1,381,730
Grand total	4,082,428	5,277,172

Source: Saskatchewan Department of Mineral Resources, Monthly Potash Report.
– Nil.



A beehive-shaped 85-ft. high storage building, being filled with potash at Kalium Chemicals Limited, Belle Plaine, Sask. The building, 190 feet in diameter, can store 40,000 tons of potash.

Rare Earths

C. J. CAJKA

The rare earth elements, sometimes called the lanthanons or lanthanides, are a group of 15 chemically similar metals having atomic numbers 57 to 71 in Group III of the periodic table of elements. Scandium and yttrium are similar to the rare earth elements in many respects and are usually classed with them.

These elements are neither rare nor earths. By comparison, cerium is more abundant than tin or cobalt and almost three times as abundant as lead. Thulium, less common than all other rare earths except promethium, is more abundant than silver, gold, and platinum combined. The metals were originally classified "rare" because they are seldom concentrated in nature like most other elements and their widespread occurrence in the earth's crust was recognized only in recent times. The term "earth" is derived from earlier terminology when insoluble oxides, the common compounds of rare earths, were simply referred to as earths.

Lanthanon-bearing minerals contain all members of the rare earth elements, but either the light (cerium) group or the heavy (yttrium) group predominates in each mineral. The rare earth metals are typically associated with alkaline complexes and pegmatites; and secondary concentration can occur in placer, beach sand and phosphatic sedimentary deposits. Commercial production has been derived from carbonatite occurrences, placer and beach sand deposits, uranium ores and phosphatic rocks. The relative abundance of the various rare earths in the ores presently being mined is not directly related to the market demand for the individual products. As a result, some rare earth products are readily available at low cost, while others, particularly high-purity metal and compounds, are considerably more expensive. Research continues to explore the properties of the rare earth metals to identify potential new markets but, for some, no significant use has yet been found. Development has proceeded, first, to find markets for those compounds that are available and, second, to find and develop sources of supply to meet changing industrial requirements.

Noteworthy advances in new markets have occurred at two to three year intervals for the past decade. Beginning with the traditional cigarette lighter flints and carbon-arc markets, new uses have grown in glass polishing compound, petroleum catalyst, television tube phosphor, nodular iron, high-strength low-alloy steel and high-strength magnet applications.

When colour television was initially introduced, the forecast for europium and yttrium consumption in phosphors was optimistic and this optimism led to overproduction by 1967. Part of the problem was a slower than anticipated growth in the TV market. A second factor was the overestimate of the quantity of rare earth metals to be used in each television set. Canadian production since 1967 has undergone drastic adjustments; yttrium concentrate suppliers have reduced shipments each successive year until 1971 when deliveries stopped. Shipments of yttrium concentrate from one Canadian producer were resumed in 1973.

New markets for specific members of the rare earth group have resulted in increased production of all rare earth metals because of their natural association in ores. Similarly, production costs for some rare earth members, byproducts of the refining process, have diminished. Availability and declining costs have been important factors in the development of new uses. There is growing optimism that the rare earth metals industry will expand at a steady rate now that several markets are well established.

Table 1. Rare earth elements

Atomic No.	Name	Symbol	Abundance in Igneous Rocks
	Light rare earths		(parts per million)
21	Scandium	Sc	5.0
57	Lanthanum	La	18.3
58	Cerium	Ce	46.0
59	Praseodymium	Pr	5.5
60	Neodymium	Nd	23.8
61	Promethium	Pm	(not measurable)
62	Samarium	Sm	6.5
63	Europium	Eu	1.1
64	Gadolinium	Gd	6.3
	Heavy rare earths		
39	Yttrium	Y	28.0
65	Terbium	Tb	0.9
66	Dysprosium	Dy	4.5
67	Holmium	Ho	1.1
68	Erbium	Er	2.5
69	Thulium	Tm	0.2
70	Ytterbium	Yb	2.6
71	Lutetium	Lu	0.7
		Total	153.0

Canadian industry

From 1966 to 1970, the world's major source of yttrium concentrate was the uranium mines in the Elliot Lake district of Ontario. All rare earths, except promethium, have been detected in these ores. The Elliot Lake ores contain about 0.11 per cent uranium oxide (U_3O_8), 0.028 per cent thorium oxide (ThO_2) and 0.057 per cent rare earth oxides (REO).

Denison Mines Limited resumed the production and shipment of yttrium concentrate in 1973. Under a contract negotiated with a United States company, Molybdenum Corporation of America, Denison has a commitment to ship yttrium concentrate to Molycorp until March 1976. Denison had previously shipped yttrium concentrate to Michigan Chemical Corporation, but production was terminated in mid-1970 when the company experienced difficulty in marketing the product. Denison shipped some concentrate in 1971, but the quantity and value was not reported.

During 1966 and 1967, Rio Algom Mines Limited recovered thorium and rare earth concentrate at its Nordic mill, but did not resume production when the milling of uranium ores was transferred to the Quirke mill.

There are no facilities in Canada for the separation of the individual rare earths from each other.

Successive declining shipments since 1967 reflect the oversupply of yttrium concentrate in world markets and the accumulation of inventories. However, renewed demand for yttrium concentrate implies that excessive stocks have been depleted. The major application for yttrium is in colour television phosphors, but it is important in stabilizing zirconia for the refractory industry, in yttrium-aluminum garnets, and in dispersion-hardened alloys. Rising consumption of yttrium, particularly in the colour television market, is forecast during the next few years.

Rare earth elements, primarily the light element group, are associated with apatite in the Nemegos No. 6 magnetite deposit, which is located in the Chapleau area of Ontario. Multi-Minerals Limited had announced plans in 1972 to stockpile the nonmagnetic tailings from the Nemegos property with the scheduled commencement of iron ore mining, and hold the tailings for future recovery of phosphate and the rare earth metals. Since then, the plans have been revised to recover iron ore and phosphate but company announcements have not included a plan to recover or stockpile rare earth metals. Nemegos nonmagnetic tailings are reported to contain 4.1 per cent rare earth oxide equivalents.

Besides the large reserves in Elliot Lake uranium ores, rare earths are also associated with uranium deposits at Agnew Lake, which is 40 miles east of Elliot Lake and where the REO content is about twice that of Elliot Lake ores, and in the Bancroft area of Ontario. Phosphorite formations in western Canada contain small quantities of rare earths as do Florida phosphates imported into Canada for the production of phosphoric acid. Other potential sources include apatite-rich carbonatites.

Shipments of rare earth concentrates since 1966 are summarized in the following table. Statistics for 1971 and 1973 have been withheld to avoid disclosing individual company confidential data.

Table 2. Canadian shipments of rare earth concentrates

	Y_2O_3 in Concentrate	Value
	(pounds)	($)
1973	...	...
1972	–	–
1971	...	...
1970	73,000	657,000
1969	85,443	671,500
1968	113,330	936,067
1967	172,551	1,594,298
1966	20,724	130,223

... Statistics withheld; – Nil.

World industry

The minerals monazite and bastnaesite are the main sources of the cerium group of rare earths. These are processed to recover mixed rare earths for low-value products such as mischmetal or further processed at much higher cost to separate individual rare earths.

Monazite recovery is a byproduct of mining beach sands for rutile, zircon and ilmenite. Australia, India, Brazil, Malaysia and the United States are the principal producers. In the United States, monazite is recovered from beach sands in Georgia and Florida.

The Molybdenum Corporation of America (Molycorp) mine at Mountain Pass, California, is the main source of concentrates for cerium group rare earths and, unlike monazite, bastnaesite concentrates from this unusual deposit in carbonatite do not contain thorium. The ore, mined in a small, low-cost open pit, grades 8 to 10 per cent rare earth oxides. The rare earth distribution in per cent oxide is cerium 50.0, lanthanum 33.0, neodymium 12.0, praseodymium 4.0, samarium 0.5, gadolinium 0.2, europium 0.1, and yttrium group 0.2. The adjacent mill produces a flotation concentrate grading 60 per cent rare earth oxide, a leached concentrate grading 70 per cent, a calcine grading 90 per cent, and seven modified concentrates. A chemical and solvent extraction plant makes intermediate rare earth products and separates a number of rare earths including europium. Further processing is carried out at Louviers, Colorado; York, Pennsylvania; and Washington, Pennsylvania.

Production from the Mountain Pass mine in 1973 was 38.7 million pounds of REO, compared with 23.6 million pounds in 1972. New milling equipment has been installed to increase capacity at the mine to 60 million pounds of REO a year.

Aluminum Company of America (Alcoa) and Molycorp have formed a joint company, Rare Earth Metal Company of America (REMCOA), and will build a pilot plant at Washington, Pa. This plant will employ a new electrolytic process, which is expected to lower production costs to produce mischmetal, rare earth metals and alloys. A full-scale plant, with an annual capacity of about 500,000 pounds, is being scheduled for 1974 completion.

A former Australian rare earth metals producer may resume operations in the near future. The mine, operated by Mary Kathleen Uranium Limited, produced uranium and a rare earth concentrate until 1963. Uranium production is scheduled to resume in early 1976. Total reserves at the mine, including tailings, contain some 400,000 tons of REO. At a planned annual mining rate of 900,000 tons of ore, the mine could recover about 5,000 tons a year of REO contained in concentrate.

Indian Rare Earths Limited (IRE) has increased annual capacity at the Alwaye processing plant, India, to 4,500 tons of monazite. The Alwaye plant produces rare earths in the chloride, fluoride, oxide and hydrate form. IRE plans to increase mineral sands production at Manavalakurichi and Chevara to double current output, and the company is considering a new mining operation in the Gapalpur area of Orissa. All IRE production, which accounts for about 10 per cent of the world's rare earth output, is under state control.

In Sri Lanka (formerly Ceylon), the Ceylon Mineral Sands Corp. plans to construct an integrated mineral sand operation at Pulmoddai by 1975. The new complex will have an annual capacity of 500 tons of monazite.

The mineral xenotime, valuable for its yttrium content, is recovered from heavy mineral rejects of the Malaysian tin industry and from retreatment of monazite concentrate, itself a byproduct, from Western Australia. A pilot plant to produce yttrium oxide from xenotime concentrate has been built by A/S Metal Extractor Group of Norway (Megon). Megon has recently announced plans to construct a commercial scale plant with an annual capacity of 50 tons of high purity yttrium oxide. Xenotime concentrates are usually treated in Europe or Japan.

Some uranium ores contain the rare earth elements and are an important source for the yttrium group. Solution liquors, following uranium and thorium extraction, are treated to recover the rare earth elements. Canadian production and potential production in Australia, the Mary Kathleen Uranium Limited, and Field Metals and Chemicals Pty. Limited deposits are of this type. The rare earth minerals euxinite, samarskite and fergusonite are another source of the yttrium group, but they are difficult to treat.

Promethium isotopes have half-lives ranging from seconds to 18 years and, therefore, are rare in nature. The commercial source of promethium 147 is from waste fission products in atomic reactors. Its radioactive properties are attractive as a power source in space research as well as in luminescent paints.

The increasing use of rare earth metals in magnets has resulted in product line changes at some rare earth processors and a number of new rare earth magnet fabricators. Th. Goldschmidt A.G. of West Germany has ceased producing all rare earth compounds and has limited its product line to rare earth metals and alloys for use in magnets. Tohoku Metal Industries in Japan has started marketing a less expensive mischmetal magnet in addition to samarium-cobalt magnets. Shin-Etsu Chemical Industry Company, also in Japan, began production of cerium-cobalt magnets. In the United States, Crucible Magnetics Division of Colt Industries Inc. began marketing mischmetal and samarium-cobalt magnets. Full scale production is scheduled in 1974. Varian Associates and Hamilton Precision Metals Co. announced commercial production of samarium-cobalt magnets in 1972. Other United States fabricators of rare earth magnets are Raytheon Co., Electron Energy Corp., Spectra-Flux Corp., Hitachi Magnetics Corp. and Indiana General.

Table 3. Principal world processors of rare earth ores and concentrates

Austria
- Treibacher Chemische Werke Aktiengesellschaft

Belgium
- S.A. de Pont-Brûlé

Brazil
- Commissao National de Energia Nuclear (Industrias Quimicas Reunidas)

Britain
- British Flint and Cerium Manufacturers Limited
- British Rare Earths Limited
- London and Scandinavian Metallurgical Company
- Rare Earth Products Limited (a Thorium Ltd. and Johnson Matthey Chemicals Limited joint venture)

Finland
- Kemira Oy

France
- Rhône-Poulenc, Etablissements Tricot

West Germany
- Otavi Minen and Eisbahn Ges.
- Th. Goldschmidt A.G.

India
- Indian Rare Earths Limited

Japan
- Ogino Chemical Company
- Nippon Yttrium Company
- Santoku Metal Industry Company
- Shin-Etsu Chemical Industry Company
- Wako Bussan Company

Norway
- A/S Metal Extractor Group of Norway (Megon)

United States
- American Potash and Chemical Corporation, Lindsay Rare Earth Division*
- Michigan Chemical Corporation
- Molybdenum Corporation of America
- Nucor Corp., Research Chemicals Division
- Reaction Metals Inc., a subsidiary of Rare Earth Industries, Inc.
- Ronson Metals Corporation, Cerium Metals and Alloys Division
- W.R. Grace and Company, Davison Chemical Division
- Gallard-Schlesinger Chemical Manufacturing Corp., Atomergic Chemetals Co. Division
- Transelco, Inc.

U.S.S.R.
- State controlled. Output is sold through Techsnabexport

*The company's processing facilities located in West Chicago, were closed in 1973.

Consumption and uses

Most rare earth metal consumption is in the form of chlorides, oxides, silicides and mischmetal. Small quantities of fluorides, oxalites, chlorates, nitrates and carbonates are used in a number of applications. High purity metal forms are used sparingly, mostly in research work. Traditionally, the rare earth metals, alloys and compounds have been expressed in terms of rare earth oxide (REO) equivalents.

The world consumption of rare earth metals has approximately doubled since 1971. In the United States, estimated consumption by industries during 1973 was: iron, steel and other metallurgical – 45 per cent, petroleum – 33 per cent, glass and ceramics – 17 per cent, electrical – 4 per cent, research and miscellaneous – 1 per cent. Iron, steel and other metallurgical applications became the dominant market for rare earth metals for the first time in 1972, displacing petroleum catalysts as the number one use.

Mischmetal is a suitable nodulizing alloy that promotes ductility in cast iron by neutralizing the harmful effects of trace elements which inhibit the formation of nodular graphite. The ductile iron industry has realized significant cost savings through the substitution of mischmetal for more expensive additives.

In recent years, the practice of adding some three pounds of mischmetal or rare earth silicides to each ton of high-strength low-alloy (HSLA) steels has become a general practice to counter the deleterious effects of sulphur. The conventional method of treating undesirable sulphur is to combine it with magnesium, but magnesium sulphide elongates when rolled and the resulting steel is weaker in the transverse direction. The addition of rare earths results in an HSLA steel that is nearly equally strong in the transverse and longitudinal directions. HSLA steels are being used increasingly in gas and oil pipelines, automobiles, trucks, trains, ships, and construction equipment. Mischmetal which is mostly cerium, lanthanum, neodymium and praseodymium, has a stable market in lighter flints. However, the lighter flint market is becoming a less important outlet as mischmetal applications grow in the iron and steel metallurgical fields.

The second largest use of the rare earth group is for catalysts in the cracking operation of petroleum refining. Although naturally mixed elements were originally used in catalysts, the trend has been to chloride mixtures of lanthanum, neodymium and praseodymium. Relative consumption in this field has been declining in recent years, but it still accounts for nearly 33 per cent. Palladium is a substitute for the rare earth elements in petroleum refining catalysts.

The third most important market for rare earth metals, in terms of volume, is the glass polishing industry. Commercial grade cerium and mixed rare earth oxides are used extensively in optical, mirror and plate glass polishing. Plate glass polishing has been reduced since the introduction of the Pilkington float glass process, but there is no comparable substitute for rare earth oxide compounds in high-quality optical polishing.

The glass industry employs rare earth additives for their many unique characteristics. Cerium oxide, in small quantities, is an effective glass decolourizer. Due to their ability to absorb ultra-violet light, cerium and neodymium oxides are used in transparent bottles to inhibit food spoilage and in welders' goggles, sunglasses and optical filters. For glass colouring, praseodymium imparts a yellow-green colour, neodymium a lilac; europium an orange-red; and erbium a pink colour. Lanthanum is a major component of optical glass and cerium glass is used for windows in atomic reactors.

Rare earth oxides and fluorides are used in significant quantities in carbon-arc lamps where a high intensity white light is desirable.

A high-value application is in the electronics field where rare earth oxides are used as phosphors in colour television tubes, temperature compensating capacitors and associated circuit components. Although the volume of europium and yttrium oxides used in colour television phosphors is comparatively small, the value is disproportionately large because of the high degree of purity required in this application. Minor quantities of the rare earth group are used in laser materials, atomic fire extinguishers, nuclear reactor absorption and shielding materials, magnesium and aluminum alloys, brazing alloys, low-corrosion alloys, gemstones, self-cleaning oven catalysts, ceramic and porcelain stains and microwave controls.

An important new market is rare earth-cobalt permanent magnets (RE magnets). Samarium-cobalt permanent magnets are now in use that have two or three times the strength of any conventional permanent magnet. These magnets are usually fabricated by powder metallurgical methods, which facilitate the procedure for inducing a high magnetic flux. High strength permanent magnets are used in special applications, such as aerospace equipment, where the greater cost can be justified in terms of better performance. Recent research has led to the development of less expensive RE magnets. Part of this improvement has resulted from better manufacturing techniques, but a more significant development is the substitution of mischmetal for more expensive samarium in magnets. Significantly lower cost RE magnets is an important factor to penetrating the large potential usage in electric motors, generators, meters, speakers and frictionless bearings. Considering all the developments that have occurred within the few years since RE magnets were first discovered, the trend indicates a strong growth rate in consumption of these magnets for the next several years.

Rare earth metals catalysts have been identified as possible inexpensive alternatives to platinoid catalysts in automobile exhaust converters. The rare earth-based converters have shown promise in reducing carbon monoxide and nitrogen oxide emissions, but more research is necessary. Initially, the automotive industry has opted for platinum-based systems to meet emission control standards set for U.S. vehicles in 1975.

Research on rare earth metals uses has taken many directions and some of the more promising investigations are indicated below. Lanthanum-nickel alloy has been suggested as a storage medium for hydrogen under low pressure. Investigations have shown that an equal volume of hydrogen can be stored in one third the space required for liquid hydrogen, and can be released safely. Hydrogen is being considered as a future fuel. The International Nickel Company of Canada, Limited, has developed a dispersion-hardened alloy containing 0.5 per cent yttrium oxide. This alloy is considered to be superior to conventional alloys because it can withstand higher temperatures. The company anticipates application in aircraft engine vanes used to guide hot gases against turbine blades. Europium hexaboride, used as a long-lived neutron absorber, is being promoted as a control in the upcoming generation of fast breeder nuclear reactors. Gadolinium oxide is currently used as a control in existing light water reactors.

Prices

The December issue of Industrial Minerals (London) quotes 70 per cent leach bastnaesite concentrate, per pound REO at 23-25 cents; Australian monazite, minimum 55 per cent REO, a long ton fob Australia, $A 140-150; Malayan xenotime concentrate, minimum 25 per cent Y_2O_3 a pound cif $U.S. 3-5.

The prices of the more common pure rare earth metals (cerium, yttrium, lanthanum and samarium) declined from a year earlier. A wide spread in prices between different products is a function of the degree of processing, purity, supply and demand. Some typical prices, given in the December 21, 1973 issue of American Metal Market, are as follows, per pound: mischmetal (99.8 per cent) $3.10; cerium free mischmetal $5.00; 99.9 per cent cerium oxide $6; cerium metal $19-20; 99.9 per cent yttrium oxide $32; yttrium metal $90; 99.9 per cent lanthanum oxide $4.15; lanthanum metal $28; 99.9 per cent thulium oxide $1,350; thulium metal $2,750; 99.9 per cent lutetium oxide $2,300; lutetium metal $6,500.

Rhenium

J.J. HOGAN

Rhenium occurs principally in low grade porphyry copper ores containing molybdenum and is recovered as a byproduct from the treatment of molybdenum concentrates. The rhenium content in porphyry copper ore is only a few parts per million (ppm) whereas the molybdenite concentrates produced from these ores have a rhenium content varying from 300 to 2,000 ppm. Rhenium has been identified in some molybdenum, manganese and uranium ores, but in concentrations too low to be of economic significance under present technology and price structure.

Canadian rhenium production comes from the copper-molybdenum ore of Utah Mines Ltd. (Island Copper mine) at Port Hardy, Vancouver Island, British Columbia. The ore occurs mainly in altered volcanics and, in this respect differs, from the porphyry copper deposits which have been the major source of rhenium in the United States and Chile. No information is available on the rhenium content of the byproduct molybdenite concentrates produced from the porphyry copper ores in the southern interior of British Columbia, although the metal has been identified in the deposits of Lornex Mining Corporation Ltd. and Brenda Mines Ltd., near Kamloops.

The United States, the largest producer of rhenium metal and salts in the noncommunist world, recovered rhenium, mainly from porphyry copper ores in the western states. The major producer of rhenium in the United States in 1973 was Cleveland Refractory Metals, Inc. (CRM) of Solon, Ohio, a division of Chase Brass & Copper Co. Incorporated (a subsidiary of Kennecott Copper Corporation). Other producers were S.W. Shattuck Chemical Co., of Denver, Colorado, a division of Engelhard Minerals & Chemicals Corporation; M & R Refractory Metals, Inc. of Winslow, New Jersey; Molybdenum Corporation of America (Molycorp) of Washington, Pennsylvania; and Continental Rhenium Corporation of Golden, Colorado, a wholly-owned subsidiary of Continental Ore Corporation. Molycorp recovered some rhenium from primary molybdenum ore which came from its Questa mine in New Mexico.

Chile recovered rhenium from its large porphyry copper ore deposits. Cia de Acero del Pacifico planned to construct a plant to recover about 3,000 pounds a year of contained rhenium as a salt or as perrhenic acid, and the plant should be in operation by 1975. New technology developed by a western European company and Hazan Research Center of the United States, will be used. Carburo y Metallurgia (Carbomet) was expanding its plant capacity from 2,000 pounds to 2,700 pounds a year.

Other rhenium producing countries are the U.S.S.R., Sweden, Belgium and Luxembourg, and West Germany. Some of these countries recover rhenium from imported molybdenite concentrates, mainly from Chile, Zaire and Canada.

Production

Rhenium is a recent addition to the metals produced in Canada, with production being first recorded in 1972. Utah Mines reported that the contained rhenium metal in the molybdenite concentrates produced at its Island Copper mine in 1973 varied between 1,200 and 1,900 ppm and averaged about 1,450 ppm. Shipments of molybdenite concentrates to refineries in the United States and western Europe totalled about 1,200 short tons. Under present technology the recovery of rhenium contained in molybdenite concentrates has been in the order of 50 to 60 per cent. The concentrates were either purchased outright by the receiving smelter, or treated on a toll basis and the rhenium returned to the company for subsequent sale.

Statistical data on the world output of rhenium and its value are not available. In 1973, production in the United States, the world's largest producer, was estimated by the U.S. Bureau of Mines at 6,500 pounds compared with 6,100 pounds in 1972. Chile is believed to be the next largest producer.

Rhenium is recovered from flue gases emitted from the roasting of byproduct molybdenite concentrates. Under properly controlled temperature conditions rhenium volatilizes as rhenium heptoxide (Re_2O_7) which is readily soluble in an aqueous solution. Flue dust particles which carry about 10 per cent of the rhenium contained in the roaster feed are recycled to the roaster. Before flue gas technology was developed the dust was the major source of the metal. To extract the rhenium, flue gases are cleaned of dust particles and wet-scrubbed to dissolve the rhenium oxide. The rhenium-bearing solution is conditioned for ion exchange treatment by the addition of certain chemicals to remove impurities. The solution is clarified, and the rhenium is adsorbed on an ion exchange resin. Further hydrometallurgical steps are carried out until a high-purity ammonium perrhenate (NH_4ReO_4) is produced which is converted to metal powder by hydrogen reduction. The metal powder is pressed and sintered into bars which are cold-rolled to form different shapes. Perrhenic acid ($HReO_4$) is obtained by the reaction of rhenium heptoxide with water. Recent research has developed processes whereby rhenium and molybdenum can be recovered from molybdenite concentrates by hydrometallurgy.

Properties and uses

Rhenium, a relatively new metal which was first isolated in 1925, has become an important industrial metal because of special or unique properties. The metal is highly refractory, having a melting point of 3,100°C, second to that of tungsten, and maintains strength and ductility at high temperatures even after heating above the crystallization temperature. Its density is 21, exceeded only by that of the platinum metals group. Pure rhenium can be cold-worked, but requires high temperature recrystallization annealing to ensure maximum ductility. It is difficult to work at normal hot-working temperatures because it tends to become brittle. The metal can be welded by tungsten arc-inert gas techniques, the welds being ductile. It has good corrosion resistance to halogen acids. Rhenium alloyed with tungsten or molybdenum improves the ductility and tensile strength of these metals. At room temperature rhenium has a high resistivity, a property which finds application in the rapid initial heating of filaments and heating elements. Stable oxide film on rhenium does not appreciably increase electrical resistance because the oxides are conductive, and this property, plus good resistance to wear and arc corrosion, makes the metal ideally suited for electrical contacts.

The United States consumes most of the world's output of rhenium, a major application being in the development of the rhenium-platinum bi-metallic catalyst used in reforming units to produce a high octane gasoline of low lead content.

Rhenium powder is used to produce ductile, high temperature tungsten- and molybdenum-based alloys which are used in the electronic field. Other applications of rhenium are high temperature thermocouples, temperature controls, electronic devices, flashbulb filaments and heat shields.

Outlook

The development of rhenium as an industrial metal has taken place recently and has not shown any clearly defined growth pattern. The potential short-term supply is limited to that available from byproduct molybdenite concentrates from low-grade porphyry copper ores.

In the short-term, the major demand for rhenium will continue to be its application as a bi-metallic rhenium-platinum catalyst in the petroleum refining industry. The metal now available to the market is greater than the demand, but demand should increase during 1975-76 to satisfy the requirements of new petroleum refining installations that have been planned. Low known reserves could be a factor in limiting industrial applications of the metal, and, thereby encouraging the development of substitutes.

Prices

According to *Metals Week*, the United States prices for rhenium during the period from January 1 to May 25, 1973, were $875 to $1,325 a pound for rhenium contained in perrhenic acid and $975 to $1,400 a pound for rhenium metal powder. Prices for the corresponding products for the period May 25 to September 7, 1973 were $875 to $900 a pound and $950 - $1,050 a pound, respectively. After a small price adjustment downwards for the period from September 7 to 21, 1973, prices were further lowered on September 21 to $725-$900 a pound for rhenium contained in perrhenic acid and $825-$1,050 a pound for rhenium metal powder.

Tariffs

Canada – not specifically enumerated in Canadian tariffs.

United States

Item No.		On and After January 1, 1972
		(%)
628.90	Rhenium unwrought and waste and scrap	5[1]
628.95	Rhenium wrought	9

Source: Tariff Schedules of the United States Annotated 1972 T.C. Publication 452.

[1] Duty on waste and scrap temporarily suspended as provided by P.L. 93-78, effective to June 30, 1975.

Salt

A. F. KILLIN

Salt production in Canada in 1973 increased only 2.7 per cent from 1972. Domestic shipments of salt for control of snow and ice on highways was lower than in 1972, but demand for salt to manufacture industrial chemicals remained strong. Export demand increased sharply over 1972 and imports declined. Most Canadian salt exports are to the United States.

Production and developments in Canada

Canadian salt production falls into three categories: mined rock salt (3 mines); fine vacuum salt (six evaporator plants); and salt in brine (from four brining plants) for chemical manufacture. One fine salt plant was using byproduct salt from a potash solution-mine, and byproduct salt from potash mines was also processed for snow and ice control on roads.

Canadian salt production in 1973* was 5,723,245 tons, shipments totalled 5,563,667 tons valued at $47,191,023; tonnage and value increased from 1972. Production of mined rock salt decreased to 3,789,934 tons from the 1972 total of 4,105,172 tons. Output of fine vacuum salt, salt in brines and salt recovered from chemical operations increased in 1973 by 235,677 tons. Shipments of each type of salt paralleled production in the two years under review.

Deposits and occurrences

Salt occurs in solution in seawater, in some spring and lake waters, in many subsurface waters, and in solid form in surface and underground deposits. Although seawaters contain the largest reserve of salt and contribute substantial quantities of solar evaporated salt to the world's annual salt output, underground bedded and dome deposits supply the largest part of mankind's salt requirements.

In Canada, underground salt deposits have been found in all provinces except British Columbia. They have also been found in the District of Mackenzie, Northwest Territories, and there are underground salt deposits in some of the Arctic islands. Bedded rock salt deposits in southwestern Ontario, Saskatchewan and Alberta, and dome deposits in Nova Scotia are the sources of most of Canada's salt output. In past years, salt has been recovered from brine springs and natural subsurface brines in Nova Scotia, New Brunswick, Ontario, Manitoba, Saskatchewan and Alberta. Salt springs are also common to certain parts of British Columbia.

Ontario. Thick salt beds underlie much of southwestern Ontario extending from Amherstburg northeastward to London and Kincardine, bordering on what is known geologically as the Michigan Basin. As many as six salt beds, occurring in the Upper Silurian Salina Formation and at depths from 900 to 2,700 feet, can be identified and traced from drilling records. Maximum bed thickness is 300 feet with aggregate thickness reaching as much as 700 feet. The beds are relatively flat lying and undisturbed thereby permitting easy mining.

In 1973, these beds were being exploited through two rock salt mines, one at Goderich and one at Ojibway, and through brining operations at Goderich, Sarnia and Windsor. Domtar Chemicals Limited neared completion of a $5.8 million expansion program which will boost the productive capacity of its Goderich mine to 2.25 million tons of salt annually.

Atlantic region. Salt deposits occur in isolated subbasins of a large sedimentary basin that underlies the northern mainland of Nova Scotia and extends westward under the bordering areas of New Brunswick, northeastward under Cape Breton Island and under Prince Edward Island, the Magdalen Islands and southwestern Newfoundland. The salt beds occur within the Mississippian Windsor Group and are generally folded and faulted. The deposits appear to be steeply dipping tabular bodies or domes and brecciated structures of rock salt.

In New Brunswick, the Department of Natural Resources continued a joint federal-provincial exploration program in which holes were drilled in 1973 to identify and evaluate evaporite deposits in the Moncton Basin. Two of these holes intersected potash and salt and the third glauberite and salt.

The only salt production in the Atlantic provinces in 1973 was from a rock salt mine and associated evaporator plant at Pugwash, Nova Scotia, and a brining operation at Amherst, Nova Scotia. Domtar Chemicals was still examining the feasibility of a salt

*Source: Statistics Canada, Catalogue 26-009-December 1973.

Table 1. Canada, salt production and trade 1972-73

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
By type				
Mined rock salt	3,901,099	22,199,000	3,889,000^e	. .
Fine vacuum salt	638,520	14,926,000	586,000^e	. .
Salt content of brines used or shipped and salt recovered in chemical operations	877,306	3,019,000	852,000^e	. .
Total	5,416,925	40,144,000	5,327,000	45,185,000
By province				
Ontario	4,037,789	24,481,406	3,980,000	28,916,000
Nova Scotia	812,596	8,558,223	744,000	8,993,000
Saskatchewan	251,587	4,258,507	258,000	4,300,000
Alberta	283,958	2,710,529	310,000	2,826,000
Manitoba	30,995	135,000	35,000	150,000
Total	5,416,925	40,143,665	5,327,000	45,185,000
Imports				
Total salt and brine				
United States	615,934	4,125,000	571,215	3,607,000
Mexico	293,480	424,000	309,361	529,000
Bahamas	22,428	142,000	27,182	153,000
Italy	25,160	113,000	5,894	74,000
Norway	1,158	31,000	896	35,000
West Germany	4,213	53,000	502	18,000
Switzerland	–	–	46	2,000
Portugal	–	–	18	1,000
France	–	–	1	1,000
Other countries	61,537	304,000	–	–
Total	1,023,910	5,192,000	915,115	4,420,000
Exports				
United States	. .	4,909,000	. .	5,948,000
Britain	. .	12,000	. .	61,000
New Zealand	. .	1,000	. .	11,000
Bermuda	. .	9,000	. .	9,000
Sweden	. .	24,000	. .	5,000
Leeward and Windward Islands	. .	7,000	. .	4,000
Cuba	. .	3,000	. .	4,000
Other countries	. .	22,000	. .	9,000
Total	. .	4,987,000	. .	6,051,000

Source: Statistics Canada.
^{p}Preliminary; . . Not available; – Nil; ^{e}Estimated by Statistics Section, Mineral Development Sector.

operation near Point Tupper on Cape Breton Island, Nova Scotia. A strike at the Pugwash mine stopped production from September 28 to November 19, 1973.

Prairie Provinces. Salt beds underlie a broad belt of the Prairie Provinces extending from the extreme southwestern corner of Manitoba, northwestward across Saskatchewan and into the north-central part of Alberta. Most of the salt deposits occur within the Prairie Evaporite Formation, which constitutes the upper part of the Middle Devonian, Elk Point Group, with thinner beds occurring in Upper Devonian rocks. Depths range from 600 feet at Fort McMurray,

Table 2. Canada, salt production and trade, 1964-73

	Production[1]					
	Mined Rock	Fine Vacuum	In Brine and Recovered in Chemical Operations	Total	Imports	Exports
	(short tons)					($)
1964	1,874,225	537,553	1,225,365	3,637,143	405,574	3,618,569
1965	2,399,919	558,346	1,289,796	4,248,061	441,601	4,996,509
1966	2,180,671	571,497	1,376,654	4,128,822	509,548	3,588,000
1967	3,023,397	554,337	1,417,894	4,995,628	567,012	5,926,000
1968	3,230,305	553,280	1,080,739	4,864,324	644,153	5,921,000
1969	3,007,256	557,028	1,093,481	4,657,765	695,638	5,107,000
1970	3,607,336	609,252	1,142,308	5,358,896	618,021	7,430,000
1971	4,045,894	625,552	870,458	5,541,904	922,013	7,029,000
1972	3,901,099	638,520	877,306	5,416,925	1,023,910	4,987,000
1973[p]	3,889,000[e]	586,000[e]	852,000[e]	5,327,000	915,115	6,051,000

Source: Statistics Canada.
[p]Preliminary; [e]Estimated by Statistics Section, Mineral Development Sector.
[1] Producers' shipments.

Alberta, to 3,000 feet in eastern Alberta, central Saskatchewan and southwestern Manitoba, and to 6,000 feet around Edmonton, Alberta, and across to southern Saskatchewan. Cumulative thicknesses reach a maximum of 1,300 feet in east-central Alberta. The beds lie relatively flat and undisturbed. The same rock sequence contains a number of potash beds that are being exploited in Saskatchewan.

Salt was produced from these deposits at four locations in the Prairie Provinces in 1973 – Saskatoon and Unity, Saskatchewan, and Lindbergh and Fort Saskatchewan, Alberta. In addition, naturally occurring subsurface salt brines in Manitoba were used for caustic soda and chlorine manufacture at Brandon. Fine salt was also produced from byproduct brines from a potash-solution mine at Belle Plaine, Saskatchewan. International Minerals & Chemical Corporation (Canada) Limited, at Esterhazy, Saskatchewan, supplied a significant quantity of salt, from waste salt from potash mining, for snow and ice control on roads.

Recovery method

Canadian producers employ three different methods for the recovery of salt from depth for the production of dry salt and for direct use in the chlor-alkali industry. The method employed depends upon the deposit and the type of salt required by the consumer. Conventional mining methods are used to mine rock salt deposits that are relatively shallow and are located in areas convenient to large markets that do not require a high-purity product.

Brining methods are used to recover salt from subsurface deposits as well, usually from greater depths. The brine can be evaporated to produce high-purity fine vacuum salt or can be used directly in the manufacture of chemicals. Salt is similarly recovered from natural subsurface brines.

The third method is to recover salt as a coproduct of potash mining, a practice quite common in Europe. In Canada, this technique is being used on a commercial scale at only one solution-type potash mine which lends itself to the recovery of a good-quality salt brine. The other potash producers generally regard the waste salt as unmarketable, although some shipments have been made for snow and ice control.

A fourth method (not used in Canada) is by solar evaporation of sea or salty lake waters, a process commonly used in warm, arid climates.

Rock salt mining

Access to rock salt deposits for conventional mining is through vertical shafts, normally 16 feet in diameter, serving the mining zone at depths of 630 to 1,760 feet. Mining is normally by the room-and-pillar method, the dimensions depending on the depth and thickness of the salt deposit. Rooms vary from 30 to 60 feet in width and from 18 to 50 feet in height and pillars vary from about 60 to 200 feet square. Extraction rates range from 40 to 60 per cent. The mining operation consists of undercutting, drilling,

Table 3. Canada, summary of salt producing and brining operations, 1973

Company	Location	Initial Production	Remarks
Nova Scotia			
The Canadian Rock Salt Company Limited	Pugwash	1959	Rock salt mining at a depth of 630 feet. A new level is being developed 200 feet below the 630-foot level.
	Pugwash	1962	Dissolving rock salt fines for vacuum pan evaporation.
Domtar Chemicals Limited	Amherst	1947	Brining for vacuum pan evaporation.
Ontario			
Allied Chemical Canada, Ltd.	Amherstburg	1919	Brining to produce soda ash.
The Canadian Rock Salt Company Limited	Ojibway	1955	Rock salt mining at a depth of 980 feet.
The Canadian Salt Company Limited	Windsor	1892	Brining, vacuum pan evaporation and fusion.
Dome Petroleum Limited	Sarnia	1969	Brining to develop storage cavity.
Dow Chemical of Canada, Limited	Sarnia	1950	Brining to produce caustic soda and chlorine.
Domtar Chemicals Limited	Goderich	1959	Rock salt mining at a depth of 1,760 feet.
	Goderich	1880	Brining for vacuum pan evaporation.
Prairie Provinces			
Dryden Chemicals Limited	Brandon, Man.	1968	Pumping natural brines to produce caustic soda and chlorine.
Northern Industrial Chemicals Ltd.*	Saskatoon, Sask.	1968	Brining to produce caustic soda and chlorine.
Domtar Chemicals Limited	Unity, Sask.	1949	Brining, vacuum pan evaporation and fusion.
The Canadian Salt Company Limited	Lindbergh, Alta.	1968	Brining, vacuum pan evaporation and fusion. New evaporation unit will increase capacity by 50%.
Dow Chemical of Canada, Limited	Fort Saskatchewan, Alta.	1968	Brining to produce caustic soda and chlorine.
The Canadian Salt Company Limited	Belle Plaine, Sask.	1969	Producing fine salt from byproduct brine from potash mine.

*Managed by Canadian Industries Limited.

Table 4. World salt production 1971-73

	1971	1972^p	1973^e
	('000 short tons)		
United States	30,377	45,022	43,860
People's Republic of China	18,200	19,800	20,900
U.S.S.R.	13,200	13,200	13,900
West Germany	9,834	10,120	10,700
United Kingdom	10,191	9,739	10,300
India	5,986	7,165	7,500
France	6,057	5,739	6,000
Canada	5,542	5,417	5,327
Mexico	4,806	4,850	5,000
Italy	5,044	4,497	4,700
Netherlands	3,491	3,530	3,700
Poland	3,262	3,318	3,500
Other countries	42,941	30,046	32,000
Total	158,931	162,443	167,387

Sources: U.S. Bureau of Mines *Minerals Yearbook* Preprint 1972, and U.S. Bureau of Mines Commodity Data Summaries, January 1974: for Canada, Statistics Canada.
^{p}Preliminary; ^{e}Estimated.

blasting, loading and primary crushing. Underground haulage is by shuttle cars, trucks and conveyor belts. Milling involves crushing, screening and sizing; at one mine the milling is done underground. The products, ranging in size from about one half inch to a fine powder, normally have a purity of 96 per cent or better. Most of the gypsum, anhydrite and limestone impurities are removed by crushing and screening. Small amounts of the coarser salt fractions are further beneficiated by use of electronic sorters.

Most of the mined rock salt in Canada is shipped in bulk by water, rail and truck, much of it being used for snow and ice control.

Brining and vacuum pan evaporation

Brining is essentially a system of injecting water into a salt deposit to dissolve the salt and then pumping a saturated salt solution to the surface. Water injection and brine recovery can be accomplished in a single borehole with casing and tubing or in a series of two or more cased wells. A brine field normally has from 2 to 20 wells depending on the quantity of brine needed for the surface operation. Depths of the brine fields in Canada range from 1,100 to 6,500 feet. Saturated salt brine contains 26 per cent NaCl, which amounts to about 3 pounds of salt per gallon of fluid. At the surface, the brine is either evaporated to produce fine vacuum salt or used directly in the manufacture of chemicals.

Canadian producers use a vacuum-pan process to evaporate the brine and produce fine salt. The brine is purified to remove gypsum and other impurities and then fed into a series of three or four large cylindrical steel vessels under vacuum for a triple- or quadruple-effect evaporation. The salt crystallizes and is removed as a slurry; it is then washed, filtered and dried. Product purity is generally 99.5 per cent or better.

Final processing involves screening, the introduction of additives, compression into blocks, briquettes and tablets, or compaction, recrushing and packaging to prepare as many as 100 different salt products. In some cases, small quantities are melted at a temperature of about 1,500°F and allowed to cool. This produces a fused salt, which is particularly suitable for use in water softeners.

Canadian consumption and trade

Salt is marketed in at least 100 different forms, packages and containers and its direct and indirect uses number in the thousands. The largest single market for salt in Canada is for snow and ice control on highways and city streets. By comparison with other uses, this market is new, having expanded in Canada from less than 100,000 tons in 1954 to an estimated 1.89 million tons in 1973.

The next largest consumer of salt is the industrial chemical industry, particularly the manufacture of caustic soda (sodium hydroxide) and chlorine. Salt for four caustic soda and chlorine plants is obtained from on-site brining or natural brines; others use mined rock salt or imported solar salt. Other industrial chemicals that require significant quantities of salt in the manufacturing process include sodium carbonate (soda ash), sodium chlorate, sodium bicarbonate, sodium chlorite and sodium hypochlorite.

The pattern of Canada's salt trade has changed considerably in the past few years. Because of its low unit value and availability in most key market areas, salt is seldom hauled long distances, except in the case of seaborne and intercoastal shipments where greater mileage entails little additional cost.

In the five years prior to 1968, Canada exported about 1.4 million tons of salt annually to the United States; about half was in the form of salt brine to feed a soda ash plant in Detroit, the balance consisted largely of mined rock salt. Brine sales ceased in 1968, and exports to the United States declined significantly but regained sharply in 1970-71, dropped off in 1972 but increased in 1973. Nearly all of Canada's salt exports to the United States are in the form of mined rock salt. Salt exports to other countries normally involve small quantities of fine salt.

Salt imports into Canada climbed steadily from 192,000 tons in 1960 to 696,000 tons in 1969, fell slightly in 1970, rose to 1,023,910 tons in 1972 and declined to 915,115 tons in 1973. From 1963 to 1969, our imports consisted mainly of: fishery salt for

Table 5. Canada, available data on salt consumption, 1970-73

	1970	1971	1972[e]	1973[e]
	(short tons)			
Industrial chemicals	1,619,936	1,643,455	1,693,150	1,793,000
Snow and ice control	1,800,000	1,890,000	1,890,000	1,890,000
Slaughtering and meat packing	45,706	43,610	47,000	51,000
Food processing				
Fish products	13,670	13,653	17,000	21,000
Bakeries	14,056	13,603	14,000	14,000
Miscellaneous food preparation	18,019	19,145	20,000	21,000
Fruit and vegetable preparation	19,301	21,694	23,000	24,000
Other food processing	. .	. .	. .	. .
Breweries	780	917	950	1,000
Dairy factories and process-cheese	11,794	12,231	12,400	13,000
Leather tanneries	7,554	7,587	8,000	8,500
Soaps and cleaning preparation	3,149	4,233	4,600	5,000
Dyeing and finishing textiles	597	835	1,400	1,900
Artificial ice	824	850	880	900
Pulp and paper mills	61,302	48,382	50,700	53,000
Grain mills[1]	50,555	50,335	53,000	56,000
Fishing industry[e]	90,000	90,000	95,000	98,000

Source: Statistics Canada.
[1]Includes feed and farm stock salt in block and loose forms.
[e]Estimated; . . Not available.

the Atlantic provinces from Spain (about 40,000 tons yearly); solar salt for use in fisheries and west coast industrial chemical plants from Caribbean countries and Mexico (rising from 118,000 to 336,543 tons); and rock salt from the United States (rising from 166,000 to 571,215 tons). Imports from Spain ceased by 1972. United States producers bordering on the lower Great Lakes are able to take advantage of low shipping rates to capture spot sales in southern Ontario and Quebec, particularly for snow and ice control salt in large metropolitan areas. Imports from Mexico decreased slightly in 1973.

Outlook

The outlook for Canada's salt industry is favourable despite pressure from imports, particularly in those areas served by water transport. Demand for salt for snow and ice control may weaken, particularly under environmental restraints, whereas consumption in the manufacture of industrial chemicals should continue to increase.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(¢ per 100 lb)	
92501-1	Common salt (including rock salt)			
	On and after Jan. 1, 1971	free	1/2	5
	On and after Jan. 1, 1972	free	free	5
92501-2	Salt for use of the sea or gulf fisheries	free	free	free
92501-3	Table salt made by the admixture of other ingredients when containing not less than 90 per cent of pure salt	(%)	(%)	(%)
	On and after Jan. 1, 1971	5	6	15
	On and after Jan. 1, 1972	5	5	15
92501-4	Salt liquors and sea water	free	free	free

United States

Item No.		On and After Jan. 1, 1971	On and After Jan. 1, 1972
420.92	Salt in brine	6%	5%
		(¢ per 100 lb)	
420.94	Salt in bulk	1	0.8
420.96	Salt, other	0.5	free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa, Canada. Tariff Schedules of the United States annotated (1972) TC Publication 452.

Sand and Gravel

D.H. STONEHOUSE

Sand is defined as granular mineral material resulting from the natural disintegration and abrasion of rock or the processing of completely friable sandstone, passing a 3/8- inch sieve, almost all passing a No. 4 (0.187-inch) sieve and almost all remaining on a No. 200 (0.003-inch) sieve. Gravel is defined as granular material resulting from similar processes and predominantly retained on a No. 4 sieve, the cutoff between commerical sand and gravel. Material finer than 200-mesh is called silt or clay, depending on the particle size.

Commerical sand and gravel deposits are generally classified into one of four catagories according to origin or method of deposition. Deposits that are composed of sand and gravel that had been carried by rivers and streams are referred to as fluvial deposits. They exhibit limited size gradation and the distribution of size ranges and shapes can vary greatly, depending on whether the streams had been meandering, fast-flowing, narrow or shallow. Glacial deposits were distributed from massive ice sheets over large areas of Canada and the United States as well as other countries. They consist of rock particles of various types, shapes and sizes and display little sorting or gradation. Marine and lake deposits are usually of hard, tough material, well segregated and well worn to rounded shapes. Unstratified mixtures of sand and gravel, covering the complete size range and occurring on top of the parent rock, are termed residual deposits. These are not usually of commerical importance because of the large amount of softer clays associated with the mass.

The quantities of sand and gravel produced in Canada bear close relation to the amount of construction being performed, particularly heavy or engineering construction. Preliminary estimates indicate that about 228 million tons were produced during 1973. As a supplier of raw materials to a volatile and cyclical industry, the sand and gravel industry must, in turn, be capable of rapid adjustment between "go" and "no go" situations.

The Canadian industry

Sand and gravel deposits are widespread throughout Canada, and large producers have established "permanent" plants as close to major consuming centres as possible. Urban expansion has greatly increased demand for sand and gravel in support of major construction. Paradoxically, urban spread has not only tended to overrun operating pits and quarries but has extended, at times, over areas containing mineral deposits, precluding use of these resources. Further complications have arisen in recent years as society has become increasingly aware of environmental problems and of the need for planned land utilization. Municipal and regional zoning must determine and regulate the optimum utilization of land. Industry must locate to minimize the environmental effects of plant operations. Also, provision must be made for rehabilitation of pit and quarry sites in order to ensure the best sequential land use. The frequency with which small quarries and pits materialize to supply short-lived, local demands, leaving unsightly properties, has prompted action by municipal and provincial governments to control or to prohibit such activity.

Ideally, the exploitation of sand, gravel and stone deposits should be done as part of the total land use planning package, such that excavations are designed to conform with a master plan of development and even to create new land forms. Ontario seems to be leading other provinces in enacting legislation to control pit and quarry licensing, operation and rehabilitation and its new laws are typical of what can be expected in other provinces. Ontario regulations apply to operations in designated areas and to rehabilitation of depleted sites. Controls and zoning can significantly reduce reserves of these building materials.

In addition to large aggregate operations usually associated with some other phase of the construction industry such as a ready-mix plant or an asphalt plant, there are many smaller, privately-owned producers serving small, localized markets. These are often operated on a seasonal or part-time basis. Many larger operations are short-term, intermittently serving as a supply arm of a heavy construction company and providing material for a given project. Provincial departments of highways operate regional or divisional quarries to supply roadbed material for new and repair work.

Sand and gravel must be quarried, screened, washed, stockpiled and transported in large volume to compensate for the relatively low unit value received. Transportation and handling often double the plant

Table 1. Canada, construction spending by provinces, 1972-74

	1972[1]	1973[2]	1974[3]
	(millions of dollars)		
Newfoundland	458	471	514
Prince Edward Island	67	108	118
Nova Scotia	488	623	709
New Brunswick	373	494	621
Quebec	3,746	4,358	5,064
Ontario	6,276	7,237	8,281
Manitoba	754	888	969
Saskatchewan	593	706	779
Alberta	1,980	2,272	2,655
British Columbia	2,275	2,642	3,052
Yukon and Northwest Territories	278	335	390
Canada	17,288	20,134	23,152

Source: Statistics Canada.
[1] Final; [2] Preliminary; [3] Forecast.

cost, making it necessary to utilize close-in reserves and influencing the scope of exploration for new deposits. The need for an inventory of aggregate materials surrounding regions of large population growth cannot be too strongly emphasized.

Materials competitive with sand and gravel include crushed stone and the lightweight aggregates, depending on the application considered. It has been estimated that total aggregate consumption in some Canadian urban centres could reach 18 tons per capita by 1980. Estimates have indicated that available sand and gravel supplies in some regions will be depleted by the 1990's. This could make outlying deposits not only attractive but necessary and could also encourage development of under-water deposits. It is not completely impossible that areas of concentrated population, such as the eastern seaboard of the United States, where reserves of aggregates are already becoming depleted, will have to import their requirements perhaps by boat or barge. Large tonnages of crushed limestone are exported annually from Canada's west coast quarries, particularly from Texada and Aristazabal islands, for cement, lime and aggregate use in Oregon and Washington.

The main uses for sand and gravel are: as fill, granular base course and finish course material for highway construction; coarse and fine aggregates in concrete manufacture; coarse aggregate in asphalt production and fine aggregate in mortar and concrete blocks. Specifications vary greatly depending on the intended use and many tests are required to determine the acceptability of aggregates for certain applications. Particle size distribution of aggregates, as assessed by grading tests or sieve analysis, affects the uniformity and workability of a concrete mix as well as the strength of the concrete, the density and strength of an asphalt mix and the durability, strength and stability of the compacted mass when aggregates are used as fill or base course material. Of importance also are tests to determine the presence of organic impurities or other deleterious material, the resistance of the aggregate to abrasion and to freeze-thaw cycles, the effects of thermal expansion, absorption, porosity, reactivity with associated materials and surface texture.

The use of sand and gravel as backfill in mines continues along with increasing use of cement and mill tailings for this purpose. Abrasive sands, glass sand, foundry sands and filter sands are also produced.

Even the common products such as sand and gravel require a sales and distribution effort which depends upon forecast data supplied by monitoring relevant

Table 2. Canada production (shipments) sand and gravel by provinces, 1971-73

	1971		1972		1973[p]	
	'000 st	$'000	'000 st	$'000	'000 st	$'000
Newfoundland	5,564	5,827	5,433	6,829	5,500	6,900
Prince Edward Island	1,554	978	1,578	1,097	1,600	1,200
Nova Scotia	6,004	6,345	9,896	9,732	10,000	10,000
New Brunswick	4,985	2,593	7,561	4,585	7,600	5,000
Quebec	41,605	20,087	44,993	20,916	45,000	23,000
Ontario	77,631	57,104	76,380	64,320	78,000	65,000
Manitoba	16,695	12,199	14,763	14,970	13,700	13,800
Saskatchewan	11,321	6,503	8,512	4,449	8,000	4,400
Alberta	18,679	16,285	20,556	17,807	20,600	18,200
British Columbia	29,253	24,707	35,522	33,395	38,000	40,000
Canada	213,291	152,628	225,194	178,100	228,000	187,500

Source: Statistics Canada.
[p] Preliminary.

Table 3. Canada, production (shipments) sand and gravel, by uses, by areas, 1971-1972

		Atlantic Provinces	Quebec	Ontario	Western Provinces	Canada
		('000 short tons)				
Roads	1971	14,182	34,675	42,597	50,294	141,748
	1972	18,931	35,869	42,944	51,797	149,541
Concrete aggregate	1971	1,039	3,541	15,618	10,243	30,441
	1972	1,511	4,822	16,116	11,397	33,846
Asphalt aggregate	1971	1,689	1,298	4,053	2,929	9,969
	1972	2,476	1,242	5,314	4,416	13,448
Railroad ballast	1971	283	561	124	3,731	4,699
	1972	205	168	782	2,323	3,478
Mortar sand	1971	46	189	1,107	368	1,710
	1972	82	218	1,361	531	2,192
Backfill for mines	1971	108	40	2,758	3	2,909
	1972	128	77	721	3	929
Other fill	1971	626	1,202	11,263	8,350	21,441
	1972	1,123	2,566	9,034	8,832	21,555
Other uses	1971	134	99	111	30	374
	1972	12	31	108	54	205
Total sand and gravel	1971	18,107	41,605	77,631	75,948	213,291
	1972	24,468	44,993	76,380	79,353	225,195

Source: Statistics Canada with breakdown by Statistics Section, Mineral Development Sector.

Table 4. Canada, exports and imports of sand and gravel, 1971-73.

	1971		1972		1973p	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
Exports						
Sand and gravel						
United States	774,639	1,089,000	697,138	997,000	880,350	937,000
West Germany	22	1,000	22	1,000	373	8,000
Belgium-Luxembourg	–	–	–	–	99	8,000
Other countries	65	4,000	14	1,000	202	. . .
Total	774,726	1,094,000	697,174	999,000	881,024	953,000
Imports						
Sand and gravel, not elsewhere stated						
United States	675,272	785,000	1,067,532	1,032,000	1,136,055	1,280,000
United Kingdom	–	–	–	–	200	1,000
Other countries	3	. . .	101	17,000	11	1,000
Total	675,275	785,000	1,067,633	1,049,000	1,136,266	1,282,000

Source: Statistics Canada.
– Nil; . . . less than $1,000.

Table 5. Canada, production (shipments) sand and gravel, by uses, 1971-72

	1971	1972
	('000 short tons)	
Roads – construction, maintenance, ice control	141,748	149,541
Concrete aggregate	30,441	33,846
Asphalt aggregate	9,969	13,448
Railroad ballast	4,699	3,478
Mortar sands	1,710	2,192
Backfill for mines	2,909	929
Other fill	21,441	21,555
Other uses	374	205
Total sand and gravel	213,291	225,194
$000	152,628	178,100

Source: Statistics Canada with breakdown by Statistics Section, Mineral Development Sector.

Table 6. Canada, production (shipments) sand and gravel, and trade, 1963-73

	Production	Imports	Exports
	(short tons)		
1963	189,570,503	561,965	356,124
1964	193,791,358	593,455	461,464
1965	205,260,264	570,977	687,941
1966	217,271,189	566,800	700,255
1967	215,212,700	757,603	601,419
1968	205,234,509	683,490	496,525
1969	201,581,498	859,898	457,918
1970	202,656,000	502,739	1,240,192
1971	213,291,000	675,275	774,726
1972	225,194,000	1,067,633	697,174
1973p	228,000,000	1,136,266	881,024

Source: Statistics Canada.
p Preliminary.

indicators. One such indicator is the number of regional housing starts which, in turn, can be projected to determine future needs for roads, driveways, shopping centres and schools. Heavy construction awards can be used to provide an estimate of the quantity of aggregate required for given projects, over given periods of time.

Movement of sand and gravel from the pit or quarry is normally by truck, and as quarry sites are being forced to locate farther from the consuming areas, costs in excess of five cents a ton-mile added to basic loading charges can become so large in total that alternative sources are continually being sought. It is only rarely that a unit-train concept would be applicable because of the wide physical distribution of consumers within an area and because optimum utilization of such facilities would be difficult to attain. Bulk "hook and haul" trains are used in the Toronto area to haul minimum loads of 4,000 tons at negotiated freight rates.

On average, total aggregate consumption will rise in line with population increases, housing requirements and construction in general. Sand and gravel consumption will continue in competition with crushed stone and, in some applications, with lightweight aggregates. New resource reserves must be located, assessed and made part of any community development planning or regional zoning, with optimum land and resource utilization in mind. In the search for new sources of sand and gravel some countries are turning to the sea bed. The use of huge pumps and specially equipped ships to draw gravel from the sea floor and deposit it in attendant barges is already common practice in Britain. Such methods of obtaining aggregates can have far reaching environmental effects.

Prices for graded, washed and crushed gravel and sand will show slow but steady increase based on greater property costs, more sophisticated operating techniques and equipment, pollution and environmental considerations and higher labour costs.

October 1974

Selenium and Tellurium

C. J. CAJKA

SELENIUM

Selenium occurs sparsely disseminated throughout the earth's crust in a wide variety of selenium-bearing minerals. None of these minerals occur in sufficient concentration to allow commercial exploitation for their selenium content alone and production is derived as a byproduct of copper refining. Minor amounts are recovered from smelter flue dusts and lead refining sludges.

The output of selenium as metal or compounds comes from the copper refining nations, including Japan, United States, Canada, Belgium and Luxembourg, Sweden, Mexico, Yugoslavia, Finland, Peru and Australia. The first three nations listed are the major producers. There is also production in the U.S.S.R. and other communist countries. Selenium supply is dependent upon copper production and, because of this, it varies with copper output and not with the pressures of demand. A minor amount of selenium is recovered from secondary sources. Preliminary world production figures for 1973 show an increase over the previous year. With the exception of the United States, all countries reporting had an increased production.

Production of selenium in all forms from Canadian ores in 1973 was 598,000 pounds valued at $5,430,000 which compares to 582,060 pounds in 1972 valued at $5,186,155 and 718,440 pounds in 1971 valued at $6,530,619. Lower copper production from copper mines in Ontario and Quebec since 1971, the major source of Canadian selenium, has contributed to declining selenium output during the last two years. Refined production from all sources, including imported material and secondary sources, was 580,537 pounds, down 19 per cent from 720,392 pounds in 1972 and down 34 per cent from 885,931 pounds in 1971.

Domestic consumption in 1973 amounted to 22,435 pounds, up from 20,677 pounds in 1972 and 15,686 pounds in 1971. An increased consumption in the glass industry for the past two years has been largely responsible for the improvement.

Canada exports most of its production and, in 1973, exports of refined metal exceeded production by 42 per cent. Table 2 shows that refined production and exports have been substantially out of balance since 1967; in some years, production has greatly exceeded exports and, in other years, the reverse has been the case. The United States is Canada's major market, followed by Britain. In 1973, Canada supplied some 87 per cent of the selenium imported into the United States.

Canadian Copper Refiners Limited at Montreal East, Quebec, operates Canada's largest selenium recovery plant. The company's refinery treats anode copper from the Noranda smelter of Noranda Mines Limited, the Murdochville smelter of Gaspé Copper Mines, Limited, both in Quebec, and blister copper from the smelter of Hudson Bay Mining and Smelting Co., Limited at Flin Flon, Manitoba. The selenium plant can produce commercial-grade metal (99.5 per cent Se), high-purity metal (99.9 per cent Se) and a variety of metallic and selenium compounds. Annual capacity is 500,000 pounds of selenium in metal and salts.

The 180,000-pound-a-year selenium recovery plant of The International Nickel Company of Canada, Limited at Copper Cliff, Ontario, treats tankhouse slimes from the company's Copper Cliff copper refinery and its Port Colborne, Ontario, nickel refinery. The marketable product is minus 200 mesh selenium powder (99.5 per cent Se).

Consumption and uses

Selenium is used in the glass, electrical-electronic, xerographic, chemical, rubber, steel and pharmaceutical industries. This metal is marketed in two grades: high-purity, used largely in rectifiers and xerography; and commercial grade, employed in a number of industries of which the glass industry is the

Table 1. Canada, selenium production, exports and consumption 1972-73

	1972		1973p	
	(pounds)	($)	(pounds)	($)
Production				
All forms[1]				
Quebec	406,898	3,625,461	370,000	3,330,000
Manitoba	52,555	468,265	105,000	947,000
Ontario	108,783	969,257	90,000	853,000
Saskatchewan	13,824	123,172	33,000	300,000
Total	582,060	5,186,155	598,000	5,430,000
Refined[2]	720,392	. .	580,537	. .
Exports (metal)				
United States	344,400	3,578,000	501,800	5,750,000
United Kingdom	134,500	1,216,000	213,600	2,148,000
Netherlands	–	–	39,600	369,000
Brazil	9,000	80,000	25,000	244,000
Argentina	5,700	51,000	12,800	130,000
Spain	700	7,000	7,900	76,000
Colombia	–	–	3,700	34,000
Other countries	10,500	70,000	18,700	168,000
Total	504,800	5,002,000	823,100	8,919,000
Consumption[3] (selenium content)	20,677	. .	22,435	. .

Source: Statistics Canada.
[1]Recoverable selenium content of blister copper treated at domestic refineries, plus refined selenium from domestic primary materials. [2]Refinery output from all sources, including imported material and secondary sources. [3]Available data, consumption of selenium products (metal, metal powder, oxide), selenium content, as reported by consumers.
pPreliminary; . . Not available; – Nil.

most important. Consumption by industrial sectors in the United States in 1973 is estimated to be: electrical-electronic – 45 per cent; ceramic and glass – 34 per cent; chemical – 13 per cent; and other – 8 per cent.

An important use of selenium in the electrical field is in the manufacturing of rectifiers used in electroplating, welding, battery charging and in other similar applications. Selenium is used in specialty transformers, varying in size from a fraction of a watt to 500 Kw. Xerography (electrostatic printing), a dry photocopying or photographing process, uses a large quantity of selenium. The photoelectric (photogalvanic) cells which find application in light-sensitive instruments are a small consumer of selenium.

The glassmaking industry is one of the major consumers of selenium. Small quantities added to the glass batch neutralize the greenish tinge imparted to glass by iron impurities in the sand. Selenium is meeting with some competition from cerium in this application. The brilliant ruby-red glass used in traffic and other signal lenses, automotive taillights, marine equipment, infrared equipment and decorative tableware is produced by adding larger quantities of selenium to the glass batch. An increasing amount of selenium is used in tinted "black" glass which is used as the outer facing of many highrise office buildings.

Selenium has wide application in the chemical industry, the most important being the manufacture of the orange-red-maroon cadmium sulphoselenide pigments. They have considerable light stability, maintain their brilliance and are resistant to heat and chemical action. Their most important application is in the expanding high-temperature-cured plastic industry, but they are also used to colour ceramics, paints, enamels and inks.

In proportions from 0.2 to 0.35 per cent, selenium imparts improved machinability to stainless steel without affecting its corrosion resistance properties, and in lesser amounts improves the forging characteristics of steel. Small quantities of iron selenide, from 0.01 to 0.05 per cent are widely used as an additive in steel casting to prevent pinhole porosity.

Finely ground metallic selenium and selenium diethyldithiocarbamate (selenac) are used in natural and synthetic rubber to increase the rate of vulcanization and to improve the aging and mechanical properties of sulphurless and low-sulphur rubber. Selenac is used as an accelerator in butyl rubber.

Table 2. Canada, selenium production, exports and consumption 1964-73

	Production			
	All Forms[1]	Refined[2]	Exports Metals[3]	Consumption[4]
	(pounds)			
1964	465,746	462,795	401,300	13,968
1965	512,077	514,595	451,200	15,888
1966	575,482	546,085	588,100	20,533
1967	724,573	754,360	539,400	21,017
1968	635,510	620,033	787,100	21,440
1969	599,415	820,277	872,300	15,572
1970	663,336	854,452	686,100	15,730
1971	718,440	885,931	571,500	15,686
1972	582,060	720,392	504,800	20,677
1973[p]	598,000	580,537	823,100	22,435

Source: Statistics Canada.
[1]Recoverable selenium content of blister copper treated at domestic refineries, plus refined selenium from domestic primary material. [2]Refinery output from all sources, including imported material and secondary sources. [3]Exports of selenium metal, metal powder, shot, etc. [4]Consumption (selenium content), as reported by consumers.
[p]Preliminary.

Table 3. Noncommunist world production of selenium, 1971-73

	1971	1972	1973[e]
	(pounds)		
United States	657,000	769,000	710,000
Japan	524,000	738,000	820,000
Canada	718,000	582,000	598,000
Belgium and Luxembourg	120,000	147,000	160,000
Sweden	110,000	140,000	160,000
Other countries	525,000	193,000	218,000
Total	2,654,000	2,569,000	2,666,000

Sources: For Canada, Statistics Canada. For other countries, U.S. Bureau of Mines *Minerals Yearbook, 1971* and U.S. Commodity Data Summaries, January 1974.
[e]Estimated.

Selenium is used in the organic chemical and pharmaceutical industries; in the manufacture of cortisone and nicotine acids; in the preparation of various proprietary medicines for the control of dermatitis in humans and animals; and in the control of certain diseases in animals and poultry. It is known that selenium is an essential element for normal physical development and prevents white muscle disease in livestock and poultry. Growing attention in this field could result in a large new market for selenium as a feed supplement. In the United States, the Food and Drug Administration has proposed that selenium be added to chicken, turkey and swine feed.

A small amount of selenium is used in the manufacture of delay-action blasting caps.

Interest has been revived in the photogalvanic cell, which converts light energy to electrical energy, as new sources of energy are sought to offset fuel and energy shortages. Also, with respect to the energy situation, an increased demand for selenium-tinted windows, which have a lower heat conductivity than conventional glass, is expected.

Table 4. Canada, industrial use of selenium 1971-73

	1971	1972	1973
	(pounds of contained selenium)		
By end use			
Glass	11,200	15,354	18,873
Other[1]	4,500	5,323	3,562
Total	15,700	20,677	22,435

Source: Statistics Canada Consumers' Reports.
[1]Electronics, rubber, steel, pharmaceuticals.

Outlook

Selenium production is primarily a byproduct of copper refining, but the relationship is trending towards a lower proportion of selenium output as existing selenium-rich copper reserves are exhausted. An increasing amount of copper production is being derived from selenium-poor ores. Furthermore, environmental standards are leading to technical changes in copper extraction processes, which may result in lower selenium recoveries unless a new technology is developed to extract selenium.

Supply is unlikely to grow in the near term and could actually decline for the reasons mentioned above. As demand increases while supply remains static, a shortage could develop and result in higher prices. Substitution is a serious threat to selenium usage if prices attain abnormally high levels. Although the substitution threat is not serious for high-purity selenium in xerography and the rectifier industry, most other applications do have ready substitutes.

The United States reduced national stockpiles of selenium from 228 tons at the beginning of 1973 to 64 tons by the end of the year, and the balance was sold in the first quarter of 1974. Prices are expected to increase further in 1974 now that the U.S. stockpile no longer overhangs the market.

Prices

According to *Metals Week,* United States Selenium prices for year 1973 were as follows:

	Commercial Grade	High-Purity Grade
January 1, 1973 to March 21	$ 9.00	$11.50
March 21, 1973 to October 26	$ 9.00 – $10.00	$11.50 – $12.50
October 26, 1973 to December 13	$ 9.00 – $11.00	$12.50 – $14.00
December 13, 1973 to December 31	$11.00 – $12.00	$14.00

Canadian producers increased their price in the United States for commercial grade selenium metal from $10.00 to $11.00 in March and high-purity metal from $11.50 to $12.50. On October 26, the Canadian producers again raised the price of high-purity selenium to $14.00 per pound.

Commercial grade selenium sold on the merchant and dealer market at prices ranging from just below $9.00 a pound early in the year to a high of $18.00 in October. Dealer selenium was offered at the $16.00 – $17.00 range at the end of 1973.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
92804–4	Selenium metal	5%	10%	15%

United States

Item No.		On and After January 1 1970	1971	1972
		(%)	(%)	(%)
632.40	Selenium metal, unwrought, other than alloys and waste and scrap	free	free	free
632.84	Selenium metal alloys, unwrought	12.5	10.5	9
633.00	Selenium metals, wrought			
420.50	Selenium dioxide	free	free	free
420.52	Selenium salts			
420.60	Selenium compounds, other	7	6	5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Tariff Schedules of the United States Annotated 1972, T.C. Publication 452.

TELLURIUM

Like selenium, tellurium is recovered in Canada from the tankhouse slimes of the two electrolytic copper refineries and the Port Colborne nickel refinery. It is refined by the same two companies, namely, Canadian Copper Refiners Limited at Montreal East, Quebec, and The International Nickel Company of Canada, Limited at Copper Cliff, Ontario.

Production of tellurium in all forms from Canadian ores in 1973 amounted to 45,000 pounds valued at $266,000, essentially unchanged from the year earlier when production was 45,649 pounds valued at $271,155. Tellurium production is related to selenium output because tellurium is a co-product of selenium recovery. Refined output from all sources, including imported material, for the years 1973 and 1972 was 93,205 and 58,446 pounds respectively.

Canadian Copper Refiners Limited has an annual capacity to produce 60,000 pounds of tellurium in the form of powder, stick, lump and dioxide. The Copper Cliff refinery has capacity to produce 18,000 pounds of tellurium a year in the form of dioxide.

The Emperor Gold Mine at Vata Koula, Fiji is scheduled to increase annual tellurium production to 40,000 pounds. This would make the Emperor Gold Mine the world's largest tellurium producer.

Table 5. Canada, tellurium production and consumption, 1972-73

	1972		1973p	
	(pounds)	($)	(pounds)	($)
Production				
All forms[1]				
Quebec	33,374	198,242	31,000	186,000
Manitoba	3,126	18,568	8,000	49,000
Ontario	8,327	49,462	3,000	16,000
Saskatchewan	822	4,883	3,000	15,000
Total	45,649	271,155	45,000	266,000
Refined[2]	58,446	..	93,205	..
Consumption[3] (refined)	1,419	..	1,222	..

Source: Statistics Canada.
[1]Recoverable tellurium content of blister copper treated, plus refined tellurium from domestic primary material. [2]Refinery output from all sources, including imported material and secondary sources. [3]Available data, reported by consumers.
pPreliminary; .. Not available.

Consumption and uses

Tellurium is mainly recovered as a byproduct of copper refining and the supply is therefore related to copper production. Under present technological practices, a low ratio of recovery is obtained but is adequate to meet demand. Low production and the odour and toxicity of tellurium continue to inhibit its use in industry. When it is absorbed into the body by direct contact or inhalation, tellurium has an adverse physiological effect, resulting in a strong garlic odour imparted to the breath and perspiration.

Most of the commercial grade tellurium sold by the primary producers is in the form of slab, stick, lump, tablet and powder. It is also sold as copper and iron alloys.

In the United States, consumption by major use is estimated to be: iron and steel products – 62 per cent; nonferrous metal products – 19 per cent; rubber products – 11 per cent; chemicals – 6 per cent; other – 2 per cent.

The primary metal industries are by far the largest consumers of tellurium. Added to copper and low carbon and alloy steels, the machinability is greatly improved. In stainless steel castings it reduces or prevents pinhole porosity. A very small quantity of tellurium added to molten iron controls the chill depth of grey iron castings. An alloy, containing 99.5 per cent copper – 0.5 per cent tellurium is used in the manufacture of welding tips, and communications equipment because it can be hot- and cold-worked, and the thermal and electrical conductivity is only slightly less than that of copper. Up to 0.1 per cent tellurium in lead forms an alloy that has improved resistance to wear, vibration breakdown and corrosion, and, because of these properties, is used to sheath marine cables and to line tanks subject to chemical corrosion.

Table 6. Canada, production and consumption of tellurium, 1964-73

	Production		Consumption
	All Forms[1]	Refined[2]	Refined[3]
		(pounds)	
1964	77,782	80,255	1,473
1965	69,794	71,730	1,870
1966	72,239	72,745	862
1967	73,219	70,105	981
1968	70,991	65,926	4,605
1969	62,048	72,664	3,532
1970	58,333	64,634	880
1971	24,488	43,558	1,178
1972	45,649	58,446	1,419
1973p	45,000	93,205	1,222

Source: Statistics Canada.
[1]Includes recoverable tellurium content of blister copper, not necessarily recovered in year designated, plus refined tellurium from domestic primary metal. [2]Refinery production from all sources, including imported material and secondary sources. [3]Available data, reported by consumers.
pPreliminary.

Tellurium, as a component of alloys containing gallium, bismuth and lead, is used in thermoelectric devices for the direct conversion of heat into electricity, and for cooling as a result of its Peltier effect. A thermonuclear heart pacemaker that employs the thermoelectric principle is under development. In the device, nuclear power provides heat and a tellurium alloy converts the heat to electrical energy. The minimum life of this experimental pacemaker is reported to be 10 years.

Tellurium is used as a secondary vulcanizing agent in natural and synthetic rubber in which it increases toughness and resistance to abrasion and heat. These characteristics made possible its application for the jacketing of portable electric cable used in mining, dredging and welding and for specialized conveyor belting. Tellurium is employed to eliminate porosity in thick rubber sections and as an accelerator for butyl applications.

Some tellurium is consumed in glass and ceramic production to develop blue-to-brown colouration; in the preparation of insecticides and germicides; and in the manufacture of delay-electric blasting caps and pigments.

Table 7. Noncommunist world production of tellurium

	1971	1972	1973[e]
		(pounds)	
United States	164,000	257,000	220,000
Japan	79,000	77,000	90,000
Peru	53,000	40,000	45,000
Canada	24,000	46,000	45,000
Total	320,000	420,000	400,000

Sources: For Canada, Statistics Canada. For other countries, U.S. Bureau of Mines *Minerals Yearbook, 1971;* U.S. Bureau of Mines Commodity Data Summaries, January 1974.
[e]Estimated.

Outlook

Supply is largely limited to that which is available from copper output and, as in the case of selenium, new copper production is increasingly derived from tellurium-poor ores. The short- to medium-term outlook is for limited availability of the metal and a static or slow growth in demand. Substitutes are readily available for the major uses and will tend to constrain price changes to modest increases.

Price

According to *Metals Week,* the United States tellurium price for powder in 100-pound lots and for slab in 150-pound lots was $6.00 a pound from January 1972 to December 10, 1973 and $7.00 per pound for the remainder of the year.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
92804–5	Tellurium metal	5%	10%	15%

United States

Item No.		On and After January 1 1970	1971	1972
		(%)	(%)	(%)
632.48	Tellurium metal, unwrought, other than alloys, and waste and scrap (duty on waste and scrap suspended to June 30, 1973)	5.5	4.5	4
632.84	Tellurium metal alloys, unwrought	12.5	10.5	9
633.00	Tellurium metal, wrought	12.5	10.5	9
421.90	Tellurium compounds	7	6	5
427.12	Tellurium salts	7	6	5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Tariff Schedule of the United States Annotated, 1972, TC Publication 452.

Silica

G.H.K. PEARSE

Silica (SiO_2) occurs as the mineral quartz in a variety of rocks and unconsolidated sediments. Although the mineral is one of the most abundant, making up an estimated 12 per cent of the earth's crust, commercial sources of silica are presently restricted to uncommonly pure sands, sandstones, quartzites and vein quartz. Further, because of its low unit value, an economically viable deposit should normally be mineable by low-cost open-pit methods and, ideally, be located close to consuming areas in order to minimize transportation costs.

The principal uses for silica are: as the chief constituent in glass; as metallurgical flux; in the manufacture of silicon carbide; as an ore of silicon and ferrosilicon; as foundry sand for metal castings; in sand blasting; and as filler materials in tile, asbestos pipe, concrete blocks and bricks.

Production of silica in Canada in 1973 was 2.8 million short tons, an increase of five per cent over 1972. The tonnage remains short of the record 3.2 million tons shipped in 1970.

Most of the silica produced in Canada is low-value lump silica and silica sand consumed as a metallurgical flux. High-quality silica sand suitable for the manufacture of glass is produced by two companies in Canada. Indusmin Limited, the largest, operates beneficiation plants in southern Ontario and Quebec. Steel Brothers Canada Ltd. quarries high-grade silica sandstone on Black Island in Lake Winnipeg and processes the material at the company's plant located at Selkirk, Manitoba. This company acquired the quarry and plant from The Winnipeg Supply and Fuel Company, Limited in 1972.

Canada imports high-grade silica sand for use in glass manufacturing along with substantial quantities of sand suitable for foundry castings. In 1973, imports, virtually all from the United States, were 1.09 million tons, 20 per cent lower than in 1972.

Some 20,000 tons of silica were imported from Belgium to supply Ahlstrom Canada Limited's glass container plant at Scoudouc, New Brunswick.

Principal producers and developments

Newfoundland. Newfoundland Enterprises Limited, a subsidiary of Armand Sicotte & Sons Limited, produces silica from a quarry at Villa Marie, on the Avalon Peninsula. The silica is hauled by truck about 12 miles to Long Harbour where it is used as a flux in the manufacture of elemental phosphorus by Erco Industries Limited. Erco's $40 million phosphorus plant requires about 100,000 tons of silica annually.

Quebec. Indusmin Limited produces a wide variety of silica products at its mill near St-Canut, Quebec. In addition to quarrying Potsdam sandstone adjacent to the St-Canut mill, the company quarries a friable Precambrian quartzite from a deposit near St-Donat. Material from the St-Donat quarry is trucked about 50 miles to the St-Canut mill for processing. Products produced at St-Canut include: silica sand suitable for glass and silicon carbide manufacture; foundry sand; and silica flour for use as a filler in tiles, asbestos pipe, concrete blocks and bricks. The silica sand suitable for glass manufacture is marketed in Quebec, while much of the product suitable for use in the construction industry is sold in Ontario. The balance of Quebec's silica sand requirements for glass manufacture is imported from the United States.

Union Carbide Canada Mining Ltd. quarries quartzitic sandstone at Melocheville, Beauharnois County, for use in ferrosilicon manufacture at Beauharnois. Fines from this operation are used in foundry work, in cement manufacture and as a metallurgical flux.

Baskatong Quartz Products produces lump silica and crushed quartz from a deposit on the south-western shore of Lake Baskatong. The lump silica is used in the manufacture of silicon metal and, to a lesser extent, as grinding pebble. The crushed quartz is sold for use as exposed aggregate in decorative concrete.

Table 1. Canada, silica production and trade, 1972-73

	1972		1973p	
	(short tons)	($)	(short tons)	($)
Production, quartz and silica sand[1]				
By province				
Ontario	1,177,753	2,750,258	1,230,000	3,360,000
Quebec	710,217	4,478,970	840,000	4,550,000
Manitoba	460,305	1,327,740	400,000	1,200,000
Saskatchewan	159,415	135,000	157,000	140,000
British Columbia	43,453	189,159	50,000	250,000
Newfoundland	. .	339,832	. .	370,000
Alberta	. .	287,659	. .	350,000
Nova Scotia	. .	27,700	. .	30,000
Total	2,663,836	9,536,318	2,800,000	10,250,000
By use				
Flux	1,126,494		. .	. .
Ferrosilicon	171,979		. .	. .
Glass and fibreglass	433,784		. .	. .
Other uses[2]	1,161,751		. .	. .
Total	2,894,008	9,536,318	. .	. .
Imports				
Silica sand				
United States	1,345,327	5,777,000	1,064,662	5,788,000
Belgium and Luxembourg	19,880	58,000	22,695	83,000
West Germany	–	–	2	2,000
Other countries	3,638	58,000	1	1,000
Total	1,368,845	5,893,000	1,087,360	5,874,000
Silex and crystallized quartz				
United States	8	64,000	1,092	182,000
Brazil	1	. . .	–	–
Total	9	64,000	1,092	182,000
Firebrick and similar shapes, silica				
United States	4,071	844,000	3,612	766,000
West Germany	1,567	359,000	26	4,000
Total	5,638	1,203,000	3,638	770,000
Exports				
Quartzite				
United States	137,569	302,000	114,044	190,000
Barbados	–	–	1	. . .
Total	137,569	302,000	114,045	190,000

Source: Statistics Canada.
[1]Producers' shipments, include crude and crushed quartz, crushed sandstone and quartzite and natural silica sand. [2]Includes foundry use, sand blasting, silica brick, concrete products, chemical manufacture, building products and silicon carbide.
pPreliminary; –Nil; . .Not available for publication; . . .Less than one thousand dollars.

Ontario. Indusmin Limited quarries a high-grade silica deposit on Badgeley Island in Georgian Bay. The deposit consists of very pure Precambrian Lorraine quartzite. A grinding and processing plant at Midland and a primary crushing plant at the deposit some 120 miles north of Midland across Georgian Bay, came on stream during the first half of 1970. The Badgeley Island operation has a capacity of approximately 1 million tons a year of washed lump silica and fine material. The Midland plant capacity is about 500,000 tons a year of refined silica products. Primary products from the crushing plant on Badgeley Island are shipped directly to manufacturers of ferrosilicon and silicon metal, and to the Midland grinding plant for further processing. Products from the Midland plant go to glass, ceramic, chemical and other industries in Ontario.

Output has been restricted at the Midland plant from the start because of difficulties experienced with the classification circuit. During 1971, the grinding unit output was little better than 50 per cent of rated capacity. The unit was converted from a rod mill to a ball mill and the efficiency of the plant was much improved. Alterations during 1972 and 1973 resulted in further improvement raising output significantly.

Table 2. Canada, silica production and trade 1964-73

	Production	Imports		Exports	Consumption
	Quartz and Silica Sand[1]	Silica Sand	Silex or Crystallized Quartz	Quartzite	Quartz and Silica Sand
			(short tons)		
1964	2,117,273	771,900	5,176	146,206	2,491,596
1965	2,433,685	834,780	5,104	111,533	3,156,466
1966	2,299,660	1,013,285	288	156,038	3,372,668
1967	2,610,740	952,459	142	56,200	3,501,186
1968	2,554,565	1,107,000	116	64,086	3,684,424
1969	2,300,374	1,285,228	35	81,488	3,526,264
1970	3,238,037	1,296,537	205	64,945	4,386,433
1971	2,553,884	1,420,278	312	100,664	3,755,133
1972	2,663,836	1,368,845	9	137,569	2,894,008
1973[p]	2,800,000	1,087,360	1,092	114,056	..

Source: Statistics Canada.
[1]Includes silica to make silica brick.
[p]Preliminary; . .Not available.

Manitoba. Steel Brothers Canada Ltd. quarries friable sandstone of the Winnipeg Formation at Black Island in Lake Winnipeg. The sandstone is then barged to the company's processing plant at Selkirk where it is washed, sized and packaged for sale. The company provides silica sand for a large portion of the western Canada market. Silica sand suitable for the manufacture of glass containers is shipped to Alberta. The majority of the remaining production is consumed in the Manitoba market, largely as foundry sand. In addition to the silica sand operation, the company quarries quartzite and sand for The International Nickel Company of Canada, Limited's smelter at Thompson, Manitoba, for use as a metallurgical flux.

British Columbia. Pacific Silica Limited ceased production of silica for ferrosilicon and silica carbide in August 1968 at its deposit near Oliver, British Columbia. Stucco dash and roof chips are being produced from existing stockpiles.

Uses and specifications

The principal uses of lump silica, silica sand and crushed quartzite, together with specifications by consuming industry, are as follows:

Lump silica. *Silica flux.* Massive quartz, quartzite, sandstone and unconsolidated sands are used for flux in smelting base-metal ores where iron and basic oxides are slagged as silicates. Because free silica is the active slagging agent, the free silica content should be as high as possible. Minor amounts of impurities such as iron and alumina are tolerable. Lump silica used as a flux is usually minus one-plus 5/16 inch in size.

Silicon and silicon alloys. Lump quartz, quartzite and well cemented sandstones are used in the manufacture of silicon, ferrosilicon and other silicon alloys. Lump silica 3/4 to 5 inches in size, obtained by crushing quartzite or indurated sandstone, is used in the manufacture of ferrosilicon. Chemical specifications are: silica, 98.0 per cent; alumina (Al_2O_3), less than 1.0 per cent; iron (Fe_2O_3) plus alumina, not over 1.5 per cent; lime and magnesia, each less than 0.2 per cent. Phosphorus and arsenic should be absent.

Silica brick. Quartz and quartzite crushed to minus 8 mesh are used in the manufacture of silica brick for high-temperature refractory furnaces. Chemical specifications for this use are: silica, 96 to 98 per cent; alumina, less than 0.1 per cent; combined iron and alumina, less than 1.5 per cent. Other impurities such as lime and magnesia should be low.

Aggregate. Crushed and sized quartz and quartzite are used as exposed aggregate in precast concrete panels for buildings, slabs, sidewalks and for other decorative landscape purposes. Colour and texture are important. Some architects prefer a white, opaque quartz, while others prefer a shiny, translucent variety.

Other uses. Lump quartz and quartzite are used as lining material in ball and tube mills and as lining and packing for acid towers. In some instances, naturally occurring quartzitic pebbles are used as grinding media in the crushing of various nonmetallic ores.

Silica sand. *Glass.* High-purity, naturally occurring sand or material produced by crushing quartzite or sandstone is used in the manufacture of glass.

Minor amounts of certain elements are particularly objectionable because they act as powerful colourants. For example, chromium should not exceed six parts per million and cobalt not over two parts per million.

Silicon carbide. Silica sand used in the manufacture of silicon carbide should have a silica content of at least 99 per cent. Iron and alumina should be less than 0.1 per cent each; lime, magnesia and phosphorus should be absent. Sand, should be plus 100 mesh, with the bulk of it plus 35 mesh.

Hydraulic fracturing. Sand is used in the hydraulic fracturing of oil-bearing strata to increase open pore spaces, thus increasing the productivity of the oil well. Sand utilized for this purpose should be clean and dry, have a high compressive strength, be free of acid-consuming constituents and have a grain size between 20 and 35 mesh. Grains should be well rounded to facilitate placement in the formation in order to provide maximum permeability.

Foundry sand. Naturally occurring sand or material produced by crushing friable sandstone is used in the foundry industry for moulding. For foundry purposes, the chemical composition of the sand is not as important as its physical properties. For the end-use, a highly refractory sand having rounded grains with frosted or pitted surface is preferred. Grain sizes vary between 20 and 200 mesh. Rounded grains are preferable to angular fragments because they allow maximum permeability of the mould and maximum escape of gas during casting.

Sodium silicate. Sand for the manufacture of sodium silicate should contain more than 99 per cent silica, less than 0.25 per cent alumina, less than 0.05 per cent lime and magnesia combined and less than 0.03 per cent iron (Fe_2O_3). All sand should be between 20 and 100 mesh.

Other minor uses. Coarsely ground, closely sized quartz, quartzite, sandstone and sand are used as abrasive grit in sandblasting and in the manufacture of sandpaper. Various grades of sand are used as filtering media in water-treatment plants; silica is also required in portland cement manufacture where there is insufficient silica in the limestone or other raw material used in the process.

Silica flour. Silica flour produced by the fine grinding of quartzite, sandstones and lump quartz, is used in the ceramics industry for enamel frits and pottery flint. For use in enamels, the silica flour must be over 97.5 per cent silica, with alumina (Al_2O_3) less than 0.5 per cent and iron (Fe_2O_3) less than 0.2 per cent. Silica flour is also used as an inert filler in rubber and asbestos cement products, as an extender in paints and as an abrasive agent in soaps and scouring pads. It is used increasingly in autoclave-cured concrete products such as building blocks and panels, approximately 45 pounds of silica flour being used for each 100 pounds of portland cement consumed.

Quartz crystal. Quartz crystal with desirable piezo-electric properties is used in radio-frequency control, radar and other electronic devices. Crystal for this purpose must be perfectly transparent and free from all impurities and flaws. The individual crystals should weigh 100 grams or more and measure at least two inches in length and one inch or more in diameter. Most of the world's crystal requirement is met by natural crystal from Brazil; however, natural crystal is being rapidly replaced by excellent quality, synthetic crystal grown in the laboratory from quartz "seed." Artificial quartz crystals are delivered already oriented for the cutter. The high degree of purity permits product yields at least four times that of natural quartz crystal.

There is no production of quartz crystal in Canada, where only a small demand exists. Domestic requirements are met largely by imports chiefly from the United States with minor amounts from Brazil. Quartz Crystals Mines Limited, Toronto, produced minor tonnages from an occurrence near Lyndhurst, Ontario, several years ago.

Table 3. Canada, available data on consumption of silica, by industries, 1971 and 1972

	1971	1972
	(short tons)	
Smelter flux[1]	1,754,321	1,126,494
Glass manufacture (incl. glass fibre)	656,304	433,784
Foundry sand	784,167	332,670
Artificial abrasives	106,709	166,018
Ferrosilicon	164,002	171,974
Metallurgical use	80,734	80,565
Concrete products	14,934	17,331
Gypsum products	3,118	351,225
Asbestos products	38,666	15,206
Chemicals	34,222	23,132
Fertilizers, stock, poultry feed	16,094	14,939
Other	101,862	160,665
Total	3,755,133	2,894,008

Source: Statistics Canada for source data. Classification by Statistics Section, Mineral Development Sector.
[1]Producers' shipments of quartz and silica for flux purposes.

Outlook

Considerable progress has been made in overcoming difficulties experienced at Indusmin's Midland plant, and sales potential through displacement of imports is well above current plant output. Base metal smelting activity continued to recover from the 1971-1972 slowdown in 1973 and the early months of 1974 resulting in increased requirements for silica flux. However, uncertainties in the world economy which began to appear in early 1974 indicate a possible downturn in most consuming sectors by later in the year and into 1975. This is further aggravated by other constraints such as, shortages of other essential raw materials, e.g., soda ash in the glass industry, and shortage of rail cars. Under the influence of these factors, total silica production is expected to increase to 3 million tons in 1974, perhaps remaining at that figure for 1975.

Tariffs

Canada

Item No.		
29500-1	Ganister and sand	free
29700-1	Silex or crystallized quartz, ground or unground	free

United States

Item No.		(¢ per lt)
513.11	Sand containing 95% or more silica, and not more than 0.6% of oxide of iron	
	On and after Jan. 1, 1972	25
513.14	Sand, other	free
514.91	Quartzite, whether or not manufactured	free
523.11	Silica, not specially provided for	free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1972), T.C. Publication 452.

Silicon, Ferrosilicon and Silicon Carbide

M.A. BOUCHER

The 1973 import-export figures for silicon, ferrosilicon and silicon carbide compared with those in 1972 are as follows: imports of ferrosilicon increased by almost 50 per cent from 9.6 to 14.2 thousand short tons; imports of ferroalloys not elsewhere specified increased by 18.6 thousand tons, while exports of ferroalloys not elsewhere specified increased by 3.4 thousand tons, for a net trade deficit of 15.2 thousand tons.

During the year, silicon and ferrosilicon were in short supply mainly because of energy and environmental problems that reduced domestic production in Japan and the United States, the two largest consumers. For this reason, prices increased for all grades of silicon and ferrosilicon.

Canada is in a position to compete world-wide in the production of silicon metal, silicon carbide and ferrosilicon. All three require considerable amounts of energy and raw materials such as good quality quartz and a source of iron, usually steel turnings. The production of silicon metal requires 15,700 kWh per ton and the production of 75 per cent ferrosilicon requires about 9,000 kWh per ton. Table 9, which shows only the relative (not the absolute) costs of electricity in different industrialized countries, demonstrates that Canada has a definite advantage over many industrialized countries. Over 90 per cent of the electric power generated in Quebec is hydro, therefore, over the long-term, the cost of producing electricity in Quebec will be relatively more stable than in areas where fossil fuels are used to generate electricity.

Canada

Ferrosilicon is produced by Chromium Mining & Smelting Corporation, Limited (Chromasco) at its ferroalloy plant at Beauharnois, Quebec. Output consists primarily of 50, 75, 85 and 90 per cent silicon grades of ferrosilicon. One electric furnace with a power rating of 15,500 kva produces ferrosilicon; a second with a power rating of 5,500 kva produces silicon metal.

Union Carbide Canada Limited, Metals and Carbon Division, has four electric furnaces with a combined rating of 81,000 kva at its ferroalloy plant also at Beauharnois, Quebec. Annual production capacity is about 75,000 short tons of silicon ferroalloys and silicon metal. Ferrosilicon in 45 to 90 per cent silicon grades, magnesium ferrosilicon, and silicon metal are the principal ferroalloys produced.

Both Union Carbide and Chromasco obtain high-quality quartzitic sandstone from a quarry at Melocheville near Beauharnois. The low-cost power rates, location on the St. Lawrence-Great Lakes waterway transport system, and access to nearby quartzite make Beauharnois a favourable production location. Union Carbide also obtains high-quality quartzitic sandstone from a quarry near Lac Baskatong in the Mont-Laurier area of Quebec.

Union Carbide also operates a ferrosilicon plant at Chicoutimi, Quebec, with a 35,000 kva electric furnace having an annual capacity of 25,000 tons of ferrosilicon. It produces ferrosilicon carrying 75 and 85 per cent silicon.

There are at least five manufacturers in Canada that produce silicon carbide and they are as follows: Canadian Carborundum Company, Limited; Electro Refractories & Abrasives Canada Ltd.; Norton Company of Canada, Limited; General Abrasives (Canada) Limited; and The Exolon Company of Canada, Ltd.

A typical charge for 50 per cent Si grade ferrosilicon consists of the following:

Material	Pounds
Quartzite	2,000
Metallurgical coke	500
Metallurgical coal	550
Wood chips	200
Scrap steel	1,100

Chromasco does not export ferroalloys to offshore markets but it does export ferroalloys to the United States and it imports ferrochrome from its ferroalloy plant at Woodstock, near Memphis, Tennessee. Most of the 85 and 95 per cent Si grade ferrosilicon produced is used at the company's specialty products plant at Haley, Ontario, where the ferrosilicon is used as a reductant in the reduction of calcined dolomite to magnesium metal. Union Carbide provides about 90 per cent of the silicon metal requirements of the Aluminum Company of Canada, Limited (Alcan). The silicon metal is consumed at aluminum smelters in Arvida, Beauharnois and Shawinigan, Quebec and Kitimat, British Columbia.

Union Carbide Corporation also owns a Norwegian subsidiary, A/S Meraker Smelteverk which can produce 10,000 metric tons a year of ferrosilicon and 25,000 tons a year of silicon metal, largely for the EEC market. Union Carbide Corporation, the parent of Union Carbide Canada Limited is a major world supplier of ferroalloys with five plants in the United States, three in Canada, two in Europe, and one in Africa.

World production and foreign developments

The United States is the largest producer and consumer of silicon and ferrosilicon alloys for metallurgical use; the European Economic Community is the second largest. Norway is the world's largest exporter of ferrosilicon; however, the Norwegian capacity estimated at about 400,000 tons a year is

Table 1. Canada, ferrosilicon, silicon carbide and some other ferroalloys[1] exports and imports, 1972-73

	1972		1973^p	
	(short tons)	($)	(short tons)	($)
Exports				
Ferrosilicon				
United States	12,163	1,411,000	23,017	2,761,000
Britain	25,421	3,540,000	20,308	2,675,000
Iran	–	–	4,402	529,000
Australia	611	183,000	963	361,000
Dominican Rep.	275	61,000	399	84,000
Japan	401	145,000	190	70,000
Ghana	–	–	100	36,000
South Africa	11	4,000	88	36,000
Other countries	9,942	1,279,000	370	77,000
Total	48,824	6,623,000	49,837	6,629,000
Silicon carbide, crude and grains				
United States	104,388	15,051,000	102,494	15,665,000
Britain	–	–	2	1,000
Total	104,388	15,051,000	102,496	15,666,000
Ferroalloys, nes				
Britain	154	435,000	1,639	1,980,000
United States	1,128	1,492,000	1,861	911,000
Argentina	251	610,000	655	766,000
Japan	–	–	215	520,000
Spain	–	–	378	129,000
Australia	19	57,000	81	90,000
Cuba	–	–	772	51,000
Other countries	1,347	327,000	680	175,000
Total	2,899	2,921,000	6,281	4,622,000
Imports				
Ferrosilicon				
United States	5,393	1,517,000	4,556	1,582,000
Yugoslavia	–	–	5,975	1,427,000
Norway	3,647	949,000	2,518	746,000
Brazil	–	–	772	207,000
Italy	55	26,000	188	90,000
Other countries	469	171,000	233	83,000
Total	9,564	2,663,000	14,242	4,135,000
Silicomanganese, incl. silico spiegel				
United States	8,431	1,666,000	7,285	1,448,000
Yugoslavia	356	63,000	1,105	221,000
Norway	6,943	1,079,000	1,213	198,000
South Africa	–	–	1,147	139,000
Korea South	907	152,000	–	–
Total	16,637	2,960,000	10,750	2,006,000

Table 1 (concl'd)

	1972		1973p	
	(short tons)	($)	(short tons)	($)
Greece	–	–	18,178	11,539,000
Dominican Rep.	938	984,000	4,049	4,007,000
United States	7,375	3,657,000	4,440	2,670,000
South Africa	2,097	576,000	4,495	988,000
Brazil	2,368	1,099,000	282	785,000
France	594	240,000	874	399,000
Britain	149	260,000	37	91,000
West Germany	110	44,000	18	8,000
Chile	55	144,000	–	–
Norway	91	32,000	–	–
Other countries	66	59,000	–	–
Total	13,843	7,095,000	32,373	20,487,000

Source: Statistics Canada.
[1] Important other ferroalloys are discussed in the mineral reviews of the respective metals; e.g., those of manganese, nickel, titanium.
p Preliminary; nes - Not elsewhere specified; – Nil.

fully utilized and expansion of output is unlikely since it would require the construction of a new hydroelectric power plant.

Aluminum Company of Canada, Foote Mineral Company, of the United States, and a unit of British Oxygen Ltd., will build a $25 million facility to produce silicon metal at Pietersburg, Republic of South Africa. The plant capacity is 30,000 tons a year and the plant is expected to be in operation in late 1975. Alcan is expected to use a larger share of the new silicon plant.

A preliminary agreement has been reached between the Icelandic government and Union Carbide Corporation involving the construction of a $28 million smelter at Hvalfjordur, Iceland for the production of 75 per cent ferrosilicon. The smelter would be operated by a joint venture corporation to be owned 65 per cent by the Icelandic government and 35 per cent by Union Carbide. The plant site was chosen because of potential availability of low cost hydropower in that area. The completion date of the operation is scheduled for 1976. The plant will produce approximately 50,000 tons a year of 75 per cent ferrosilicon. The plant is expected to incorporate the latest available pollution control technology in order to comply with Icelandic environmental protection laws. During the year, Spain started a plant with a production capacity of 20,000 tons a year.

Table 2. Ferrosilicon consumption and steel production in Canada, 1963-73

	Crude Steel Production	Ferrosilicon Consumption
	(st)	(lb/ton steel)
1963	8,190,000	3.6
1964	9,128,000	3.8
1965	10,068,000	4.2
1966	10,020,000	4.4
1967	9,701,000	3.8
1968	11,198,000	4.2
1969	10,048,000	4.9
1970	12,249,000	4.6
1971	12,170,000	4.3
1972	13,073,000	4.1
1973p	14,755,000	. .

Source: Statistics Canada.
p Preliminary; . . Not available.

Uses

Silicon in iron and steel. Silicon alloys include ferrosilicon, silvery pig iron, silicomanganese, ferrochromium-silicon, ferromanganese-silicon and other metal silicides, all of which are used principally in metallurgical industries. Ferrosilicon accounts for the largest tonnage of silicon alloys produced. Silicon, introduced in the form of ferrosilicon and silicon metal into molten steel, is an effective and economical deoxidizer.

In importance, silicon is second only to manganese in steelmaking as a ferroalloy additive; the latter deoxidizes steel and reduces its sulphur content.

Silicon additions of up to 0.3 per cent in standard alloy steels increase their tensile and yield strengths. At higher silicon content, the hardenability of steel and its yield strength are increased with a loss of ductility and impact resistance. Probably the most important silicon-containing alloy steels are the elec-

Table 3. Canada, consumption, exports and imports of ferrosilicon, 1964-73

	Consumption	Exports		Imports	
	(st)	(st)	($)	(st)	($)
1964	27,275	45,987	4,525,306	3,433	892,938
1965	33,811	46,424	4,706,724	6,260	1,799,546
1966	37,664	38,023	3,784,105	5,877	1,629,368
1967	34,807	41,929	4,189,328	21,740	3,534,000
1968	51,449	47,215	5,424,665	9,816	2,615,000
1969	50,737	48,499	5,257,000	9,050	2,010,000
1970	55,728	49,984	8,284,000	10,446	2,386,000
1971	43,619	51,827	8,503,000	10,380	2,679,000
1972	46,594	48,824	6,623,000	9,564	2,663,000
1973p	61,520	49,837	6,629,000	14,242	4,135,000

Source: Statistics Canada.
p Preliminary.

Table 4. Canada, ferrosilicon consumption in the steel industry, 1963-72

	High Silicon (over 55% Si)	Medium Silicon	Low Silicon (under 45% Si)	Sil-X	Total
		(short tons)		(short tons)	
1963	2,009	12,587	65	62	14,723
1964	1,987	15,294	159	71	17,511
1965	3,326	17,774	205	94	21,399
1966	3,914	17,828	130	88	21,960
1967	3,585	14,467	234	9	18,295
1968	5,783	15,788	1,841	13	23,425
1969	7,173	15,454	1,847	11	24,485
1970	7,154	17,965	2,877	7	28,003
1971	8,026	15,520	2,891	17	26,454
1972	7,934	17,731	1,315	9	26,989

Source: Statistics Canada, Annual Report, Iron and Steel Mills.

trical (sheet) steels. Silicon reduces to a minimum those oxides and carbides that have strong magnetic properties and, for this reason, steel that is used for making electrical lamination sheets usually contains from 0.5 to 5.0 per cent silicon. Grain-oriented silicon steels are used in the construction of cores of transformers, generators and electric motors.

Silicon is added to stainless steels to improve the heat-resisting qualities of chrome, nickel-chrome and chrome-tungsten steels, and to improve their oxidation resistance at high temperatures. Carbon steels for making springs usually contain 0.5 to 2.0 per cent silicon with 0.6 to 1.0 per cent manganese. Silicomanganese can be used to introduce both manganese and silicon to the metal.

The silicon content of iron is second only to its carbon content in regard to its effectiveness in controlling the properties of iron castings. Cast iron usually contains less than 3.0 per cent silicon.

The amount of gases, chiefly oxygen, dissolved in liquid steel and the amount of gases released during solidification determine the types of ingots: rimmed, semi-killed, and capped. The amount of oxygen dissolved in molten steel depends on the carbon content of the steel and upon the type and amount of deoxidizers added to the steel. The several types of ingot steel produced are determined by different steelmaking practices, and the final structure of a steel ingot is determined by the degree to which the steel from which it was poured has been deoxidized.

The term "killed" indicates that steel has been deoxidized to the point that it will remain perfectly still after being poured into an ingot mould. The silicon content of rimmed steel is nil to 0.05 per cent, semi-killed steel contains up to 0.1 per cent silicon and killed steel contains between 0.1 and 0.5 per cent silicon.

Ferrosilicon and silicon alloys. Ferrosilicon properly contains from 45 to 95 per cent silicon. Silvery pig iron is made in blast furnaces and contains up to 12 per cent silicon. Byproduct ferrosilicon from the manufacture of a silicon carbide abrasive in electric resistance furnaces contains from 16 to 18 per cent silicon.

The lower grades of ferrosilicon (below 25 per cent Si) are not suitable for ladle addition because the large amount required would have an excessive chilling effect on steel; they are used as bath (melt) additions and are available in the form of pigs or coarse lumps. The most extensively used silicon alloy is 50 per cent ferrosilicon. It is used as a deoxidizer and alloying agent in the production of killed and semi-killed steels. The 65 per cent ferrosilicon is used as a ladle addition when the endothermic effect of the lower grade cannot be tolerated. The 75 and 90 per cent ferrosilicon grades are used for high-alloy steels requiring large additions of silicon. The 85 per cent grade is used mainly by cast-iron foundries. Sil-X is a briquetted mixture of ferrosilicon and sodium nitrate which is highly exothermic when added to the steel bath.

The low-aluminum grade (0.40 per cent Al maximum) 50 per cent ferrosilicon is used as a source of silicon for electrical steels containing less than 2 per cent silicon.

High-silicon ferrosilicon is also used in the silicothermic method of producing low-carbon ferroalloys, such as ferromolybdenum, ferrotungsten and ferrovanadium.

Magnesium ferrosilicon containing about 9 per cent magnesium, 42 to 46 per cent silicon and 0.3 per cent cerium is used in making ductile iron and pipeline steel.

Silicon carbide. Silicon carbide is essentially a manufactured abrasive but very small amounts are also used in ferrous metallurgy as a deoxidant. When it is added to molten metal a vigorous exothermic reaction results from the oxidation of both silicon and carbide to produce a hotter melt. The silicon carbide addition produces a more random dispersion of graphite flakes to give a more machinable cast iron.

Silicon metal. Silicon metal having a purity of approximately 98 per cent silicon is obtained by carbon reduction of high-purity silica material in the submerged-arc electric furnace. Over half of silicon metal output is used as a deoxidizer in the production of steel. Most of the remainder is used in the manufacture of aluminum alloys by permanent mould and die-casting operations. It is alloyed in amounts ranging up to 13 per cent with aluminum to improve such casting qualities as fluidity during casting and freedom

Table 5. Canada, ferrosilicon production[1], 1964-1972

	Ferrous Industry[2]	Other Industries[3]	Total
	(short tons)		
1964	57,169	12,660	69,829
1965	59,068	14,907	73,975
1966	53,263	16,547	69,810
1967	42,387	12,609	54,996
1968	78,456	10,392	88,848
1969	77,587	12,599	90,186
1970	86,352	8,914	95,266
1971	70,661	14,405	85,066
1972	72,555	13,299	85,854

Source: Statistics Canada.
[1] Producers' shipments; [2] Estimated by the Mineral Development Sector; [3] Principally abrasives industry.

Table 6. Ferrosilicon production and trade, 1971

	Production	Imports	Exports
	(short tons, gross weight)		
Austria	..	14,424	..
Belgium and Luxembourg	..	32,593	..
Canada	..	10,380	51,827
France	..	..	50,073
West Germany	..	115,479	16,810
India	32,362	..	1,544
Italy	91,968	26,778	..
Japan	..	2,653	..
Norway	..	..	209,562
South Africa	..	9,410	..
Sweden	45,024	16,405	19,914
United Kingdom	..	113,007	..
United States	561,972	24,467	25,506
U.S.S.R.	..	..	136,686
Yugoslavia	..	..	24,498

Sources: Metal Bulletin 1973; for Canada, Statistics Canada; for U.S., Bureau of Mines *Minerals Yearbook* Preprint 1971.
.. Not available.

from hot-shrinkage and hot-cracking. Silicon also increases the corrosion resistance, hardness and tensile strength of aluminum alloys to provide improved impact toughness and resistance to friction. Silicon metal is alloyed with copper to produce silicon bronzes with up to 3 per cent silicon. Such alloys have good working qualities and excellent corrosion resistance. Silicon metal can be used as a ladle addition to deoxidize steel and serve as an alloying element in the production of steel and iron castings.

Because of its unique chemical characteristics, silicon metal is a basic raw material in the production of silicon-type lubricants, hydraulic fluids, resins, plastics, enamels and rubber. Purified silicon metal possesses semiconductive properties suitable for use in miniaturized electronic circuits.

Table 7. Canada, manufacturers' shipments of silicon carbide, 1962-72

	Crude Silicon Carbide	
	(short tons)	($)
1962	65,853	10,233,000
1963	78,370	11,040,000
1964	85,433	11,398,000
1965	98,545	13,967,000
1966	108,351	14,777,000
1967	96,212	13,564,000
1968	109,174	16,192,000
1969	108,197	15,815,000
1970	114,764	17,653,000
1971	103,484	15,798,000
1972	114,808	17,880,000

Source: Statistics Canada.

Table 8. Canada, exports of silicon carbide, 1963-73

	(short tons)	($)
1963	72,905	9,855,821
1964	81,058	10,625,294
1965	90,902	12,243,784
1966	98,878	12,831,523
1967	87,166	11,461,930
1968	102,924	14,690,146
1969	103,501	14,974,000
1970	105,996	15,976,000
1971	93,859	13,593,000
1972	104,388	15,051,000
1973p	102,496	15,666,000

Source: Statistics Canada.
p Preliminary.

Table 9. Comparative electric costs (U.S. ¢/kWh) in late 1973

Country	Industrial Consumer
	(D)
Canada	1.1
U.S.	1.4
Italy	1.6
France	1.7
U.K.	1.7
Belgium	2.3
W. Germany	3.0
Japan	3.0+

Class (D) customer 1,000 kw – 450,000 kWh.

Raw material specifications

The essential raw material for the metallurgical production of silicon and silicon alloys is silica in the form of quartz usually as quartzite or sandstone. The material should meet the following chemical specifications: SiO_2 about 98 per cent; alumina (Al_2O_3), less than 1 per cent; iron oxide (Fe_2O_3) plus alumina, less than 1.5 per cent; and lime and magnesia, each less than 0.2 per cent. Phosphorus should be less than 0.003 per cent and arsenic should be absent even as a trace element. An iron content of less than 0.5 per cent is required if the material is used to produce silicon metal for addition to aluminum. For larger furnaces, the material should be sized between 1 and 4½ inches and contain no fines. Silica containing occluded water and chert or chalcedony which also contain combined water are not desirable since they will decrepitate upon heating in the electric furnace.

Outlook

Because of the high pollution that is usually associated with the production of silicon, ferrosilicon and silicon carbide and because of new standards being introduced by the industrialized countries, combined with high energy costs it is probable that new production will come from countries that have low population density and low energy costs and this includes Canada.

Prices

All prices for ferrosilicon and silicon metal went up during the year. It is believed that the prices will go higher in 1974 unless there is a severe steel production cutback because no new major production or production expansion is planned for the next year.

Prices

Prices published by Metals Week in December 1972 and 1973

		1972	1973
		(U.S. ¢)	
Ferrosilicon, pound contained silicon, fob shipping point, freight equalized to nearest main producer, carload lots, lump bulk			
High-purity (% Si)			
	75	19.6	21.6
	85	20.3	21.3
	90	20.3	20.3
Regular	50	15.0-16.0	15.0-17.5
Silicon metal, pound contained silicon, fob shipping point, freight equalized to nearest main producer, carload lots, lump bulk			
(% max. Fe)	(% max. Ca)		
0.35	0.07	25.4	30.9
0.50	0.07	23.7	29.2
1.00	0.07	21.5	27.0
Magnesium ferrosilicon 44/48 Si			
(% Mg)	(% Ce)		
9		23.95	23.95
9	0.5	26.25	26.25
5	0.5	19.80	19.80
35-40 zirconium silicon		33.75	33.75

Prices published by American Metal Market in December 1972 and 1973

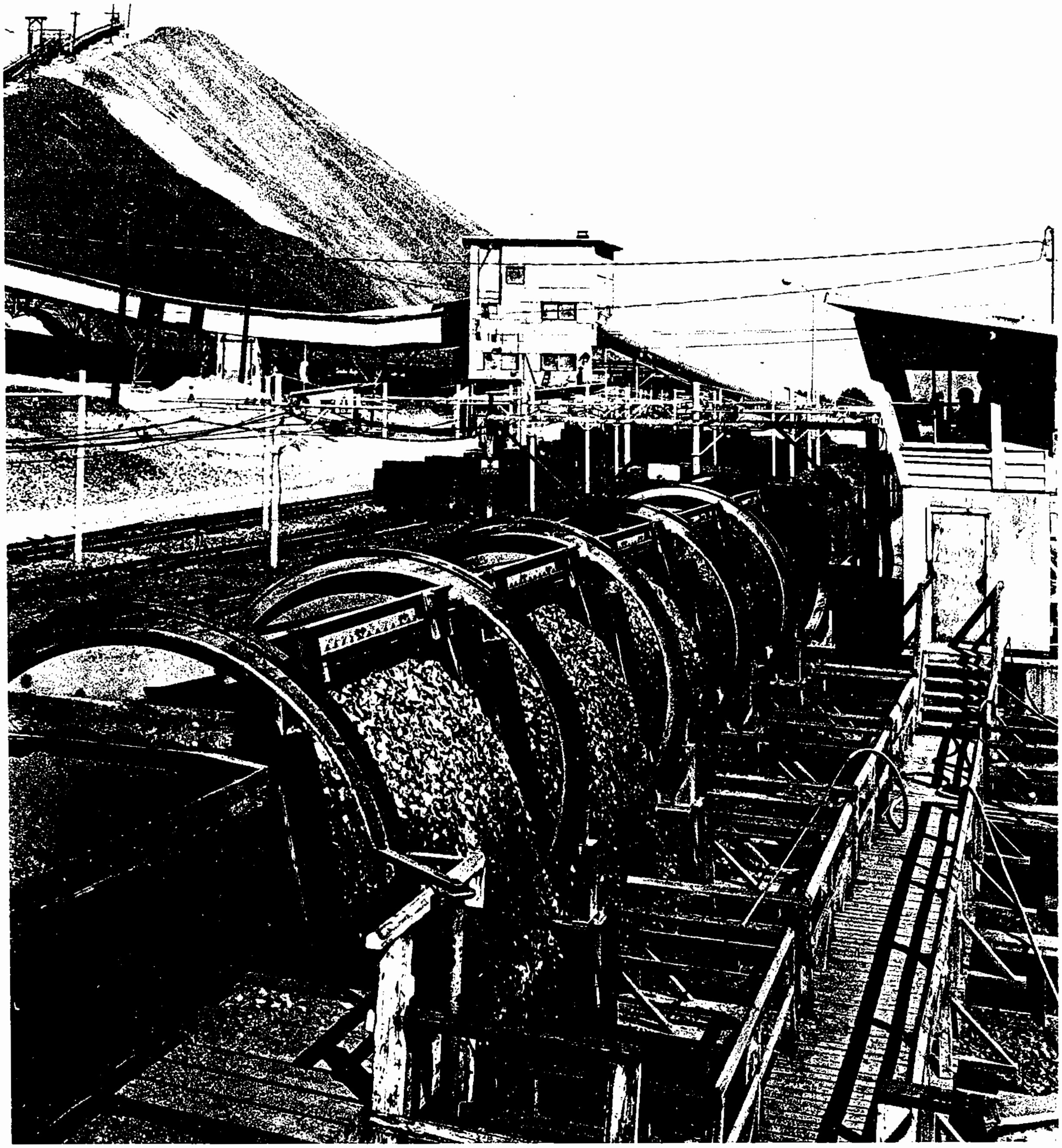
	1972	1973
	(U.S. ¢)	
SMZ alloy: 60-65% Si, 5-7% Mn, 5-6% Zr, 15-ton lots, per pound of alloy	23.0	23.0
Calcium-silicon and calsibar alloy, fob producer, 15-ton lots, per pound	24.75	24.75
Electric furnaces silvery pig iron, fob Niagara Falls	(U.S. $)	(U.S.$)
16% Si, per ton	90.00	105.00
22% Si, per gross ton	106.00	121.00

Tariffs

Canada Item No.		British Preferential	Most Favoured Nation	General
	Ferrosilicon, an alloy of iron and silicon, effective June 4, 1969		(¢)	(¢)
37503-1	containing 8% or more by weight of silicon and less than 60% per pound, or fraction thereof	free	free	1.75
37504-1	containing 60% or more by weight of silicon and less than 90% per pound, or fraction thereof, on the silicon contained therein	free	0.75	2.75
37505-1	containing 90% or more by weight of silicon per pound, or fraction thereof, on the silicon contained therein	free	2½	5½

United States Item No.		On and After Jan. 1, 1971	On and After Jan. 1, 1972
		(¢)	(¢)
	Ferrosilicon, per pound Si content		
607.50	containing over 8% but not over 60% by weight of silicon	0.1	free
607.51	containing over 60% but not over 80% by weight of silicon	0.55	0.5
607.52	containing over 80% but not over 90% by weight of silicon	1.2	1
607.53	containing over 90% by weight of silicon	2.4	2
607.55	Ferrosilicon chromium	10%	10%
607.57	Ferrosilicon manganese per pound Mn content	0.56¢ + 4.5%	0.46¢ + 3.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972) TC Publication 452.



Dumping ore cars at the concentrator bins at Cominco's Sullivan mine, Kimberley, B.C., (Cominco photo).

Silver

J.G. GEORGE

Canada's mine production of silver in 1973, 48,843,000 troy ounces*, was 4.05 million ounces greater than in 1972 and the highest on record. The increase was mainly attributable to greater output of several base-metal mines which produce silver as a byproduct, particularly that of Mattabi Mines Limited which completed its first full year of operations at its zinc-copper-lead-silver property in the Sturgeon Lake area of northwestern Ontario. Significantly higher production by Agnico-Eagle Mines Limited at its silver-cobalt property in the Cobalt district of northern Ontario and by Echo Bay Mines Ltd. at its silver-copper property near Port Radium in the Northwest Territories also contributed to the greater Canadian output. Declines in production in Newfoundland, New Brunswick and Quebec were more than offset by higher output in the other provinces, Yukon Territory and Northwest Territories. Ontario was again, by far, the leading silver-producing province, primarily because of the substantial byproduct silver produced at the Kidd Creek base-metal mine of Ecstall Mining Limited near Timmins. Output in the Cobalt-Gowganda area of Ontario was somewhat less than in 1972. The value of Canadian production was $122.1 million, or $47.3 million more than in 1972 because of higher prices and greater output.

Canada's exports of silver in ores, concentrates and as refined metal totalled 48,914,239 ounces in 1973, or some 6.9 million ounces more than the corresponding amount in 1972. The United States continued to be the major market, importing more than 70 per cent of Canada's total exports. Canadian imports of refined silver increased from 1,116,875 ounces in 1972 to 8,754,786 ounces in 1973. Most of the imports came from the United States, with minor quantities coming from the United Kingdom and Mexico.

Preliminary statistics indicate that Canadian consumption of silver in 1973 was estimated to be 16,870,000 ounces compared with 8,424,314 ounces in 1972.

Domestic production

Mine production. The principal source of silver was again base-metal ores, which accounted for almost 95 per cent of total production. The major portion of the remaining five per cent came from silver-cobalt ores mined in the Cobalt district of northern Ontario and the balance was byproduct recovery from lode and placer gold ores. The principal mine producers of silver in Canada are listed in Table 4. The accompanying map shows their approximate locations. The four largest producers in declining order of output were Ecstall Mining Limited and Mattabi Mines Limited in Ontario, Cominco Ltd. (Sullivan Mine) in southeastern British Columbia and United Keno Hill Mines Limited in the Yukon Territory. Base-metal ores mined by these four producers accounted for some 40 per cent of total Canadian silver production. The largest producer in the Cobalt-Gowganda area of Ontario was Teck Corporation Limited, Silverfields Division, with output of 1,210,000 ounces.

Metal production. Production of refined silver in 1973 at the five Canadian primary silver refineries was as follows:

	Production,[1] Refined Silver	Annual Rated Capacity[2]
Brunswick Mining and Smelting Corporation Limited, Smelting Division, Belledune, N.B.	1,254,700	2,000,000
Canadian Copper Refiners Limited, Montreal East, Quebec	14,599,000	13,000,000
Cominco Ltd., Trail, B.C.	9,629,000	15,000,000
Royal Canadian Mint, Ottawa, Ont.	210,000	7,000,000[3]
The International Nickel Company of Canada, Limited, Copper Cliff, Ont.	2,170,000[4]	. .

[1]Figures obtained from company annual reports. [2]January 1, 1973. [3]Total capacity for producing refined gold and silver, of which about 10% is silver. [4]Silver delivered to markets.
. . Not available.

*Wherever used in this review, the term "ounce" refers to the "troy ounce".

Table 1. Canada, silver production, trade and consumption, 1972-73

	1972		1973p	
	(ounces)	($)	(ounces)	($)
Production[1]				
By province and territories				
Ontario	19,587,694	32,711,449	19,938,000	49,845,000
British Columbia	6,926,036	11,566,480	8,671,000	21,677,000
Yukon Territory	4,988,967	8,331,575	6,156,000	15,391,000
Northwest Territories	4,059,261	6,778,965	5,520,000	13,801,000
New Brunswick	3,906,470	6,523,805	3,688,000	9,220,000
Quebec	3,558,027	5,941,905	2,970,000	7,421,000
Manitoba	808,376	1,349,988	1,061,000	2,653,000
Saskatchewan	384,443	642,020	451,000	1,128,000
Newfoundland	572,928	956,790	362,000	906,000
Nova Scotia	7	11	26,000	65,000
Total	44,792,209	74,802,988	48,843,000	122,107,000
By source				
Base-metal ores	42,030,225	70,190,479	46,026,000	115,065,000
Gold ores	216,753	361,968	504,000	1,260,000
Silver-cobalt ores	2,544,305	4,248,992	2,312,000	5,780,000
Placer gold ores	926	1,549	1,000	2,000
Total	44,792,209	74,802,988	48,843,000	122,107,000
Refined silver	22,740,796	..	25,596,479	..
Exports				
In ores and concentrates				
United States	14,141,017	19,471,000	13,397,375	22,751,000
Japan	4,319,055	5,835,000	6,112,459	11,435,000
West Germany	1,637,129	1,207,000	3,299,204	5,572,000
Belgium and Luxembourg	737,252	679,000	2,170,645	3,769,000
Italy	223,066	209,000	487,504	354,000
Netherlands	233,061	79,000	515,200	176,000
Norway	79,334	98,000	24,423	70,000
Others	828,715	932,000	2,500	7,000
Total	22,198,629	28,510,000	26,009,310	44,134,000
Refined metal				
United States	18,173,883	29,805,000	20,976,372	53,557,000
Belgium and Luxembourg	1,191,342	1,673,000	1,534,018	3,850,000
Trinidad and Tobago	204,851	346,000	206,971	518,000
Jamaica	149,844	295,000	135,242	432,000
United Kingdom	3,080	10,000	29,741	61,000
Guyana	3,000	6,000	12,259	33,000
Others	99,475	145,000	10,326	27,000
Total	19,825,475	32,280,000	22,904,929	58,478,000
Imports				
Refined metal				
United States	1,116,434	1,962,000	7,322,302	18,599,000
United Kingdom	441	1,000	878,876	2,252,000
Mexico	–	–	538,568	1,404,000
Other	–	–	15,040	32,000
Total	1,116,875	1,963,000	8,754,786	22,287,000

Table 1. (concl'd)

	1972		1973^p	
	(ounces)	($)	(ounces)	($)
Consumption, by use				
Silver alloys	895,459^r		1,195,340	
Sterling	2,066,193		2,856,346	
Wire and rod	36,105		56,360	
Other[2]	5,426,557		12,762,883	
	8,424,314^r		16,870,929	

Source: Statistics Canada.

[1]Includes silver: recoverable in ores, concentrates and matte shipped for export; in crude gold bullion produced; in blister and anode copper produced at Canadian smelters; in base bullion produced from domestic ores; and bullion produced from the treatment of domestic silver-cobalt ores at Cobalt, Ontario.

[2]Includes sheet, silver salts, coinage and miscellaneous uses.

^{p}Preliminary; ^{r}Revised; – Nil; . . Not available.

Table 2. Canada, silver production, trade and consumption, 1964-73

	Production		Exports				
	All Forms[1]	Refined Silver	In ores and Concentrates	Refined Silver	Total	Imports, Refined Silver	Consumption[2] Refined Silver
				(ounces)			
1964	29,902,611	20,744,682	9,478,317	10,583,439	20,061,756	5,197,764	18,775,307
1965	32,272,464	20,630,190	12,245,877	11,268,110	23,513,987	13,413,434	30,170,097
1966	33,417,874	21,298,325	11,850,469	12,221,142	24,071,611	14,477,787	21,303,704
1967	36,315,189	20,658,556	10,407,418	13,735,675	24,143,093	5,383,872	14,576,608
1968	45,012,797	34,611,344	21,502,022	28,104,562	49,606,584	14,060,635	13,598,358
1969	43,530,941	38,678,520	21,883,028	34,658,937	56,541,965	19,168,785	5,747,068
1970	44,250,804	30,725,450	21,819,924	24,199,524	46,019,448	4,319,357	6,034,028
1971	46,023,570	20,544,196^r	25,562,579	18,201,371	43,763,950	722,815	7,050,956
1972	44,792,209	22,740,796	22,198,629	19,825,475	42,024,104	1,116,875	8,424,314
1973^p	48,843,000	25,596,479	26,009,310	22,904,929	48,914,239	8,754,786	16,870,929

Source: Statistics Canada.

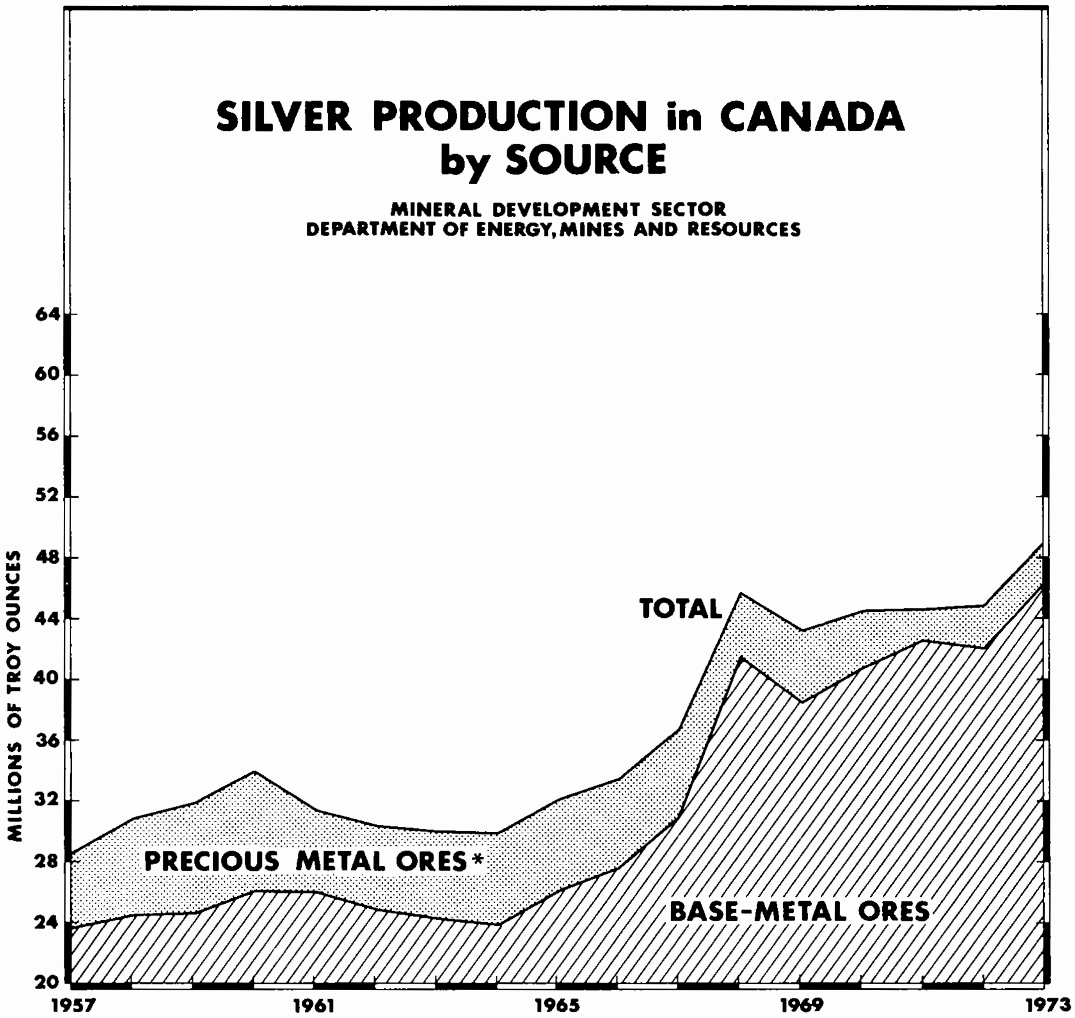
[1]Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; base bullion produced from domestic ores; bullion produced from the treatment of silver-cobalt ores at Cobalt, Ontario.

[2]Includes consumption for coinage.

^{p}Preliminary; ^{r}Revised.

Canadian Copper Refiners Limited at Montreal East, Quebec, was again Canada's largest producer of refined silver, recovering it from the treatment of anode and blister copper. The silver refinery of Cominco Ltd., at Trail, British Columbia, was the second-largest producer, recovering byproduct silver in the processing of lead and zinc ores and concentrates. Other producers of refined silver were The International Nickel Company of Canada, Limited, at Copper Cliff, Ontario (from nickel-copper concentrates); and the Royal Canadian Mint at Ottawa, Ontario (from gold bullion). At Belledune, New Brunswick, Brunswick Mining and Smelting Corporation, Limited, Smelting Division, recovered byproduct silver bullion from lead concentrates treated in a blast furnace.

At its electronic materials plants at Trail, B.C., Cominco Ltd. also produces high-purity silver metal with metallic impurities totalling one part per million



or less. This specialty metal product is manufactured mainly for applications in the electronics industry such as solder preforms, brazing preforms and lead wire.

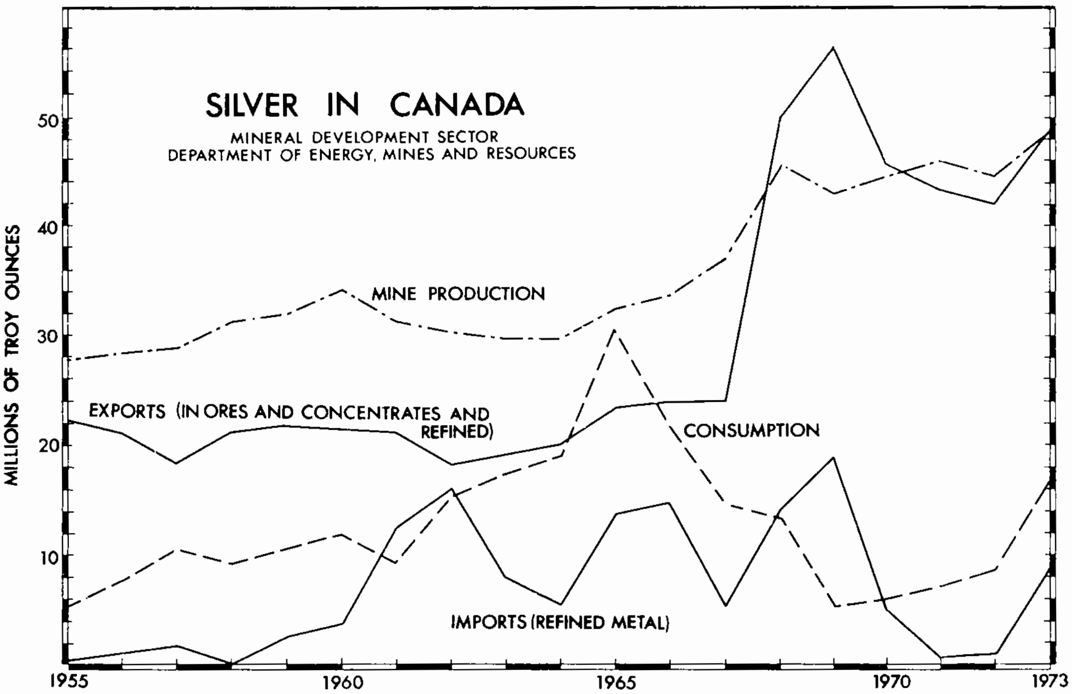
World production, consumption and economic factors

Silver production in the noncommunist world in 1973, according to an estimate of Handy and Harman*, was 249.0 million ounces, or 5.3 million ounces more than in 1972. In 1973 noncommunist world consumption for both industrial and coinage uses was 483.0 million ounces compared with 427.8 million ounces in 1972.

The Silver Market 1973, compiled by Handy and Harman, a large U.S. silver consumer.

The gap between new production and consumption was 234.0 million ounces, or considerably more than in 1972.

Consumption of silver for coinage in the noncommunist world was 20.0 million ounces, about 16.5 million ounces less than in 1972. Except for minor quantities used in 1971 in the minting of commemorative coins and in 1972 in the minting of Canadian silver dollars, silver had not been used in the production of Canadian coinage since 1968. On November 14, 1973, however, the Royal Canadian Mint struck the first new Olympic coin. It marked the beginning of production of coins containing 92.5 per cent silver to commemorate the Olympic Games to be held in Montreal in 1976. The coins are of $5 and $10 face value and the total face value of all the coins to be



issued may be up to $450 million as provided by legislation contained in a special Act of Parliament passed in July 1973. The total amount of silver involved in minting the coins could be up to 65 million ounces, and the total number of coins issued could exceed 60 million.

Based on preliminary figures, Canada in 1973 was again the world's largest mine producer of silver; other leading producers were Peru, the U.S.S.R., Mexico and the United States.

New production of silver in the United States increased slightly from 37.2 million ounces in 1972 to an estimated 37.8 million ounces in 1973. In the United States, the world's largest silver consumer, consumption for industrial uses and coinage was 195.9 and 0.9 million ounces, respectively, in 1973. The large deficit in requirements was again met by imports, demonitized coinage, secondary silver derived from discarded jewellery, silverware, films, etc., liquidation of speculative holdings and withdrawals from United States Treasury stocks. Most of the requirements for United States coinage were again obtained from Treasury stocks which (in the form of bullion, coin bars and coinage metal fund silver) declined during 1973 from 45.8 to 45.1 million ounces, excluding 139.5 million ounces contained in the strategic stockpile and 6.1 million ounces held by the Department of Defense. Although the stockpile objective remained unchanged at 139.5 million ounces, under plans announced by the United States administration in March 1973 it was proposed that the objective be reduced to 22.0 million ounces. Of the suggested reduction of 117.5 million ounces, some 110,000,000 ounces would be sold to U.S. industrial consumers and the remaining 7,500,000 ounces would be held for potential U.S. coinage requirements. However, Congressional reaction to the proposed stockpile reduction and the rate of its disposal have yet to be determined.

In May 1971 the United States Mint began the minting of 150 million Eisenhower dollar coins containing 40 per cent silver. Production of these commemorative coins was authorized in a provision included in Public Law PL-91-607 signed by President Nixon on December 31, 1970. The use of the metal in these special coins will not have any significant effect on the silver market as the United States Treasury Department, in 1970, had already set aside the silver (about 47 million ounces) that will be required. Part of these requirements resulted from a transfer of 25.5 million ounces from the strategic stockpile to the United States Mint. Some 0.92 million ounces of silver was consumed in the minting of the Eisenhower dollar coins in 1973, compared with 2.28 million ounces in 1972.

Public Law PL-93-127 was enacted October 18, 1973 directing the Secretary of the U.S. Treasury to mint prior to July 4, 1975 for issuance on or after such date, 45 million silver-clad alloy coins commemorating the Bicentennial of the American Revolution. An additional 15 million of these coins can be minted if there

Table 3. World production[1] of silver, 1972-73

	1972^p	1973^e
	(ounces)	
Canada	44,792,000	48,843,000
Peru	40,188,000	42,021,000
U.S.S.R.^{e}	40,000,000	41,000,000
Mexico	37,483,000	38,788,000
United States	37,233,000	37,827,000
Australia	22,796,000	23,201,000
Japan	10,021,000	8,552,000
East Germany^e	5,000,000	7,000,000
Bolivia[2]	5,659,000	5,708,000
Chile	2,859,000	5,035,000
Sweden	3,900,000	4,500,000
Yugoslavia	3,582,000	4,302,000
France	1,858,000	4,180,000
Republic of South Africa	3,294,000	3,652,000
Morocco	1,866,000	3,518,000
Honduras	3,595,000	3,152,000
Other countries	25,058,000	25,324,000
Total	289,184,000	306,603,000

Sources: Statistics Canada for Canada for 1972 and 1973. Other 1972 statistics from U.S. Bureau of Mines *Minerals Yearbook 1972*. Other 1973 statistics from U.S. Bureau of Mines, Mineral Industry Surveys, Gold and Silver in June 1974.

[1]Recoverable content of ores and concentrates produced unless otherwise noted. [2]Production by the state mining company, Corporacion Minera de Bolivia (COMIBOL), plus exports of medium and small (private sector) mines.

^{p}Preliminary; ^{e}Estimated.

is public demand for them. Such coins will contain 40 per cent silver which will be supplied from current U.S. government stocks.

The rising trend in silver prices which began early in 1972 continued in 1973. Increasing industrial demand and speculative activity, together with a decline in visible stocks, were the main factors which caused a sharp rise in prices. On June 13, 1973 a general price freeze was imposed on the United States economy for a period of 60 days. Under this second general price freeze the ceiling price for silver for most producers and processors was 271.6¢ an ounce. In the beginning the freeze had little effect on transactions in silver because the market remained somewhat below the ceiling. However, scarcities soon developed and on July 6, 1973 silver was obtainable in New York only from abroad and at prices above the domestic ceiling. Because of this situation, Handy and Harman suspended publication of its daily silver quotation. It was not until August 9, just two business days before Freeze II expired on August 13, that normal operations could be resumed. Freeze II was replaced by Phase IV, under the government's price and wage controls program, and the regulations promulgated under Phase IV specifically exempted silver from price controls, just as had been the case under control phases prior to Freeze II.

On the New York Commodity Exchange (Comex), the principal futures market for contracts in silver in the United States, the volume of trading in silver in 1973 amounted to 1,237,860 contracts of 10,000 ounces each, compared with 815,168 contracts traded in 1972. As similar evidence of increasing speculative interest, the volume of silver traded on the Chicago Board of Trade in 1973 amounted to 1,631,298 contracts of 5,000 ounces each, compared with 754,045 contracts traded in 1972. Silver traded on the London Metal Exchange was 644,000,000 ounces in 1973 compared with 389,000,000 ounces in 1972.

New York Commodity Exchange (Comex) silver stocks at the end of 1973 were 64.30 million ounces compared with 77.56 million ounces at December 31, 1972. Chicago Board of Trade stocks at the end of 1973 were 27.29 million ounces compared with 22.81 million ounces at December 31, 1972. London Metal Exchange stocks at the end of 1973 were 16.3 million ounces compared with 7.49 million ounces at the end of 1972. United States industrial stocks* on December 31, 1973 were reported to be some 38.4 million ounces compared with about 58.0 million ounces at the end of 1972.

Outlook

Canada's primary production** of silver in 1974 is forecast to be some 48 million ounces and is expected to range between 47 and 55 million ounces annually from 1975-79.

In spite of rampant world-wide inflation and shortages of many basic materials, the silver industry strengthened in 1973 mainly because of the prolonged buoyancy of the United States economy and the improvement in the economies of Europe and Japan. World silver markets during 1973 were fostered by strong industrial demand, but were marked especially by growing speculative activity caused mainly by widespread monetary unrest, the Arabian oil embargo and growing inflationary pressures. From the beginning of the year, prices trended sharply higher amid extreme intervening fluctuations. New record-high prices were established and at the end of 1973 silver prices were still moving upward.

The rising trend in world consumption of silver, which began in 1972, continued in 1973 but is expected to moderate somewhat in 1974. The higher consumption, partly attributable to the increasing use of silver in commemorative coins and medals and collector items, will continue to exceed primary production because mine output of silver is largely related to the production of the major base-metal ores. About 70 per cent (some 95 per cent in Canada) of the world's mine output of silver is derived as a byproduct or coproduct in the mining of such ores and, accordingly, the supply of newly mined silver continues to depend more on the production of base-metal ores than on the demand for silver.

*Refiner, fabricator and dealer stocks.
**As defined in the footnote to Table 1.

In the near-term, however, there should be no real shortage for industrial requirements since sufficient quantities of secondary silver, speculative holdings and some hoarded silver coins will continue to find their way into the market. Because of higher prices and the increasing emphasis on recycling in both the governmental and industrial sectors of the economy, greater quantities of secondary silver are expected to reach the market. Also, some 117.5 million ounces could enter the U.S. market, possibly over the next two years, as a result of the proposed reduction in the U.S. strategic stockpile of silver announced by President Nixon in March 1973. Additional supplies may continue to come from the U.S.S.R., and especially from India because early in 1974 the Indian government withdrew its curb on exports of silver bullion, sheet and plate, thus reversing a long-standing embargo on silver shipments abroad.

Although world silver consumption may decline somewhat in 1974, mainly because of the slowing down of business activity, the long-term demand for silver for both industrial uses and coinage (especially commemorative coins) is expected to increase significantly. Although world silver prices trended sharply higher in 1973, in the short-term they should be somewhat stabilized, mainly because of recessionary pressures. The long-term price trend will, however, be upward, with price fluctuations above and below the trend line and which will depend on speculative reaction to economic, monetary, political and social developments as they occur.

Canadian developments

Atlantic provinces. Silver production in the Atlantic provinces was somewhat lower in 1973 than in the previous year mainly because of lower byproduct output by American Smelting and Refining Company at its zinc-lead-copper-silver mine at Buchans, Nfld. Silver output in 1973 at the Buchan's mine was significantly curtailed when a 7½-month labour strike interrupted operations.

As a result of an extensive exploration program, lead-zinc ore reserves at the No. 12 mine of Brunswick Mining and Smelting Corporation Limited near Bathurst, N.B., were substantially increased to 84.7 million short tons* at December 31, 1973, grading 9.38 per cent zinc, 3.84 per cent lead, 0.27 per cent copper and 2.79 ounces silver a ton. It was therefore decided to sink a new shaft to a depth of 4,300 feet and install equipment capable of hoisting 11,000 tons of ore a day. Ore production from the No. 12 mine will be increased to 7,500 tons a day by 1976 and to 11,000 tons in 1979. The open-pit operation at the No. 6 mine is due to be terminated in late 1975 or early 1976.

Because of improved metal prices, Nigadoo River Mines Limited began, about mid-1973, to rehabilitate the mine and surface facilities at its zinc-lead-copper-silver property near Bathurst, N.B. Operations were scheduled to resume early in 1974. The property had been idle since January 1972 when mining and milling operations were suspended following economic and labour problems.

Quebec. Silver output in the province, derived mostly from base-metal ores, was lower in 1973 than in 1972 mainly because of lower byproduct output by Gaspé Copper Mines, Limited at Murdochville.

In December 1972 Orchan Mines Limited acquired the zinc-copper-silver property of Norita Quebec Mines Limited about eight miles northeast of the main Orchan mine in the Matagami Lake area of northwestern Quebec. Diamond drilling has indicated a deposit of 1,637,000 tons averaging 7.6 per cent zinc, 0.7 per cent copper and 1.0 ounce silver a ton before allowing for dilution. Orchan plans to bring the Norita property into production by 1976 at a rate of 900 tons of ore a day and process it at the Orchan concentrator. The Norita site preparation has been completed and a mining plant erected. A shaft was collared, and sinking of it to a depth of 1,600 feet began early in 1974.

Because of higher zinc and silver prices, Manitou-Barvue Mines Limited planned to dewater, in 1974, the open-pit and underground workings of its Barraute Township zinc-silver property. A production feasibility study is also being carried out to determine the merits of bringing the property into production late in 1975 at a rate of 1,000 tons of ore a day. When production ceased at the property in 1957 the mineralized deposit contained 4.0 million tons grading 3.5 per cent zinc and 1.2 ounces of silver a ton to the 600-foot level.

Exploration work continued in 1973 on the copper-zinc-precious metals deposit of Copperfields Mining Corporation Limited which was discovered in 1972 in Hebecourt Township 20 miles northwest of Noranda. It is a massive sulphide deposit containing sections of high-grade copper and/or zinc with precious metals. Teck Corporation Limited and its affiliate, Iso Mines Limited, are participating with Copperfields in assessing the project. Diamond drilling in 1972 indicated two deposits, one of some 1.69 million tons grading 2.25 per cent copper, 0.4 per cent zinc, 1.2 ounces of silver and 0.01 ounce of gold a ton, and the other of 2.05 million tons grading 0.4 per cent copper, 5.5 per cent zinc, 0.6 ounce of silver and 0.046 ounce of gold a ton. Preliminary mine planning indicated the advisability of an open-pit operation in the initial years of production followed by conversion to underground mining. Engineering investigations relative to a feasibility study are also under way.

Lemoine Mines Limited was incorporated early in 1974 and plans to develop to production the copper-zinc discovery made in Lemoine township by Patino Mines (Quebec) Limited late in 1973. The deposit is located 37 miles by road southeast of the town of Chibougamau and has been diamond drilled to a depth of 1,000 feet from surface. Proven and probable ore reserves total some 625,000 tons to a depth of 1,000

*The short ton (2,000 pounds avoirdupois) is used throughout unless otherwise stated.

Table 4. Principal silver (mine) producers in Canada, 1973 and (1972)

Company and Location	Mill or Mine Capacity	Grade of Ore Produced: Silver	Copper	Lead	Zinc	Ore Produced	Contained Silver Produced	Remarks
	(tons of ore/day)	(oz/ton)	(%)	(%)	(%)	(tons)	(ounces)	
Newfoundland								
American Smelting and Refining Company (Buchans Unit), Buchans	1,250 [1,250]	3.45 [3.73]	1.00 [1.13]	6.48 [7.18]	11.51 [12.89]	124,000 [291,000]	375,615 [949,439]	Operations suspended March 15 to October 3, 1973 due to labour strike.
Consolidated Rambler Mines Limited, Ming mine, Baie Verte	1,200 [1,200]	0.46 [. .]	3.05 [2.79]	– [–]	– [–]	210,375 [181,753]	73,250 [83,053]	About mid-1973 began sinking new Boundary shaft on Ming mine to planned depth of 2,000 feet.
Nova Scotia								
Dresser Minerals, Division of Dresser Industries, Inc., Walton	120 [120]	5.43 [–]	0.27 [–]	6.68 [–]	1.00 [–]	8,178 [–]	44,477 [–]	Might operate on small salvage basis in 1974.
New Brunswick								
Brunswick Mining and Smelting Corporation Limited, Bathurst Nos. 12 and 6 mines[1]	9,850 [9,850]	2.53 [. .]	0.34 [. .]	2.81 [. .]	7.00 [. .]	3,288,081 [3,257,559]	4,994,799 [4,797,074]	Open-pit operation at No. 6 mine due to be terminated in late 1975 or early 1976.
Heath Steele Mines Limited, Newcastle	3,000 [3,000]	1.83 [1.70]	0.86 [1.13]	1.64 [1.46]	4.90 [3.93]	1,077,816 [835,867]	1,098,918 [806,668]	In 1973 began sinking No. 5 shaft which is scheduled for completion to depth of 3,000 feet by end of 1974.
Nigadoo River Mines Limited, Bathurst	1,000 [1,000]	. . [–]	. . [–]	. . [–]	. . [–]	. . [–]	. . [–]	Mill tune-up operations resumed late in 1973 and nominal amount of ore produced in 1973.
Quebec								
Campbell Chibougamau Mines Ltd., Main Mine, Cedar Bay and Henderson mines, Chibougamau	4,000 [4,000]	0.2442 [0.2451]	1.30 [1.48]	– [–]	– [–]	1,186,842 [987,266]	182,844 [158,728]	Exploration and development work increased in 1973 at company's Chibougamau properties because of higher metal prices.

D'Estrie Mining Company Ltd., Stratford Centre	700 [300]	1.227 [1.212]	2.74 [2.70]	0.74 [0.72]	3.16 [3.28]	130,265 [109,138]	102,831 [113,970]	Proven ore reserves at August 31, 1973 were: 972,400 tons averaging 3.12% copper, 2.07% zinc, 0.67% lead and 1.127 ounces silver a ton.
Falconbridge Copper Limited, Lake Dufault Division, Millenbach and Norbec mines, Noranda	1,500 [1,500]	1.41 [1.40]	3.65 [3.16]	– [–]	4.41 [4.39]	555,292 [561,625]	558,489 [534,786]	Continued exploration of property from surface and underground planned for 1974.
Falconbridge Copper Limited, Opemiska Division, Perry, Springer and Robitaille mines, Chapais	3,000 [3,000]	0.34 [0.33]	2.14 [2.20]	– [–]	– [–]	1,062,818 [1,156,864]	299,530 [324,255]	In 1973, Company's new Cooke mine was being developed for production at rate of 300 tpd ore.
Gaspé Copper Mines, Limited, Needle Mountain and Copper Mountain mines, Murdochville	33,750 [11,000]	0.05 [0.147]	0.62 [0.91]	– [–]	– [–]	6,729,078 [3,939,738]	342,147 [578,881]	Late and difficult start up of expanded production facilities resulted in lower ore production than planned for 1973.
Madeleine Mines Ltd., Ste-Anne-des-Monts	2,500 [2,500]	. . [0.30]	1.31 [1.42]	– [–]	– [–]	713,980 [729,608]	164,200 [173,729]	Company plans limited surface diamond drilling and extensive underground exploratory drilling.
Manitou-Barvue Mines Limited, Golden Manitou mine[2] Val-d'Or	1,600 [1,600]	2.96 [4.68]	– [–]	0.30 [0.33]	2.07 [1.16]	197,930 [60,234]	439,631 [226,527]	Proven and indicated silver-zinc ore reserves, after allowing for dilution, at December 31, 1973 totalled 1,220,900 tons averaging 2.77% zinc, 0.28% lead, 3.94 ounces silver and 0.021 ounce gold a ton.
Mattagami Lake Mines Limited, Matagami	3,850 [3,850]	0.84 [0.88]	0.57 [0.56]	– [–]	7.4 [7.4]	1,387,251 [1,370,167]	434,252 [397,365]	Search for new ore continues with further deep diamond drilling below No. 1 orebody scheduled for 1974.
Noranda Mines Limited, Horne Division, Noranda	3,200 [3,000]	0.56 [0.488]	2.51 [2.30]	– [–]	-- [–]	485,783 [686,566]	167,140 [204,431]	Mine expected to cease operations towards end of 1974.
Normetal Mines Limited, Normetal	1,000 [1,000]	1.37 [1.43]	1.38 [1.73]	– [–]	4.86 [5.29]	297,889 [326,475]	238,640 [299,480]	Ore reserves will be depleted in 1974.
Orchan Mines Limited, Matagami	2,000 [2,000]	0.69 [1.1]	1.16 [1.05]	– [–]	5.77 [10.6]	450,230 [376,840]	93,993 [208,341]	Regular production of ore began in January 1973 at company's nearby Garon Lake base-metal mine.

Table 4. (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Produced: Silver	Grade of Ore Produced: Copper	Grade of Ore Produced: Lead	Grade of Ore Produced: Zinc	Ore Produced	Contained Silver Produced	Remarks
	(tons of ore/day)	(oz/ton)	(%)	(%)	(%)	(tons)	(ounces)	
Quebec (cont'd)								
Patino Mines (Quebec) Limited, Chibougamau	2,800 [2,800]	0.186 [0.194]	1.61 [1.77]	– [–]	– [–]	973,395 [1,018,633]	132,187 [163,597]	Investigating new copper ore structure located at depth in 1973.
Sullivan Mining Group Ltd., Cupra Division, Stratford Centre	1,500 [1,500]	1.092 [0.990]	2.41 [2.24]	0.66 [0.60]	4.88 [3.97]	89,814 [117,339]	63,588 [99,485]	Ore reserves at August 31, 1973 were 250,000 tons averaging 2.41% copper, 3.76% zinc, 0.49% lead, 0.832 ounce of silver and 0.011 ounce of gold a ton.
Ontario								
Agnico-Eagle Mines Limited, Trout Lake No. 3 shaft mine, Cobalt district	400 [400]	43.66 [. .]	. . [. .]	– [–]	– [–]	27,028 [. .]	1,130,966 [99,169]	Company's Penn concentrator operated on seasonal basis from June to October 1973 and is expected to resume operations in June 1974.
Ecstall Mining Limited (Texasgulf Inc.), Kidd Creek mine, Timmins	10,000 [10,000]	3.72 [4.35]	1.61 [1.44]	0.33 [0.39]	9.78 [10.14]	3,609,657 [3,628,501]	10,452,021 [13,136,000]	Installation of underground crusher and related equipment completed in 1973.
Falconbridge Nickel Mines Limited, Ontario mines, Sudbury district	12,600 [13,600]	. . [. .]	. . [. .]	– [–]	– [–]	4,292,900 [4,152,185]	. . [. .]	Significant new base-metal deposits indicated by deep drilling on company's Onaping mine in Sudbury district.
Mattabi Mines Limited, Sturgeon Lake	3,000 [3,000]	5.31 [4.99]	1.10 [1.27]	1.06 [1.27]	11.37 [11.97]	1,111,765 [438,838]	4,182,324 [1,516,677]	Major drilling program began early in 1974 to define known ore occurrences and search for new ore on Mattabi property.
Noranda Mines Limited, Geco Division, Manitouwadge	5,000 [5,000]	1.63 [1.93]	1.70 [2.12]	. . [0.15]	4.53 [4.30]	1,463,585 [1,815,164]	1,648,135 [2,529,862]	Operations suspended April 12 to June 11, 1973 due to labour strike.

Selco Mining Corporation Limited, South Bay Division, Uchi Lake area	500 [500]	3.18 [3.2]	1.86 [2.1]	. . [. .]	13.04 [12.0]	191,614 [183,000]	480,844 [485,716]	Ore reserves at the end of 1973 were some 400,000 tons averaging 12.5% zinc, 1.9% copper and 3.0 ounces silver a ton.
Siscoe Metals of Ontario Limited, Gowganda district	– [275]	– [26.7]	– [. .]	– [–]	– [–]	– [29,495]	– [788,695]	Mining and milling operations suspended November 1972.
Teck Corporation Limited, Silverfields Division, Cobalt district	270 [270]	13.0 [17.5]	0.4 [0.07]	– [–]	– [–]	96,556 [79,319]	1,210,000 [1,343,918]	Exploration work done in southeast part of property.
The International Nickel Company of Canada, Limited, Sudbury, Ont. and Thompson, Man.	83,400 [97,500]	. . [. .]	. . [. .]	– [–]	– [–]	19,410,303 [18,938,225]	2,170,000[3] [1,930,000][3]	In the Sudbury district, in January 1974, production from the reactivated Crean Hill mine was resumed and the new Levack West mine began regular production.
Willroy Mines Limited, Willroy and Willecho mines, Manitouwadge	1,700 [1,700]	1.42 [1.41]	0.98 [1.10]	0.17 [0.14]	2.74 [3.27]	430,486 [431,067]	433,337 [454,971]	In 1973 continued to develop new good grade ore.
Manitoba – Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon and Snow Lake districts	8,500 [6,800]	0.747 [0.59]	2.448 [2.67]	. . [. .]	3.611 [3.28]	1,815,027 [1,847,903]	976,470 [837,529]	Development of new Centennial mine started in 1973 and production is scheduled to begin in 1975.
British Columbia								
Bethlehem Copper Corporation Ltd., Highland Valley	16,000 [16,300]	. . [. .]	0.581 [0.540]	– [–]	– [–]	6,339,122 [5,964,696]	165,832 [162,000]	Diamond drilling in 1973 proved up substantial extension to Jersey orebody.
Bradina Joint Venture, Houston	500 [600]	4.88 [5.31]	0.43 [0.42]	1.02 [0.89]	4.57 [4.45]	98,471 [111,024]	283,363 [329,378]	Mining and milling operations suspended August 31, 1973.
Brenda Mines Ltd., Peachland	24,000 [24,000]	. . [. .]	0.203 [0.208]	– [–]	– [–]	8,867,800 [9,503,190]	245,986 [302,600]	Operations suspended March 11 to April 12, 1973 due to labour strike.
Cominco Ltd., Sullivan mine, Kimberley	10,000 [10,000]	1.76 [. .]	. . [. .]	4.97 [. .]	4.99 [. .]	2,214,415 [1,925,099]	3,328,727 [3,026,084]	Cominco's total output of refined silver from all sources was 9,629,000 ounces in 1973.

Table 4. (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Produced: Silver	Copper	Lead	Zinc	Ore Produced	Contained Silver Produced	Remarks
	(tons of ore/day)	(oz/ton)	(%)	(%)	(%)	(tons)	(ounces)	
British Columbia (cont'd)								
Consolidated Columbia River Mines Ltd., Ruth-Vermont mine, Golden (formerly Columbia River Mines Ltd.)	500 [–]	5.02 [–]	0.09 [–]	3.69 [–]	5.08 [–]	26,957 [–]	87,123[e] [–]	Mine reopened in 1973 on a trial basis.
Gibraltar Mines Ltd., McLeese Lake, Cariboo district	40,000 [38,000]	. . [. .]	0.484 [0.455]	– [–]	– [–]	15,082,231 [11,243,221]	. . [. .]	Initial production from Granite Lake open pit was scheduled for early 1974.
The Granby Mining Company Limited, Granisle mine, Babine Lake	13,000 [13,000]	0.09 [. .]	0.472 [0.55]	– [–]	– [–]	4,565,105 [2,537,138]	183,036 [. .]	Hard grinding ore in one section of pit prevented concentrator achieving planned capacity of 14,000 tpd ore.
The Granby Mining Company Limited, Phoenix Copper Division, Greenwood	2,750 [2,600]	0.177 [0.258]	0.50 [0.677]	– [–]	– [–]	1,003,815 [873,982]	78,618 [99,119]	Mill capacity increased from 2,600 to 2,750 tpd of ore.
Granduc Operating Company, Stewart	8,000 [7,500]	. . [. .]	1.25 [1.35]	– [–]	– [–]	2,797,949 [2,089,865]	623,005 [476,962]	Sub-level caving system of mining changed from partly transverse to entirely longitudinal.
Kam-Kotia Mines Limited, Silmonac mine, Slocan district	150 [150]	14.45 [16.44]	. . [. .]	5.36 [5.81]	5.41 [6.62]	14,015 [27,429]	190,134 [425,065]	Continuing operations depend on developing additional ore reserves.
Lornex Mining Corporation Ltd., Highland Valley	38,000 [38,000]	. . [0.03]	0.424 [0.427]	– [–]	– [–]	13,986,958 [5,468,794]	479,127 [169,200]	Comprehensive program began late in 1973 to define total ore reserves contained in Lornex property.
Placid Oil Company, Bull River mine, Cranbrook	750 [700]	0.7142 [0.378]	2.4 [1.32]	– [–]	– [–]	206,812 [206,331]	88,692 [54,366]	Plan exploration adit into an underground deposit for verification of grade, quality and mineability.
Reeves MacDonald Mines Limited, Annex mine, Remac	1,000 [1,000]	1.06 [1.91]	. . [. .]	1.67 [0.59]	4.49 [7.07]	191,438 [180,188]	159,510 [284,822]	Underground exploration is in progress at adjoining property owned by Hecla Mining Company.

Similkameen Mining Company Limited, Ingerbelle Pit, Princeton	15,000 [15,000]	. . [. .]	0.45 [0.44]	– [–]	– [–]	5,356,829 [2,992,664]	130,808 [72,000]	Construction of 50% increase in concentrator capacity to 22,000 tpd of ore began in spring of 1974 and completion is expected early in 1975.
Teck Corporation Limited,[4] Beaverdell mine, Beaverdell	120 [120]	12.36 [18.23]	0.002 [0.003]	0.62 [0.72]	0.61 [0.76]	37,202 [37,091]	459,883 [676,046]	Mining was routine in 1973 and no new developments or expansion occurred.
Utah Mines Ltd., Island Copper mine, Coal Harbour, Vancouver Island	33,000 [33,000]	. . [. .]	0.50 [0.53]	– [–]	– [–]	12,071,000 [7,980,429]	263,600 [207,500]	Production was much higher in 1973 due to additional operating experience and refinement of mining and concentrating techniques.
Wesfrob Mines Limited, Tasu Harbour, Queen Charlotte Islands	8,000 [8,000]	. . [. .]	0.408 [0.47]	. . [. .]	. . [. .]	762,978[5] [595,505][5]	87,305 [72,808]	In 1973 began development of access to underground orebody.
Western Mines Limited,[6] Buttle Lake, Vancouver Island	1,100 [1,100]	4.60 [. .]	1.39 [1.85]	1.28 [0.68]	8.29 [6.02]	354,240 [374,022]	1,424,437 [571,838]	An adit, started early in 1973 to connect nearby Price property with Myra 13 level, advanced 2,312 feet.
Northwest Territories								
Echo Bay Mines Ltd., Port Radium	150 [100]	84.04 [67.0]	1.25 [1.14]	– [–]	– [–]	37,393 [37,290]	3,064,000 [2,440,000]	At the end of 1973 ore reserves were somewhat in excess of 13,000 tons.
Terra Mining and Exploration Limited, Camsell River area	175 [175]	35.4 [81.63]	0.7 [0.38]	– [–]	– [–]	41,116 [24,723]	1,393,323 [1,921,338]	Production during year beginning July 1, 1974 will be primarily from new No. 10 vein and is expected to exceed 2.5 million ounces silver.
Yukon Territory								
Anvil Mining Corporation Limited, Faro	10,000 [8,000]	. . [. .]	. . [. .]	4.88 [4.63]	6.37 [6.22]	2,899,145 [2,905,530]	2,811,482 [2,857,900]	Expansion of concentrator capacity from 8,000 to 10,000 tpd ore completed by end of 1973.
United Keno Hill Mines Limited, Elsa, Husky and No Cash mines, Elsa	550 [550]	34.62 [34.23]	. . [. .]	4.00 [4.61]	1.00 [3.19]	94,819 [80,646]	3,135,000 [2,634,176]	Keno mine to be reopened and was scheduled to resume operations early in 1974.

Table 4. (concl'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Produced: Silver	Copper	Lead	Zinc	Ore Produced	Contained Silver Produced	Remarks
	(tons of ore/day)	(oz/ton)	(%)	(%)	(%)	(tons)	(ounces)	
Yukon Territory (cont'd)								
Whitehorse Copper Mines Ltd., Little Chief mine, Whitehorse	2,400 [2,000]	. . [0.40]	1.83 [1.92]	– [–]	– [–]	700,054 [10,707]	254,000 [4,297]	Middle Chief orebody to be developed in 1974 to provide a standby working area.

Source: Company reports.

[1]All statistical data, including mill capacity, represent combined results for Nos. 12 and 6 mines and mills. [2]Grade and production statistics do not include 272,712 and 253,323 tons of copper ore custom milled in separate circuits in 1972 and 1973, respectively. [3]Silver delivered to markets. [4]Grade and production statistics for 1972 are for fiscal year ended September 30, 1972. [5]Ore produced in No. 3 zone only. [6]Grade of ore statistics for 1973 have been estimated.

[e]Estimate; – Nil; . . Not available.

Table 5. Prospective[1] silver producing mines in Canada

Company and Location	Year Production Expected	Planned Mill or Mine Capacity	Indicated Ore Reserves	Average Grade of Ore: Lead	Zinc	Copper	Silver	Remarks
		(tons ore/day)	(tons)	(%)	(%)	(%)	(oz/ton)	
New Brunswick								
Heath Steele Mines Limited, Little River mine, Newcastle	1975	..	..	..	..	..	..	Ore to be milled at company's existing concentrator.
Nigadoo River Mines Limited, Bathurst	1974	1,000	1,248,000	3.23	3.22	0.24	4.04	Mine dewatered in 1973 and operations scheduled to begin early 1974.
Quebec								
Falconbridge Copper Limited, Opemiska Division, Cooke mine, Chapais	..	300	555,000	–	–	1.46	..	Indicated ore reserves estimated to contain 0.30 ounce gold a ton.
Orchan Mines Limited, Norita mine, Matagami	1976	900	1,637,000[2]	–	7.6	0.7	1.0	Site preparation completed and mining plant erected. Shaft collared and sinking to a depth of 1,600 feet was to begin in March 1974.
Ontario								
Sturgeon Lake Mines Limited, Sturgeon Lake area	1974	1,200	2,111,000	1.47	10.64	2.98	6.14	Concentrator erected and closed in in late 1973 and open-pit operations expected to begin late 1974.
Manitoba								
Hudson Bay Mining and Smelting Co., Limited, Centennial mine, Flin Flon district	1975	..	1,400,000	..	2.6	2.06	..	Ore to be milled at company's central mill at Flin Flon.
British Columbia								
Dankoe Mines Ltd., Keremeos	1974	150	75,000[3]	..	..	..	9.5[3]	Operations expected to resume early 1974.

Table 5. (concl'd)

Company and Location	Year Production Expected	Planned Mill or Mine Capacity	Indicated Ore Reserves	Average Grade of Ore Lead	Zinc	Copper	Silver	Remarks
		(tons ore/day)	(tons)	(%)	(%)	(%)	(%)	
Northwest Territories								
Mineral Resources International Limited, Strathcona Sound, Baffin Island	1977	1,500	7,000,000	1.4	14.1	..	1.8	Feasibility study to be completed early 1974 and construction of mine and concentrator to begin in same year.

[1]Those mines which have announced production plans. [2]Ore reserve figure does not allow for dilution in mining. [3]Figures based on press reports.
– Nil; .. Not available.

feet grading 4.5 per cent copper, 10.8 per cent zinc, 0.138 ounce of gold and 2.70 ounces of silver a ton. Shaft sinking to a depth of 1,000 feet has begun with the aim of bringing the property into production by late 1975 at a rate of 300 to 500 tons of ore a day.

Ontario. Ontario was again, by far, the leading silver-producing province with its output accounting for some 40 per cent of Canadian mine production. The largest producer was again Ecstall Mining Limited, which recovered almost 10.5 million ounces in lead, copper and zinc concentrates at its Kidd Creek property, the largest single mine producer of silver in Canada. In the Cobalt-Gowganda area of northern Ontario some 2.3 million ounces were derived from silver-cobalt mines. Output was lower than in 1972 because of the lack of production from the veteran producer in the Cobalt-Gowganda area, Siscoe Metals of Ontario Limited, which suspended operations late in 1972 because of exhaustion of ore reserves.

Late in 1973 Texasgulf Inc. announced plans for a two-phase expansion at its Kidd Creek mine. The first stage consists of mine and mill expansion to increase annual ore production from 3.6 to 4.0 million tons by late 1974. Date of completion of the second increase, to 5.0 million tons of ore a year, is still indefinite, but will require the sinking of a new shaft to the 5,200-foot level and enlargement of the concentrator from three to four processing circuits. Production from the open-pit mine is gradually being phased out, and by 1978 total mine production should be from underground operations. Late in 1973, ore reserves above the 2,800-foot level were reported to be some 95 million tons.

Early in 1973 it was decided to bring into production the "Boundary" orebody of Sturgeon Lake Mines Limited in the Sturgeon Lake district of northwestern Ontario. Open-pit production of the orebody at a rate of 1,200 tons of ore a day was scheduled to start late in 1974. By the end of 1973, stripping of the pit was 45 per cent complete and the concentrator had been erected. Open-pit ore reserves have been estimated at 2,111,000 tons grading 10.64 per cent zinc, 2.98 per cent copper, 1.47 per cent lead, 6.14 ounces of silver and 0.02 ounce of gold a ton.

Mattagami Lake Mines Limited continued diamond drilling on its Lyon Lake and Creek ore zones about five miles east of the Mattabi mine. Total mineable ore reserves at the two zones down to the 1,000-foot horizon after allowing for dilution were, at the end of 1973, 3,096,000 tons grading 6.20 per cent zinc, 1.15 per cent copper, 0.60 per cent lead, 3.30 ounces of silver and 0.11 ounce of gold a ton. A feasibility study suggested that the deposits can be economically mined from a single 1,500-foot vertical shaft at a production rate of 1,000 tons of ore a day.

Manitoba-Saskatchewan. In Manitoba and Saskatchewan most of the silver continued to come from nine base-metal mines operated by Hudson Bay Mining and Smelting Co., Limited near Flin Flon and Snow Lake, Manitoba. Development of the company's Centennial base-metal mine began in 1973. It is nine miles southeast of Flin Flon, Man., and production is scheduled to begin in 1975.

British Columbia. Base-metal ores continued to be the main source of British Columbia's mine output of silver. Cominco Ltd., the largest silver producer in the province, derived its output from the lead-zinc-silver ores of its Sullivan mine in southeastern British Columbia, and from purchased ores and concentrates.

Reeves MacDonald Mines Limited developed sufficient ore reserves in the 1250 West area of its Annex mine to sustain operations for most of 1974. Exploration work continued on the adjoining Redbird base-metal property of Hecla Operating Company. Reeves is conducting this exploration work for Hecla on a contract basis with an option to operate the property if the work is successful.

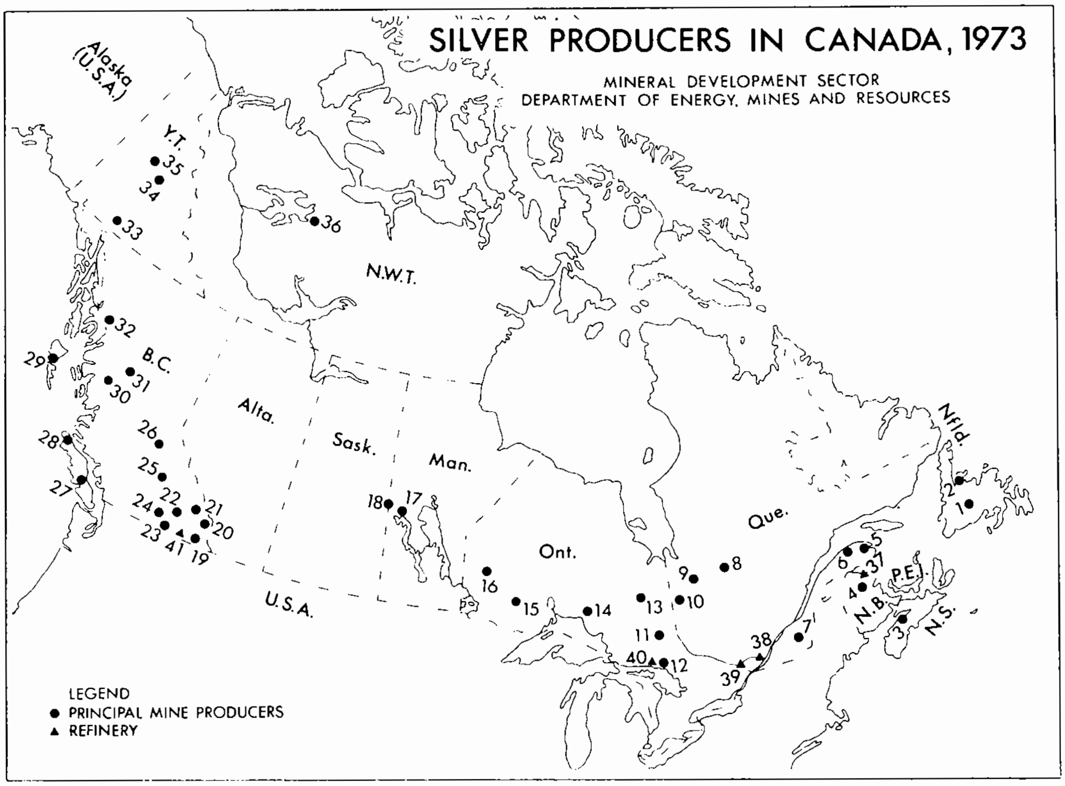
Dankoe Mines Ltd. planned to resume production early in 1974, at a rate of 150 tons of ore a day, at its silver-base-metals property near Keremeos in south-central British Columbia. The mine, equipped with a 450-ton-a-day concentrator, suspended operations in March 1970 because of low silver prices obtaining at that time.

Surface and underground exploration work continued at the Brandywine Falls gold-silver property of Northair Mines Ltd. about 70 miles north of Vancouver. The company is considering bringing the property into production late in 1975 at a rate of some 300 tons of ore a day. Late in 1973, indicated ore reserves were reported to be 120,000 tons grading 0.37 ounce of gold and 17.55 ounces of silver a ton.

Northwest Territories. Somewhat higher silver production in 1973 in the Northwest Territories resulted from greater output by Echo Bay Mines Ltd. Echo Bay and Terra Mining and Exploration Limited, which operate silver-copper properties near Port Radium on the east shore of Great Bear Lake, were again the principal silver producers in the Northwest Territories.

Mineral Resources International Limited (MRI) completed a feasibility study on its zinc-lead-silver property at Strathcona Sound on the northwest end of Baffin Island. The study recommended that the property be put into production at a rate of about 1,500 tons of ore a day. Underground mine construction could begin in 1974 with the mine becoming operational in 1976 or 1977. Ore reserves have been reported to be 7 million tons averaging 14.1 per cent zinc, 1.4 per cent lead and 1.8 ounces silver a ton.

Further diamond drilling was done in 1973 on the zinc-lead-silver-copper prospect which Cominco Ltd. has optioned from Bathurst Norsemines Ltd. The property is in the Hackett River area, District of Mackenzie, on the Arctic coast about 300 air-miles northeast of Yellowknife, N.W.T. Base-metal sulphides have been discovered in at least six separate zones, the more important ones being the "A" or main zone, the Finger Lake zone and the East Cleaver Lake zone. Drilling results have indicated the "A" zone contains a deposit of 5,300 tons per vertical foot averaging 8.5



per cent zinc, 1.4 per cent lead, 0.25 per cent copper, 7.0 ounces of silver and 0.05 ounce of gold a ton. Drilling in 1973 indicated the presence of above average grade in zinc and silver mineralization in the East Cleaver Lake zone.

Principal Mine Producers

(numbers refer to numbers on the map)

1. American Smelting and Refining Company (Buchans Unit)
2. Consolidated Rambler Mines Limited
3. Dresser Minerals, Division of Dresser Industries, Inc.
4. Brunswick Mining and Smelting Corporation Limited (Nos. 12 and 6 mines)
   Heath Steele Mines Limited
5. Gaspé Copper Mines, Limited
6. Madeleine Mines Ltd.
7. D'Estrie Mining Company Ltd.
   Sullivan Mining Group Ltd., Cupra Division
8. Campbell Chibougamau Mines Ltd.
   Falconbridge Copper Limited, Opemiska Division
   Patino Mines (Quebec) Limited
9. Mattagami Lake Mines Limited
   Orchan Mines Limited
10. Falconbridge Copper Limited, Lake Dufault Division
    Manitou-Barvue Mines Limited
    Noranda Mines Limited, Horne Division
    Normetal Mines Limited
11. Agnico-Eagle Mines Limited
    Teck Corporation Limited, Silverfields Division
12. The International Nickel Company of Canada, Limited
    Falconbridge Nickel Mines Limited
13. Ecstall Mining Limited
14. Noranda Mines Limited, Geco Division
    Willroy Mines Limited
15. Mattabi Mines Limited
16. Selco Mining Corporation Limited, South Bay Division
17. Hudson Bay Mining and Smelting Co., Limited (Anderson Lake, Chisel Lake, Dickstone, Osborne Lake and Stall Lake mines)
18. Hudson Bay Mining and Smelting Co., Limited (Flexar, Flin Flon, Ghost Lake, Schist Lake and White Lake mines)
19. Reeves MacDonald Mines Limited
20. Cominco Ltd. (Sullivan mine)
21. Kam-Kotia Mines Limited (Silmonac mine)
22. Brenda Mines Ltd.
    Similkameen Mining Company Limited

Principal Mine producers (cont'd)

23. The Granby Mining Company Limited, Phoenix Copper Division
24. Teck Corporation Limited (Beaverdell mine)
25. Bethlehem Copper Corporation Ltd.
    Lornex Mining Corporation Ltd.
26. Gibraltar Mines Ltd.
27. Western Mines Limited
28. Utah Mines Ltd.
29. Wesfrob Mines Limited
30. Bradina Joint Venture
31. The Granby Mining Company Limited, Granisle mine
32. Granduc Operating Company
33. Whitehorse Copper Mines Ltd.
34. Anvil Mining Corporation Limited
35. United Keno Hill Mines Limited
36. Echo Bay Mines Ltd.
    Terra Mining and Exploration Limited

Refineries

(numbers refer to numbers on the map)

37. Brunswick Mining and Smelting Corporation Limited, Smelting Division
38. Canadian Copper Refiners Limited
39. Royal Canadian Mint
40. The International Nickel Company of Canada, Limited
41. Cominco Ltd.

Yukon Territory. A significant increase in silver production in 1973 in the Yukon Territory resulted from greater byproduct output at the silver-base-metal properties of United Keno Hill Mines Limited and Whitehorse Copper Mines Ltd. At the Keno Hill property the Dixie and Townsite Adits failed to develop as much ore as expected and both were placed on a salvage basis at the end of 1973. Because of higher silver prices it was decided to resume operations at the Keno Mine in 1974 to recover the remaining ore reserves and as a base from which to examine the Shamrock "J" structure from underground.

Bulldozer trenching was carried out in 1973 by Dynasty Explorations Limited and its associate, Atlas Explorations Limited, on the Plata silver-gold-lead property in the Hess Mountains area 110 miles north of Ross River, Y.T. Dynasty is financing the project and holds an 80 per cent interest in the venture, with Atlas having a 20 per cent carried interest. A principal vein fault over 6,000 feet long was revealed. It assayed 50 to 60 ounces of silver a ton and 0.02 to 0.20 ounce of gold a ton across widths of three to five feet. Although average values in this main structure are submarginal, several subsidiary veins have been discovered which carry higher silver values. Additional trenching is planned for several of the vein zones in 1974.

Uses

Although the number of industrial applications for silver has increased, significant quantities of the metal are still used in the manufacture of coinage, especially commemorative coins. This is because it strongly resists corrosion, has good alloying properties, an attractive appearance and intrinsic value. The quantity of silver required for coinage, however, declined in 1973 because of the continuing trend towards using silverless coins or ones of reduced silver content. According to Handy and Harman, noncommunist world consumption of silver for coinage dropped from a high of 381.1 million ounces in 1965 to 20.0 million ounces in 1973. Silver is used extensively in jewelry, sterling and plated silverware, and as a decorative material, because of the same properties that made it popular in the past as a coinage metal as well as for its high malleability, ductility and ability to take a fine finish. Phillips Petroleum Company recently developed a very promising anti-tarnish compound called Meos which permits treated silver to remain untarnished 20 to 60 times longer than untreated silver. The photographic industry, in which the use of silver is based on the light sensitivity and ease of reduction of certain silver compounds, is the metal's greatest single user. Silver halide is the light-sensitive chemical coating on film that makes photography possible. In 1973 photographic materials accounted for about 26.9[1] per cent of total industrial consumption of silver in the United States. The only significant development that could bring about a real change in the substantial use and growth of silver in this major outlet would be the discovery of a suitable and economic substitute. In spite of the vast amount of research that has been done in this field for several years, and the repeated rumours and announcements of imminent replacement, a suitable silverless photographic process does not yet appear to be in prospect. Even if a satisfactory substitute should be found, it could take some years to effect the transition.

Substantial quantities are being used in the electrical and electronics industries because of the good demand for silver contacts, conductors, and other silver-bearing components. These applications include extensive quantities of silver used in the component parts of complex electronics systems to assure maximum conductivity and reliability in guidance systems for spacecraft. In 1973, electrical and electronic products accounted for about 22.1[1] per cent of total industrial consumption of silver in the United States. Silver is an important constituent of many brazing and soldering alloys because of the low melting point of silver-copper and silver-copper-zinc alloys, their resistance to corrosion, high-tensile strength and ability to join together almost all nonferrous metals and alloys as well as iron and silver.

[1] Based on figures contained in Table 6.

These solders and brazing alloys are widely used in the manufacture of air conditioning and refrigeration equipment, electrical appliances and automotive parts.

Silver-zinc and silver-cadmium batteries are increasingly used in portable equipment where good output, long life and rechargeability are required. These batteries are also used in jet aircraft, missiles, satellites and space capsules where weight and dependability are of prime importance. High-energy silver-zinc batteries played a vital part in the historic Apollo flights to the moon, servicing both the command and lunar excursion modules. Silver-zinc batteries powered TV transmissions from Appollo 17's Lunar Rover. Similar batteries also provide high-intensity light for lanterns and flashlights for plant protection and security officers. A single silver-zinc battery in a nuclear submarine may use as much as 168,000 ounces of silver.

As a catalyst, silver is used to control the oxidation of methanol to formaldehyde, and ethylene to ethylene oxide, all of which is essential to the production of plastics, antifreeze and polyester products. Silver catalysts are also used in the manufacture of carpets and permanent-press synthetic fabrics. Another growing industrial use is the almost invisible silver threads embedded in the glass of rear car windows (backlites), and which are connected to the vehicle's battery, to serve as heaters for deicing and defogging the windows. A low-cost, highly effective silver nitrate cream has been developed for the treatment of severe burns. Silver powder, 99.999 per cent pure, in the form of round beads has applications in powder metallurgy, electronic circuits, and in silver brazing. Meteorological applications involving the use of silver iodide for cloud seeding to produce rain could become a significant outlet for silver as many countries are making efforts to regulate the weather. Other promising new outlets for the metal are as fungicides and bactericides because of the increasing attention being paid to the ecology and environment. Research is being done on the use of silver in compounds for the

Table 6. United States consumption of silver by end use, 1972-73

	1972	1973p
	(ounces)	
Electroplated ware	12,715,928	14,470,379
Sterling ware	27,162,656	40,099,538
Jewelry	4,870,595	5,777,563
Photographic materials	38,251,064	51,979,282
Dental and medical supplies	1,990,739	3,017,125
Mirrors	1,225,534	2,578,946
Brazing alloys and solders	12,213,575	16,685,895
Electrical and electronic products:		
batteries	6,043,537	4,201,463
contacts and conductors	36,434,350	38,533,717
Bearings	343,929	375,876
Catalysts	3,429,719	6,004,772
Miscellaneous[1]	6,380,997	9,438,554
Total net industrial consumption	151,062,623	193,163,110
Coinage	2,284,360	920,460
Total consumption	153,346,983	194,083,570

Source: U.S. Bureau of Mines, Mineral Industry Surveys, Gold and Silver in December 1973.

[1]Includes silver-bearing copper, silver-bearing lead anodes, ceramic paints, etc.

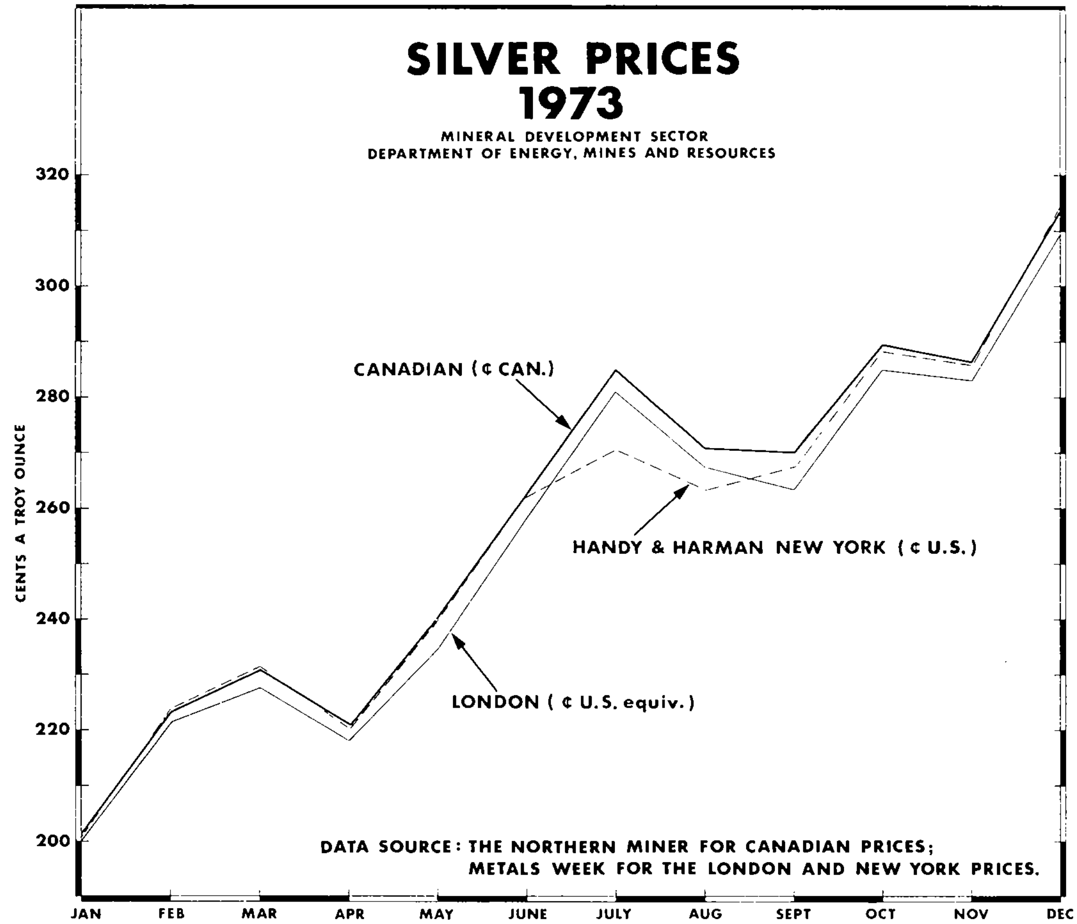
pPreliminary.

Table 7. Annual average silver prices: Canada, United States and United Kingdom, 1964-73

	Canada	United States Handy and Harman, New York	United Kingdom London Spot	United Kingdom London Spot
	($ Can.)	($ U.S.)	(pence)	($ U.S. Equiv.)[3]
		(per ounce)		
1964	1.400	1.293	111.920	1.920
1965	1.399	1.293	111.583	1.300
1966	1.398	1.293	111.815	1.301
1967	1.725	1.550	141.977	1.626
1968	2.311	2.145	219.529	2.189
1969	1.931	1.791	180.774	1.800
1970	1.851	1.771	177.068	1.768
1971	1.571	1.546	63.086[2]	1.542
1972	1.671	1.685	67.403[2]	1.686
1973p	2.567	2.558[1]	103.783[2]	2.544

Source: Canadian prices are those quoted by *The Northern Miner* (arithmetical average of daily quotations). United States and United Kingdom prices are those quoted by *Metals Week*.

[1]The 60-day general price freeze in effect in the United States from June 13 through August 12, 1973 forced intermittent suspension of Handy and Harman's daily quotation during July and August for a total of 22 days. [2]1971, 1972 and 1973 prices are expressed in new British pence, following British conversion to decimal currency, February 11, 1971, at the rate of 100 pence per pound sterling. Previous rate was 240 pence per pound. [3]Prices have been converted at the yearly average exchange rates quoted by *Metals Week*.



improved treatment of swimming pool water. Tests indicate that the addition of small amounts of silver can significantly reduce the quantities of other chemicals used in swimming pools for purification purposes. Recycling water with minute quantities of silver chloride also helps to eliminate unpleasant odors and tastes in the water and acts as a bactericide. Silver chloride, which has recently become available in the form of a fine-sized free-flowing powder, was specially developed for use in the treatment of water to remove slime, algae and bacteria as well as in industrial and laboratory applications.

A new system called "laser photo" was recently developed. This system will enable an office to transmit, within minutes, a detailed positive print photograph to a branch office a continent away, without requiring wet processing or other intermediate steps. This new application for silver uses a laser as a light source and dry silver paper as the reproductive medium which is processed simply by the application of heat.

Prices

The New York Handy and Harman silver price displayed a somewhat erratic but sharply rising trend throughout 1973. On January 2 the price was $2.032 an ounce. A low of $1.962 obtained on January 24 and a high of $3.280 on December 27; at year-end the price was $3.260. In 1973 the London silver price ranged between a low of 82.90 pence an ounce, equivalent to $1.966 (U.S.), on January 29 and a high of 140.20 pence, equivalent to $3.243 (U.S.), on December 27.

In 1973 the Canadian silver price closely followed its United States counterpart with the essential difference being the exchange rate. It fluctuated between a low of $1.966 an ounce on January 24 and a high of $3.279 on December 27 which latter was a new all-time high. Average for the year was $2.568.

Tariffs

Canada Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
32900-1	Ores of metals, nop	free	free	free
35800-1	Anodes of silver	free	free	10
35900-1	Silver in ingots, blocks, bars, drops, sheets or plates, unmanufactured; silver sweepings	free	free	free
35905-1	Scrap silver and metal alloy scrap containing silver (expires Oct. 31, 1975)	free	free	25
36100-1	Silver leaf	12½	20	30
36200-1	Articles consisting wholly or in part of sterling or other silverware, nop; manufactures of silver, nop	17½	22½	45

United States Item No.		
601.39	Precious metal ores, silver content	free
605.20	Silver bullion, silver dore and silver precipitates	free
605.65	Rolled silver, effective Jan. 1, 1972	10.5%
605.70	Precious metal sweepings and other precious metal waste and scrap, silver content	free
	Silver (including platinum-plated or gold-plated silver, but not rolled silver), unwrought or semi-manufactured, effective Jan. 1, 1972:	
605.46	platinum-plated	16%
605.47	gold-plated	25%
605.48	other unwrought silver	10.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972) TC Publication 452.

nop: Not otherwise provided for.

Sodium Sulphate

A. F. KILLIN

Sodium sulphate (Na_2SO_4) commonly known as 'salt cake', is an industrial chemical used principally in the manufacture of pulp and paper by the 'kraft' process, and in the manufacture of glass and detergents. It can be produced from natural deposits and brines in alkaline lakes in areas with dry climates and little or no drainage, from subsurface deposits and brines, or as a byproduct of chemical processes. Canada's sodium sulphate industry is based on natural brines and deposits in many alkaline lakes in the southern prairies of Saskatchewan and Alberta. Seven plants operated in Canada in 1973. Small quantities of byproduct sodium sulphate are recovered at a viscose-rayon plant and at a pulp and paper mill in Ontario, and at a strontium sulphate-carbonate plant in Nova Scotia.

In the United States, naturally occurring sodium sulphate is produced in California, Texas and Wyoming, and byproduct salt cake is produced in the eastern states.

Production and developments in Canada

Production (shipments) of sodium sulphate in Canada in 1973 amounted to 525,000 tons valued at $6.93 million. These figures are preliminary and do not include approximately 50,000 tons of byproduct salt cake. Production in 1973 increased 3.5 per cent over 1972 and value increased 11.8 per cent. Prices firmed in 1973 and demand for higher priced detergent grade material is expected to rise in 1974.

Deposits. Apart from the lakes in Saskatchewan and Alberta, sodium sulphate has also been found associated with magnesium sulphate in British Columbia and with calcium sulphate in New Brunswick. The New Brunswick deposits are deeply buried and occur as glauberite, the anhydrous double sulphate of sodium and calcium.

The sodium sulphate deposits in Saskatchewan and the bordering areas of Alberta have formed in shallow, undrained lakes and ponds where runoff waters carry in dissolved sulphate from the surrounding soils. Through the years, high rates of summer evaporation have concentrated the brine, and cooler fall temperatures have caused sodium sulphate to crystallize out as mirabilite (Na_2SO_4-$10H_2O$). The cycle has been repeated year after year thereby accumulating thick deposits of hydrous sodium sulphate, commonly known as Glauber's salt. Occasionally, some of the sodium sulphate formed is of the anhydrous variety known as thenardite (Na_2SO_4).

Some lakes have not accumulated thick beds because the crystals of sodium sulphate that are deposited during the fall and winter are redissolved each spring, to reform a brine rich in sodium sulphate. These same lakes commonly contain a high concentration of magnesium sulphate, a mineral that may prove valuable in the future.

Reserves in Saskatchewan have been estimated at 100 million tons of anhydrous sodium sulphate, of which about one half is considered economically recoverable with current technology. Ten deposits in Saskatchewan each contain reserves ranging from 2 million to as much as 9 million tons. One deposit in Alberta contains 3 million tons of Na_2SO_4.

Recovery and processing. For most Saskatchewan producers, weather is as important for the recovery of sodium sulphate as it is for its deposition. A supply of fresh water is also essential.

Sodium sulphate recovery generally begins by pumping concentrated lake brines into reservoirs during the summer. Pumping takes place when the brine is at the highest concentration. To supplement the brining system, one producer uses a floating dredge to excavate crystals from the lake bed and pumps a slurry directly to the processing plant.

The recovery cycle in the reservoir is completed when cool fall weather causes precipitation of hydrous sodium sulphate; excess fluid with impurities is drained or pumped back to the lake. The crystal bed, normally 2 to 4 feet deep, is then excavated by scrapers, shovels or draglines and moved to a stockpile. Stockpiling is done in the winter, and provides sufficient feed to operate a processing plant throughout the year.

Processing consists essentially of the dehydration of the natural crystal (Glauber's salt contains 55.9 per cent H_2O by weight) and drying. Processing equipment includes submerged combustion units, evaporators, classifiers, centrifuges, rotary kiln dryers, screens and crushers. The end product, a powdery white substance commonly known as salt cake, contains a minimum of 97 per cent Na_2SO_4 and can reach as much as 99.77 per cent. Uniform grain size and free flow are important in material handling and use.

Table 1. Canada, sodium sulphate production and trade, 1972-73

	1972		1973ᵖ	
	(short tons)	($)	(short tons)	($)
Production				
Shipments	507,275	6,200,598	525,000	6,930,000
Imports				
Total crude salt cake and Glauber's salt				
Belgium and Luxembourg	3,741	79,000	12,793	334,000
United States	18,195	270,000	14,179	292,000
United Kingdom	5,024	91,000	2,833	110,000
Other countries	–	–	–	–
Total	26,960	440,000	29,805	736,000
Exports				
Crude sodium sulphate				
United States	131,152	2,411,000	154,356	3,382,000
Philippines	–	–	2,751	87,000
New Zealand	–	–	563	30,000
Trinidad-Tobago	5	...	2	...
Jamaica	5	1,000	–	–
Total	131,162	2,412,000	157,672	3,499,000

Source: Statistics Canada.
ᵖPreliminary; – nil; . . . less than one thousand dollars.

The Alberta-based producer uses a solution recovery system rather than seasonal harvesting. The raw Glauber's salt is recovered from the lake bed by solution methods which have proven very successful during both summer and winter. The brine is then subjected to an evaporation and crystallization process to recover the sodium sulphate.

In July 1972, Saskatchewan Minerals suspended production at Bishopric, Saskatchewan, the smallest and oldest of the firm's three plants. A stockpile of raw sodium sulphate remains at the plant site, and pumping and harvesting is likely to continue for a few years pending improved marketing conditions. Also, in 1972, Saskatchewan Minerals began converting the Ingebrigt operation from the conventional pumping, harvesting and processing to solution-extraction; the changeover was scheduled for June 1973 when the raw stockpile was depleted.

By- and coproduct recovery. Courtaulds (Canada) Limited produced about 15,000 tons of byproduct sodium sulphate in 1973 from its Cornwall, Ontario viscose-rayon plant.

Kaiser Strontium Products Limited, a subsidiary of Kaiser Aluminum & Chemical Canada Limited, recovered coproduct salt cake at Point Edward, Nova Scotia. At the plant, strontium sulphate concentrates are reacted with natural sodium carbonate to produce strontium carbonate and sodium sulphate. The designed capacity is 90 tons of strontium carbonate and 100 tons of sodium sulphate a day. Operating difficulties prevented the plant from reaching capacity in 1973.

In July 1973, Ontario Paper Company Limited brought on stream a byproduct salt cake unit at its paper mill at Thorold, Ontario. Operating problems and a one month strike at the plant prevented output from reaching rated capacity of about 80 tons a day. Production in 1974 is expected to reach 75,000 tons.

Consumption and trade

The pulp and paper industry is still the major consumer of sodium sulphate despite a rise in use in glass and detergents manufacture. The increased demand for kraft paper has strengthened the market and prices rose during the year. The 'kraft' process yields a pulp with a very long fibre that allows manufacture of a strong paper. Consumption of sodium sulphate in the pulp and paper industry in 1973 is estimated at 400,000 tons.

Table 2. Canada, sodium sulphate production, trade and consumption, 1964-73

	Production[1]	Imports[2]	Exports	Consumption
	(short tons)			
1964	333,263	30,833	107,318	244,592
1965	345,469	29,347	116,345	275,620
1966	405,314	31,261	101,417	336,346
1967	428,316	27,621	123,833	347,140
1968	459,669	25,018	108,984	391,953
1969	518,299	29,609	120,414	437,055
1970	490,547	29,155	119,888	406,812
1971	481,919	21,299	122,523	401,908^r
1972	507,275	26,960	131,162	303,656^r
1973^p	525,000	29,805	157,672	..

Source: Statistics Canada.
[1]Producers' shipments of crude sodium sulphate.
[2]Includes Glauber's salt and crude salt cake.
^{p}Preliminary; ^{r}Revised; . . Not available.

Table 4. Canada, available data on sodium sulphate consumption, 1971-73

	1971	1972^r	1973^e
	(short tons)		
Pulp and paper	368,028^r	393,909	400,000
Glass and glass wool	6,779	7,844	8,000
Soaps	13,352	12,761	13,000
Other products[1]	13,749	14,566	14,000
Total	401,908^r	429,080	435,000

Source: Statistics Canada, breakdown by Mineral Development Sector.
[1]Colours, pigments, foundries, feed supplements and other minor uses.
^{e}Estimated; ^{r}Revised.

Sodium sulphate is also used in mineral-feed supplements, medicinals and other chemical products, and in base metal smelting.

Canadian exports at 157,672 tons reached a new high as did imports of 29,805 tons. Ninety-eight per cent of Canadian exports of salt cake went to the United States of America. Canada obtained 47.5 per cent of its imports from the United States.

Outlook

A strong demand for sodium sulphate from the pulp and paper, glass and detergent industries provides a favourable outlook for the near-term marketing situation. Prices have risen and should stabilize at levels high enough to provide reasonable profits to the industry.

Table 3. Canada, natural sodium sulphate plants, 1973

	Plant Location	Source Lake	Annual Capacity
			(st)
Alberta			
Alberta Sulphate Limited	Metiskow	Horseshoe	100,000
Saskatchewan			
Francana Minerals Ltd.	Cabri	Snakehole	100,000
Sodium Sulphate (Saskatchewan) Ltd.	Alsask[1]	Alsask	50,000
Midwest Chemicals Limited	Palo	Whitehorse	120,000
Ormiston Mining and Smelting Co. Ltd.	Ormiston	Horseshoe	100,000
Saskatchewan Minerals	Chaplin	Chaplin	150,000
Saskatchewan Minerals	Bishopric[2]	Frederick	40,000
Saskatchewan Minerals	Fox Valley	Ingebrigt	150,000
Sybouts Sodium Sulphate Co., Ltd.	Gladmar	East Coteau	50,000
Total			860,000

[1]Inactive.
[2]Processing suspended in July 1972.

Prices

The posted price for sodium sulphate during the year rose in response to the strengthening demand. The value per ton as reported by Statistics Canada was considerably below the posted price during the year.

Canadian Prices of sodium sulphate, as quoted by Canadian Chemical Processing, Buyers Guide, December 1973

	(Can. $ per short ton)
Sodium sulphate (salt cake)	
Bulk, carload lots, fob works	18.00
Detergent – grade bulk, fob works	22.00

United States prices according to Chemical Marketing Reporter, December 31, 1973

	(U.S. $ per short ton)
Salt cake, 100% Na_2SO_4 basis fob works	28.00
Salt cake, domestic, West bulk, carlots, fob producing point	18.50
Sodium sulphate, detergent, rayon-grade, carlots, fob works bulk East	33.00

Tariffs

Canada

Item No

21000-1 Natural sodium sulphate: British Preferential 10%; Most Favoured Nation 15%; General 25%.

United States

Item No.					
421.42	Crude (salt cake)*	free			
		On and After January 1			
		1969	1970	1971	1972
		(cents per long ton)			
421.44	Anhydrous	40	35	30	40
421.46	Crystallized (Glauber's salt)	80	70	60	80

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States (Annotated), 1972, TC Publication 452.
* Rates of duty for 1970, 1971 and 1972 were to become effective unless the European Economic Community and Britain had not proceeded with certain reductions provided for in their respective schedules annexed to the Geneva (1967) Protocol to GATT. These two participants have not so proceeded, and the President has proclaimed that the rate of duty under 1969 will continue in effect until the President proclaims that the two participants have agreed to proceed with reductions.

Stone

D.H. STONEHOUSE

Naturally occurring rock material, quarried or mined for industrial use with no change in its chemical state and with its physical character altered only by shaping or by sizing, is commercially termed "stone." Dimension stone is shaped for use as a building block, slab or panel. It may be rough, cut, sawn or polished and its application may depend on its strength, hardness, durability and ornamental qualities. Broken, irregular, screened and sized pieces constitute the crushed stone category. It is used mainly as an aggregate in concrete and asphalt, in highway and railway construction and as heavy riprap for facing wharves and breakwaters.

Dimension stone. Granite, limestone, marble and sandstone are the principal rock types from which building and ornamental stone is fashioned. Construction uses account for over 85 per cent of the consumption of building and ornamental stone produced and sold in Canada; the remainder is used as monumental stone.

Today in the building sector of the construction industry, granite, limestone and marble are used as facing stone in the form of cut and polished panels, in conjunction with steel and concrete for institutional and commercial buildings, while in residential buildings, the use of a limestone or sandstone ashlar, or coursing stone, is becoming increasingly popular. The emphasis has changed from stone used for structural qualities to stone used for its aesthetic qualities. The architect and contractor can design and build for lasting beauty using Canadian building stones.

Crushed stone. Many quarries which produce crushed stone are operated primarily to produce stone for other purposes – granite for building blocks and monuments, limestone for cement or lime manufacture, or for metallurgical use, marble for monuments and building panels, sandstone for riprap and cut stone. Quarries removing solid rock by drilling, blasting and crushing are not likely to be operated for small, local needs as are gravel pits and are, therefore, usually operated by large companies associated with the construction industry. Depending on cost and availability, crushed stone competes with gravel and crushed gravel as an aggregate in concrete and asphalt and as railway ballast and road metal. In these applications, it is subject to the same physical and chemical testing procedures as the gravel and sand aggregates.

Other uses for crushed stone include the manufacture of roofing granules from granite and marble, the production of poultry grit from limestone and granite and the production of rock wool from limestone and sandstone. Pulverized stone is used as follows: granite, limestone and sandstone as asphalt filler; limestone for dusting coal mines; and limestone and marble for agricultural application.

Limestone is also produced for chemical and metallurgical uses in the iron and steel industry, the glass industry, the pulp and paper industry and in sugar manufacture.

Stone production in Canada, either as dimension stone or as crushed stone, is used directly or indirectly by the construction industry except for small amounts used as monuments. Indirect usage includes that portion of the resource that is utilized by the chemical industry (mainly limestone) for the manufacture of lime, cement, iron and steel, all of which are associated with various phases of the construction industry. Activity in both building construction and heavy or engineering construction can be indicative of demands for quarried stone.

Canadian industry

Atlantic provinces. *Limestone.* At Corner Brook, Newfoundland, a high-calcium limestone for use by Bowaters Newfoundland Limited in the calcium-acid sulphite process of pulp preparation is quarried at the nearby Dormiston Quarry. About 20,000 tons a year is used. During 1973 an extensive program to outline high-calcium limestones near Port au Port began as a joint venture by British Newfoundland Exploration Limited (Brinex) of Montreal and Lehigh Portland Cement Company of Allentown, Pa. Establishment of a portland cement plant capable of an annual output of 1 million tons is a possibility, depending on the results of a multiphased feasibility study.

Mosher Limestone Company Limited quarries a dolomitic limestone at Upper Musquodoboit, Nova Scotia. Pulverized material is sold for agricultural use throughout the Atlantic provinces. Sydney Steel Corporation produces a high-calcium, fossiliferous limestone at Irish Cove, Nova Scotia, and a high-purity dolomite at Frenchvale, Nova Scotia, both for use in the Sydney steel plant. A quarry providing sized limestone to Scott Paper Limited at Abercrombie, Nova Scotia, was begun in 1968 near Antigonish Harbour by Calpo Limited. Marble Mountain Quarries

Table 1. Canada, total production (shipments) of stone, 1971 to 1973

	1971		1972		1973^p	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
By province						
Newfoundland	204,091	577,021	204,245	531,910	300,000	700,000
Prince Edward Island	–	–	–	–	–	–
Nova Scotia	1,643,081	2,996,647	1,047,413	2,588,047	1,100,000	2,700,000
New Brunswick	1,431,075	2,900,250	1,901,171	3,556,927	1,900,000	3,200,000
Quebec	37,515,419	44,108,629	41,383,701	46,467,889	44,700,000	49,300,000
Ontario	28,238,491	38,483,600	31,091,493	41,230,596	32,700,000	41,800,000
Manitoba	1,012,371	1,128,831	609,609	1,255,695	700,000	1,400,000
Alberta	183,609	708,570	195,773	808,429	200,000	900,000
British Columbia	3,286,705	5,633,525	3,769,119	6,886,662	3,900,000	7,000,000
Canada	73,514,842	96,537,073	80,202,524	103,326,155	85,500,000	107,000,000
By use[1]						
Building stone						
Rough	62,094	1,927,608	108,449	2,273,623		
Dressed	18,540	650,114	–	–		
Monumental, ornamental stone						
Rough	29,199	978,449	30,260	992,050		
Dressed	4,392	238,141	–	–		
Flagstone	4,177	63,623	48,895[2]	728,386[2]		
Curbstone	15,488	336,044	–	–		
Paving blocks	488	8,005	–	–		
Chemical and metallurgical						
Cement plants, foreign	817,464	775,687	1,310,666	1,434,886		
Lining, open-hearth furnaces	306,854	360,466	356,525	431,777		
Flux in iron and steel furnaces	1,433,522	2,122,067	1,310,826	1,897,958		
Flux in nonferrous smelters	167,469	219,779	30,086	43,950		
Glass factories	208,223	788,916	189,163	905,113		
Lime kilns, foreign	207,611	509,443	259,005	587,095		
Pulp and paper mills	276,778	993,976	258,318	923,878		
Sugar refineries	88,436	235,255	113,772	228,291		
Other chemical uses	507,600	702,126	332,938	898,162		
Pulverized stone						
Whiting (substitute)	158,002	543,636	8,221	191,169		
Asphalt filter	326,250	541,687	40,313	180,535		
Dusting, coal mines	10,420	58,640	6,713	66,850		
Agricultural purposes and fertilizer plants	857,153	1,942,910	592,359	2,162,877		
Other uses	417,621	939,188	865,420	1,474,626		
Crushed stone						
For manufacture of artificial stone	112,653	390,161	259,479	469,715		
Roofing granules	120,040	2,536,581	181,026	3,689,128		
Poultry grit	23,625	231,402	25,943	224,038		
Stucco dash	12,297	330,304	23,114	575,908		
Terrazzo chips	20,882	263,934	14,663	209,310		
Rock wool	5,329	5,242	–	–		
Rubble and riprap	2,089,090	3,047,744	1,724,206	1,917,995		
Concrete aggregate	10,655,570	13,189,010	11,203,880	14,131,954		
Asphalt aggregate	6,427,833	6,967,122	6,746,132	7,976,734		
Road metal	22,223,834	25,477,162	27,649,781	31,099,040		
Railroad ballast	3,136,233	4,311,731	3,348,176	3,556,276		
Other uses	22,769,675	24,850,920	23,164,195	24,054,831		
Total	73,514,842	96,537,073	80,202,524	103,326,155		

Source: Statistics Canada.
[1]Breakdown by use, 1972, by Statistics Section, Mineral Development Sector. [2]Includes flagstone, curbstone, paving blocks, etc.
^{p}Preliminary; – Nil.

Limited removed material from quarry stockpiles for crushing by Nova Scotia Sand and Gravel Limited and for use as an exposed aggregate in terrazzo tile and precast concrete panels. Extensive exploration for and assessment of limestones in Nova Scotia continues to provide mineral inventory data for prospective consumers.

In New Brunswick, limestone is quarried at three locations – Brookville, Elm Tree and Havelock – for use as a crushed stone, as an aggregate, or for agricultural application. Havelock Processing Ltd. has expanded its plant to offer a range of products including washed, crushed and sized aggregates for asphalt and concrete application to finely pulverized filler material.

There are three cement producers and one lime manufacturing plant in the Atlantic provinces, each operating its own limestone quarry.*

Granite. Current operations in Nova Scotia are at Nictaux, Shelburne and Erinville. A grey granite is produced from three operations near Nictaux and from one quarry at Shelburne for use mainly in the monument industry, while a black granite from Shelburne and a diorite from Erinville are used as facing stone. Quartzitic rock referred to as "bluestone" is quarried at Lake Echo, north of Dartmouth, for use as facing stone. Crushed quartzite for use as an aggregate is produced at a number of locations within Halifax County. At Folly Lake in Colchester County a diorite rock is quarried mainly for use as railway ballast.

In New Brunswick, a red, fine- to medium-grained granite is quarried near St. Stephen, and fine-grained, pink, grey and blue-grey granites are available in the Hampstead (Spoon Island) district. In the Bathurst area, a brown-to-grey, coarse-grained granite is quarried upon demand, as is a salmon-coloured, medium-grained granite near Antinouri Lake, and a black, ferromagnesian rock in the Bocabec River area. Red granite is available in the St. George district. Granite for use as a crushed stone is produced near Fredericton and at two locations near Moncton.

Sandstone. A medium-grained, buff sandstone is quarried at Wallace, Nova Scotia, for use as heavy riprap and for dimension stone applications. Recently, considerable tonnages were used in the reconstruction of the fortress at Louisbourg. Small deposits in many parts of the province are quarried periodically for local use.

In New Brunswick, a red, fine- to medium-grained sandstone has been quarried in Sackville for use in construction of buildings on the Mount Allison University campus. Deposits are exploited from time to time throughout Kent and Westmorland counties for local projects and for highway work.

Quebec. *Limestone.* Limestone occurs in the St. Lawrence and Ottawa river valleys and in the Eastern Townships. Other major deposits in the province are located in the Lac Saint-Jean – Saguenay River area and in the Gaspé region. The limestones range geologically from Precambrian to carboniferous, and vary widely in purity, colour, texture and chemical composition.

Of over 90 limestone producers in Quebec, about 50 are classed as stone quarries with non-cement, non-lime associations. These are located near major market areas such as Montreal, Quebec, Sherbrooke, Ottawa-Hull and Trois-Rivières and supply crushed stone to the construction industry mainly for use in concrete and asphalt and as highway subgrade.

The pulp and paper industry, the metallurgical industry and the agricultural industry use substantial quantities of limestone. At Kilmar, in western Quebec, Dresser Industries Canada, Ltd., formerly Canadian Refractories Limited, mines a magnesite-dolomite ore from which it produces refractory-grade magnesia and magnesia products.

Five companies operate a total of seven cement manufacturing plants in Quebec while lime is produced by four companies at four locations.*

A fine-grained, brownish-grey, fossiliferous limestone is available in the St-Marc-des-Carrières region of Quebec. A fine-grained dolomite, meeting the Ministry of Transport specifications, is being quarried from a deposit with proven reserves of 30 million cubic yards near the site of the new Montreal International Airport at Ste-Scholastique for use in runway construction.

Limestone blocks and other shapes are produced for the construction trade in the Montreal region and at various locations throughout the province as the need arises. Marble has been produced in the Stukely and Philipsburg areas.

Granite. Nearly 60 per cent of Canada's granite production comes from Quebec from long-established operations in two general regions–the region north of the St. Lawrence and Ottawa rivers, including the Lac Saint-Jean area, and the region south of the St. Lawrence River. Precambrian rocks contain granites of various colours, compositions and textures: red, brown, pink and black granites in the Lac Saint-Jean area; a fine-grained pink granite and a black anorthositic rock near Alma, and in the St-Luger-de-Milot area; coarse-grained, blue-grey and dark green granites at Rivière-à-Pierre; black and grey gneissic rocks at Rivière-à-Pierre and at Notre-Dame-des-Anges; red-pink granite at St-Alban and a banded, pink-red gneiss at St-Raymond; fine-grained, pink-coloured granite in the Laurier-Guenette area and a grey-pink gneiss at L'Annonciation; an augen-type granite near Mont-

*See the Cement and Lime sections of the *Canadian Minerals Yearbook 1973*

Table 2. Canada, production (shipments) of limestone, 1971-72

	1971		1972	
	(short tons)	($)	(short tons)	($)
By province				
Newfoundland	250	462	27,953	39,236
Nova Scotia	326,572	732,603	242,454	965,898
New Brunswick	425,810	~~1,069,791~~ 1090791	410,477	1,121,056
Quebec	33,133,303	35,003,376	35,540,638	36,139,497
Ontario	27,193,671	33,382,138	30,797,143	36,793,037
Manitoba	973,071	651,381	601,296	960,079
Alberta	183,320	702,202	195,385	797,030
British Columbia	2,787,609	4,269,925	2,936,774	4,881,731
Canada	65,023,606	75,838,878	70,752,120	81,697,564
By use[1]				
Building stone				
Rough	4,187	59,099	50,433	285,894
Dressed	8,592	304,266		
Monumental and ornamental				
Rough	727	22,286	607	13,469
Dressed	2,455	31,438	–	–
Flagstone	2,593	33,268	4,667[2]	82,863[2]
Curbstone	–	–	–	–
Paving blocks	–	–	–	–
Chemical and metallurgical				
Cement plants, foreign	817,464	775,687	1,310,666	1,434,886
Lining, open-hearth furnaces	306,854	360,466	356,520	431,727
Flux, iron and steel furnaces	1,433,522	2,122,067	1,310,826	1,897,958
Flux nonferrous smelters	167,469	219,779	30,086	43,950
Glass factories	208,223	788,916	189,163	905,113
Lime kilns, foreign	207,611	509,443	259,005	587,095
Pulp and paper mills	276,778	993,976	248,051	872,991
Sugar refineries	88,436	235,255	113,772	228,291
Other chemical uses	507,600	702,126	332,803	897,757
Pulverized stone				
Whiting substitute	158,002	543,636	8,221	191,169
Asphalt filler	260,493	407,416	30,710	156,467
Dusting coal mines	10,420	58,640	6,713	66,850
Agricultural purposes and fertilizer plants	842,712	1,906,705	534,614	1,987,255
Other uses	371,330	811,552	865,420	1,474,626
Crushed stone				
For artificial stone	105,157	374,593	225,930	292,203
Roofing granules	2,718	26,840	12,435	39,290
Poultry grit	18,180	163,645	19,314	148,007
Stucco dash	11,297	321,304	21,167	560,755
Terrazzo chips	142	994	–	–
Rock wool	5,329	5,242	–	–
Rubble and riprap	1,412,889	1,549,860	1,665,985	1,818,688
Concrete aggregate	9,039,935	9,982,009	9,274,410	10,416,842
Asphalt aggregate	5,617,029	5,670,019	5,517,913	5,994,299
Road metal	19,409,826	21,314,246	24,246,029	26,627,789
Railroad ballast	2,152,339	2,514,409	2,596,688	2,367,514
Other uses	21,573,297	23,029,696	21,519,972	21,873,816
Total	65,023,606	75,838,878	70,752,120	81,697,564

Source: Statistics Canada. – Nil.
[1]Breakdown by use, 1972, by Statistics Section, Mineral Development Sector.
[2]Includes flagstone, curbstone, paving blocks, etc.

Table 3. Canada, production (shipments) of marble, 1971-72

	1971		1972	
	(short tons)	($)	(short tons)	($)
By provinces				
Quebec	166,816	388,050	307,871	730,287
Ontario	9,615	173,074	9,299	165,366
Total, Canada	176,431	561,124	317,170	895,653
By use[1]				
Building stone				
Rough	–	–	–	–
Dressed	–	–	–	–
Chemical process stone				
Pulp and paper mills	–	–	10,267	50,887
Other uses	–	–	135	405
Pulverized stone				
Agricultural purposes and fertilizer plants	14,000	34,000	57,170	172,602
Other uses	43,691	111,584	–	–
Crushed stone				
For manufacture of artificial stone	1,000	9,000	33,549	177,512
Roofing granules	6,000	29,600	1,000	10,359
Poultry grit	–	–	172	1,301
Stucco dash	1,000	9,000	1,947	15,153
Terrazzo chips	20,740	262,940	14,663	209,310
Rubble and riprap	–	–	1,923	11,543
Concrete aggregate	15,000	20,000	–	–
Asphalt aggregate	35,000	40,000	–	–
Road metal	40,000	45,000	118,000	146,500
Other uses	–	–	78,344	100,081
Total	176,431	561,124	317,170	895,653

Source: Statistics Canada. – Nil.
[1]Breakdown by use, 1972, by Statistics Section, Mineral Development Sector.

Tremblant and a coarse-grained, brown granite in the St-Alexis-des-Monts area; grey-speckled, black and gabbroic rock in the Montpellier area and a dark-coloured anorthositic rock in the Rouyn area; brown-red to green-brown syenites in the Grenville District, a mauve-red granite in the Ville-Marie area on Lake Timiskaming. Many areas underlain by granite are too remote from transportation and markets to be economically attractive.

In the region south of the St. Lawrence River, granites are much younger and are, essentially, greyish.

Sandstone. Operations in Quebec in which sandstone was being quarried for construction purposes supplied material for use as facing stone and as aggregate. Deposits in the vicinity of Trois-Pistoles and near Quebec City are available for exploitation.

Ontario. *Limestone.* Although limestones in Ontario range from Precambrian through Devonian, the major production comes from Ordovician, Silurian and Devonian deposits. Of particular importance are the limestones and dolomites from the following geological sequences: the Black River and Trenton formations, extending from the lower end of Georgian Bay across southern Ontario to Kingston; the Guelph-Lockport Formation, extending from Niagara Falls to the Bruce Peninsula and forming the Niagara Escarpment; and the Middle Devonian limestones extending from Fort Erie through London and Woodstock to Lake Huron. Production of building stone, fluxstone and crushed aggregate from the limestones of these areas normally account for over 90 per cent of total stone production in Ontario.

Marble, ranging from blue to pink, has been quarried for construction purposes from deposits near Perth. Marble is widely distributed over southeastern Ontario and, according to the Ontario Ministry of Natural Resources reports, underlies as much as 100 square miles.

The limestone industries of Ontario are described in detail in publications of the Ontario Ministry of Natural Resources.

Eight companies operated a total of ten lime-producing facilities in Ontario in 1972, and four companies produced portland cement at a total of six locations.* Crushed stone was shipped from most of these plants.

*See Cement and Lime sections of the *Canadian Minerals Yearbook 1973*

Granite. Granites occur in northern, northwestern and southeastern Ontario. Few deposits have been exploited for the production of building stone because the major consuming centres are in southern and southwestern Ontario where ample, good-quality limestones and sandstones are readily available for building. The areas most active in granite building stone production have been the Vermilion Bay area near Kenora, the River Valley area near North Bay, and the Lyndhurst-Gananoque area in southeastern Ontario. Rough building blocks were quarried from a gneissic rock near Parry Sound, while at Havelock a massive red-granite rock was quarried.

Sandstone. Sandstone quarried near Toronto, Ottawa and Kingston has been used widely in Ontario as building stone. Production is currently from the Limehouse-Georgetown-Inglewood district where Medina sandstone is quarried and from the Kingston area where Potsdam sandstone is quarried. Medina sandstones vary from grey, through buff and brown to red and are also mottled. They are fine- to medium-grained. The Potsdam stone is medium grained and the colour ranges from grey-white through salmon-red to purple, and it also can be mottled. Current uses are as rough building stone, mill blocks from which sawn pieces are obtained, ashlar and flagstone.

Table 4. Canada, production (shipments) of granite, 1971-72

	1971		1972	
	(short tons)	($)	(short tons)	($)
By provinces				
Newfoundland	22,218	121,416	16,490	82,450
Nova Scotia	10,624	75,687	804,959	1,622,149
New Brunswick	809,570	1,438,798	1,478,684	2,372,481
Quebec	2,563,973	6,073,266	2,205,787	5,437,984
Ontario	1,019,562	4,672,792	263,891	3,955,643
Manitoba	39,300	477,450	8,313	295,616
British Columbia	283,554	457,390	562,904	999,012
Total, Canada	4,748,801	13,316,799	5,341,028	14,765,335
By use[1]				
Building stone				
Rough	40,690	1,579,155	33,102	1,470,450
Dressed	1,400	205,750	–	–
Monumental and ornamental				
Rough	28,472	956,163	29,653	978,581
Dressed	1,937	206,703	–	–
Flagstone	425	14,250	32,686[2]	476,557[2]
Curbstone	7,388	276,044	–	–
Lining open-hearth furnaces	–	–	5	50
Chemical uses				
Pulp and paper mills	–	–	–	–
Pulverized stone				
Asphalt filler	2,857	8,471	9,603	24,068
Other pulverized uses	500	5,552	–	–
Crushed stone				
For artificial stone	–	–	–	–
Roofing granules	105,322	2,466,641	158,922	3,617,373
Poultry grit	3,445	56,757	3,732	57,699
Stucco dash	–	–	–	–
Rubble and riprap	634,067	1,450,080	46,801	72,961
Concrete aggregate	1,011,131	1,732,629	1,648,502	2,663,134
Asphalt aggregate	419,753	664,035	895,473	1,387,129
Road metal	766,350	1,066,353	921,173	1,744,675
Railroad ballast	507,686	806,992	325,619	543,427
Other uses	1,196,378	1,821,224	1,235,757	1,729,231
Total	4,727,801	13,316,799	5,341,028	14,765,335

Source: Statistics Canada. – Nil.
[1]Breakdown by uses, 1972, by Statistics Section, Mineral Development Sector.
[2]Includes flagstone, curbstone, paving blocks etc.

Table 5. Canada, production (shipments) of sandstone, 1971-72.

	1971		1972	
	(short tons)	($)	(short tons)	($)
By provinces				
Newfoundland	181,623	455,143	159,802	410,224
Nova Scotia	1,305,885	2,188,357	–	–
New Brunswick	195,695	364,661	12,010	63,390
Quebec	1,606,647	2,625,184	3,096,396	4,008,665
Ontario	15,643	255,596	21,160	316,550
Alberta	289	6,368	388	11,399
British Columbia	–	–	212,550	384,820
Total, Canada	3,305,782	5,895,309	3,502,306	5,195,048
By use				
Building stone[1]				
Rough	17,217	289,354	24,914	517,279
Dressed	8,548	140,098	–	–
Flagstone	1,159	16,105	11,542[2]	168,966[2]
Curbstone	8,100	60,000	–	–
Paving blocks	488	8,005	–	–
Pulverized stone				
Asphalt filler	62,900	125,800	–	–
Agricultural purposes and fertilizer plants	441	2,205	575	3,020
Crushed stone				
For artificial stone	6,496	6,568	–	–
Roofing granules	6,000	13,500	8,669	22,106
Poultry grit	2,000	11,000	2,725	17,031
Terrazzo chips	–	–	–	–
Rubble and riprap	42,134	47,804	9,497	14,803
Concrete aggregate	414,903	675,035	224,077	430,879
Asphalt aggregate	356,051	593,068	332,746	595,306
Road metal	1,947,817	2,935,190	2,352,866	2,572,463
Railroad ballast	431,528	971,577	425,869	645,335
Other uses	–	–	108,826	207,860
Total	3,305,782	5,895,309	3,502,306	5,195,048

Source: Statistics Canada. – Nil.
[1]Breakdown by use, 1972, by Statistics Section, Mineral Development Sector.
[2]Includes flagstone, curbstone, paving blocks etc.

Western provinces. *Limestone.* From east to west through the southern half of Manitoba, rocks of the following geological ages are represented–Precambrian, Ordovician, Silurian, Devonian and Cretaceous. Limestones of commercial importance occur in the three middle classifications and range from magnesian limestone through dolomite to high-calcium limestones. Although building stone does not account for a large percentage of total limestone produced, perhaps the best known of the Manitoba limestones is Tyndall Stone, a mottled dolomitic limestone often referred to as "tapestry" stone. It is widely accepted as an attractive building stone and is quarried at Garson, Manitoba, about 30 miles northeast of Winnipeg.

Limestone from Moosehorn, 100 miles northwest of Winnipeg and from Mafeking, 25 miles east of the Saskatchewan border and 100 miles south of The Pas, is transported to Manitoba and Saskatchewan centres for use in metallurgical, chemical, agricultural and construction industries. Limestone from Steep Rock and from Lily Bay is used by cement manufacturers in Winnipeg and limestone from Faulkner is now being used by the lime plant at Spearhill. The possibility of utilizing marl, an unconsolidated calcareous material, from deposits in the Sturgeon Lake region, for the pulp and paper, cement and lime industries has been investigated. Marl from a deposit 40 miles north of Edmonton, Alberta has been assessed for use in cement manufacture.

Table 6. Canada, production (shipments) of shale, 1971-72

	1971		1972	
	(short tons)	($)	(short tons)	($)
By province				
Quebec	44,680	18,753	233,009	151,456
British Columbia	215,542	906,210	56,891	621,099
Canada	260,222	924,963	289,900	772,555
By use[1]				
Chemical and metallurgical				
Cement plants, foreign	–	–	–	–
Pulverized stone				
Other uses	2,100	10,500	–	–
Crushed stone				
Concrete aggregate	153,601	779,337	56,891	621,099
Road metal	59,841	116,373	11,713	7,613
Railroad ballast	44,680	18,753	–	–
Other uses	–	–	221,296	143,843
Total	260,222	924,963	289,900	772,555

Source: Statistics Canada. – Nil. [1] Breakdown by use, 1972 by Statistics Section, Mineral Development Sector.

Table 7. Canada, production (shipments) of stone by types, 1963-73

	Granite		Limestone		Marble		Sandstone	
	(short tons)	($)	(short tons)	($)	(short tons)	($)	(short tons)	($)
1963	5,679,264	15,070,882	51,021,396	58,053,321	71,714	755,889	5,732,276	5,776,107
1964	7,310,629	16,854,742	57,019,890	63,140,728	95,455	891,617	4,433,555	5,264,849
1965	7,829,220	16,569,762	62,178,833	69,974,005	78,440	1,049,264	4,172,981	5,328,404
1966	19,598,325	25,423,394	69,760,441	77,431,007	157,789	1,190,592	5,202,281	5,949,172
1967	19,876,638	29,016,622	57,155,517	66,062,095	191,286	1,093,024	6,350,611	7,103,735
1968	16,654,735	23,310,531	54,538,796	65,619,953	165,007	637,845	4,267,391	5,136,658
1969	5,399,812	15,832,160	59,610,356	67,219,003	85,848	390,599	2,275,996	4,203,388
1970	4,837,239	15,231,891	57,896,297	67,563,790	61,835	350,903	2,328,957	4,133,708
1971	4,748,801	13,316,799	65,023,606	75,838,878	176,431	561,124	3,305,782	5,895,309
1972	5,341,028	14,765,335	70,752,120	81,697,564	317,170	895,653	3,502,306	5,195,048
1973^p	. .	. .	. .	. .	. .	. .	. .	. .

	Shale		Slate		Total	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
1963	104,130	199,070	46,549	28,150	62,655,329	79,883,419
1964	743,564	621,197	191,265	109,550	69,794,358	86,882,683
1965	2,338,460	1,837,492	160,171	88,094	76,758,105	94,847,021
1966	1,103,218	974,544	–	–	95,822,054	110,968,709
1967	433,256	612,796	–	–	84,007,308	103,888,272
1968	313,838	953,088	–	–	75,939,767	95,658,075
1969	105,000	541,112	–	–	67,477,012	88,186,262
1970	198,512	695,458	–	–	65,322,840	87,975,750
1971	260,222	924,963	–	–	73,514,842	96,537,073
1972	289,900	772,555	–	–	80,202,524	103,326,155
1973^p	. .	. .	. .	. .	85,500,000	107,000,000

Source: Statistics Canada.
^{p} Preliminary; . . Not available; – Nil.

The eastern ranges of the Rocky Mountains contain limestone spanning the geological ages from Cambrian to Triassic with major deposits in the Devonian and Carboniferous systems in which a wide variety of types occur. In southwestern Alberta high-calcium limestone is mined at Exshaw, Kananaskis and Crowsnest chiefly for the production of cement and lime, for metallurgical and chemical uses and for use as a crushed stone. Similar uses are made of limestone quarried at Cadomin, near Jasper.

In British Columbia, large volumes of limestone are mined each year for cement and lime manufacture, for use by the pulp and paper industry and for various construction applications. A large amount is exported to northwestern United States for cement and lime manufacture. Four companies mined limestone on Texada Island with the entire output being moved by barge to Vancouver and to the State of Washington. Deposits on Aristazabal Island have recently been developed for the export market as well. Other operations at Terrace, Clinton, Westwold, Popkum, Dahl Lake, Doeye River and Cobble Hill produced stone for construction use, for filler use and for cement manufacture. Periodically, interest is revived in the possible use of travertine from a British Columbia source.

Eight cement plants and seven lime plants were operated in western Canada in 1973.*

Granite. In Manitoba, at Lac du Bonnet northeast of Winnipeg, a durable, red granite is quarried for building and monumental use. Grey granite east of Winnipeg near the Ontario border, is a potential source of building stone.

In British Columbia, a light-grey to blue-grey, even-grained granodiorite of medium texture is available from Nelson Island. An andesite has been quarried at Haddington Island, off the northeast coast of Vancouver Island, for use as a building stone.

Sandstone. Sandstone for building and ornamental uses, quarried near Banff, Alberta, is hard, fine-grained, medium-grey and is referred to as "Rundal Stone."

*See Cement and Lime sections of the *Canadian Minerals Yearbook 1973* (preprints Nos. 10 and 24).

Table 8. Canada, stone imports and exports, 1971-73

	1971		1972		1973^p	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
Exports						
Building stone, rough	19,230	869,000	15,900	761,000	16,436	929,000
Crushed limestone, limestone refuse	1,579,926	2,201,000	1,710,260	2,463,000	1,690,755	2,426,000
Stone crude, nes	228,085	537,000	673,785	1,010,000	382,860	1,010,000
Natural stone, basic products	..	2,879,000	..	2,532,000	..	1,946,000
Total	1,827,241	6,486,000	2,399,945	6,766,000	2,090,051	6,311,000
Imports						
Building stone, rough	13,145	535,000	10,983	456,000	10,912	528,000
Crushed limestone, limestone refuse	1,845,443	2,926,000	1,813,287	3,034,000	2,341,659	3,741,000
Crushed stone including stone refuse, nes	52,598	1,356,000	67,955	1,825,000	60,458	1,984,000
Stone crude, nes	2,185	32,000	956	59,000	1,519	153,000
Granite, rough	13,254	549,000	12,705	637,000	19,951	1,127,000
Marble, rough	2,199	275,000	3,292	373,000	5,464	680,000
Shaped or dressed granite	..	1,161,000	..	826,000	..	345,000
Shaped or dressed marble	..	785,000	..	989,000	..	964,000
Natural stone basic products	..	216,000	..	252,000	..	410,000
Total	1,928,824	7,835,000	1,909,178	8,451,000	2,439,963	9,932,000

Source: Statistics Canada.
^{p} Preliminary; .. Not available; nes Not elsewhere specified.

The environment

There is justifiable concern for the future development, operation and rehabilitation of pits and quarries in all locations, especially in and near areas of urban development. Although an open-pit mining operation close to residential areas is seldom desirable, nonrenewable mineral resources must be fully and wisely utilized. Where urban sprawl has been unexpectedly rapid, conflicts for land use can materialize and potential sources of raw mineral materials for the construction industry can be overrun. Master plans are required to co-ordinate all phases of development so that mineral exploitation is part of the urban growth pattern.

Rehabilitation of stone quarries for subsequent land use is generally more difficult and more costly than rehabilitation of gravel pits. They provide the same disruptions to the natural environment and to urban development and are therefore included in continuing studies to plan efficient land use. Legislation imposing strict controls has become necessary, and although Ontario presently seems to be leading in this field, its newly enacted laws are typical of what can be expected in other provinces regarding urban spread and pit and quarry development. Ontario regulations apply to operations in designated areas and to rehabilitation of depleted sites.

Markets, outlook and trade

Limestones are widely distributed in Canada and generally are available in sufficient quantity and with such chemical or physical specifications that long transportation hauls are unnecessary. Limestone products are low-priced commodities and only rarely, when a market exists for a high-quality, specialized product such as white portland cement or a high-purity extender, are they beneficiated or moved long distances. Provided the specifications are met, the nearest source is usually considered, regardless of provincial or national boundaries.

Over 70 per cent of Canada's annual production of limestone is used as a crushed stone. This includes about 50 per cent used as road metal (broken, screened stone for macadam roads), about 20 per cent used as concrete aggregate and about 2 per cent used as railroad ballast.

Some major uses in the chemical field are: neutralization of acid waste liquors; extraction of aluminum oxide from bauxite; manufacture of soda ash, calcium carbide, calcium nitrate and carbon dioxide; in pharmaceuticals; as a disinfectant; in the manufacture of dyes, rayons, paper, sugar and glass; and in the treatment of water. Dolomitic limestone is used in the production of magnesium chloride and other magnesium compounds.

Table 9. Value of construction in Canada, 1972-74

	1972	1973	1974[1]	Change 1973-74
	(millions of dollars)			(%)
Building construction				
Residential	5,870.6	7,133.0	7,863.6	+10.2
Industrial	926.7	1,075.8	1,275.3	+18.5
Commercial	1,706.2	2,089.1	2,598.1	+24.4
Institutional	1,249.3	1,151.5	1,240.1	+ 7.7
Other building	574.7	680.1	833.7	+22.6
Total	10,327.5	12,129.5	13,810.8	+13.9
Engineering construction				
Marine	145.6	149.9	181.9	+21.4
Highways, aerodromes	1,670.8	1,872.1	2,110.2	+12.7
Waterworks, sewage systems	714.3	831.5	1,002.6	+20.6
Dams, irrigation	77.9	87.0	110.6	+27.1
Electric power	1,235.2	1,609.3	1,834.8	+14.0
Railway, telephones	666.1	795.0	939.7	+18.2
Gas and oil facilities	1,385.7	1,531.2	1,833.0	+19.7
Other engineering	1,065.8	1,132.8	1,329.7	+17.4
Total	6,961.4	8,008.8	9,342.5	+16.7
Total construction	17,288.9	20,138.3	23,153.3	+15.0

Source: Statistics Canada.
[1] Intentions.

Table 10. Canada, value of construction work performed by principal type of construction, by industry, 1971-74

	1971			1972			1973			1974[1]		
Industry	Building	Engi-neering	Total	Building	Engi-neering	Total	Building	Engi-neering	Total	Building	Engi-neering	Total
	(millions of dollars)											
Agriculture and fishing	206	112	318	265	143	408	312	169	481	378	204	582
Forestry	5	56	61	8	64	72	17	92	109	19	120	139
Mining, quarrying, oil wells	348	1,116	1,464	174	1,099	1,273	196	1,230	1,426	234	1,528	1,762
Construction	24	–	24	60	1	61	65	1	66	71	1	72
Manufacturing	693	388	1,081	688	392	1,080	826	469	1,295	998	638	1,636
Utilities	208	2,413	2,621	235	2,551	2,786	254	2,978	3,232	314	3,308	3,622
Trade	232	14	246	265	10	275	350	9	359	401	10	411
Finance, insurance, real estate	533	13	546	755	77	832	921	89	1,010	1,118	100	1,218
Commercial services	244	2	246	259	1	260	315	1	316	451	1	452
Housing	4,976	–	4,976	5,871	–	5,871	7,133	–	7,133	7,864	–	7,864
Institutional services	1,304	14	1,318	1,112	12	1,124	1,004	13	1,017	1,054	14	1,068
Government departments	594	2,370	2,964	635	2,612	3,247	736	2,958	3,694	909	3,418	4,327
Total	9,367	6,498	15,865	10,327	6,962	17,289	12,129	8,009	20,138	13,811	9,342	23,153

Source: Statistics Canada.
[1] Intentions. – Nil.

Limestone is used in the metallurgical industries as a fluxing material, where it combines with impurities in ore to form a fluid slag that can be separated from molten metal. Calcium limestones are used in open-hearth steel manufacture whereas both calcium limestones and dolomitic limestones are used as a flux in the production of pig iron in blast furnaces.

Limestone is used extensively as a filler or an extender and, where quality permits, as whiting. In such applications both physical and chemical properties are important. Specifications vary widely but, in general, a uniform, white material passing 325 mesh would meet the physical requirements. Whiting is used in ceramic bodies, plastics, floor coverings, insecticides, paper, wood putty, rubber, paints and as a filler in many other commodities. In paint manufacture, the material may be used as a pigment extender.

Agricultural limestone is used to control soil acidity and to add calcium and magnesium to the soil. Limestone and lime are used as soil stabilizers, particularly on highway construction projects.

Dolomite is the source of magnesium metal produced at Haley, Ontario; the company also uses a high-calcium lime from southeastern Ontario in the production of calcium metal. Dead-burned dolomitic limestone, for use as a refractory, is produced at Dundas, Ontario.

Limestone from deposits in coastal areas of British Columbia is mined, crushed, loaded on barges of up to 20,000 tons capacity, and transported as much as 400 miles to consuming centres along the west coast in both Canada and the United States. One Canadian company, Domtar Chemicals Limited, manufactures lime at Tacoma, Washington, using limestone from Texada Island.

Crushed stone will continue to compete with sand and gravel for major markets where the latter are scarce. Through vertical integration, large operations based on construction materials can, by mergers and acquisitions, obtain captive markets for their products in operating construction firms. Construction firms can also integrate backwards into the resource field.

The possibility of substitutes for aggregates is not likely to occur soon in Canada although in countries where such resources are scarce other materials such as compressed garbage are being used. The use of lime or cement to stabilize soils could reduce the amount of aggregate fill required on some highway or railway projects.

Trade, mostly with the United States, takes place in immediate border regions where transportation costs rather than quality of material are the main reason for using a foreign material.

Traditional markets for building stone have been lost to competitive building materials such as steel and concrete. Modern design and construction methods favour the flexibility offered by the use of steel and precast or cast-in-place concrete. For aesthetic qualities not available elsewhere, rough or polished stone is used in many modern structures. Monumental stone continues to be in demand.

The present structure of the building stone industry in Canada is unlikely to change very soon. Recent efforts have been made on behalf of the industry to illustrate to contractors and architects the availability of a wide range of Canadian building stones and their adaptability in modern building design.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
29635-1	Limestone, not further processed than crushed or screened	free	free	25
30500-1	Flagstone, sandstone and all building stone, not hammered, sawn or chiselled	free	free	20
30505-1	Marble, rough, not hammered or chiselled	10	10	20
30510-1	Granite, rough, not hammered or chiselled	free	free	20
30515-1	Marble, sawn or sand rubbed, not polished	free	10	35
30520-1	Granite, sawn	free	7½	35
30525-1	Paving blocks of stone	free	7½	35
30530-1	Flagstone and building stone, other than marble or granite, sawn on not more than two sides	free	7½	35
30605-1	Building stone, other than marble or granite, sawn on more than two sides but not sawn on more than four sides	5	7½	10
30610-1	Building stone, other than marble or granite planed, turned, cut or further manufactured than sawn on four sides	7½	12½	15

Tariffs (concl'd)

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
30615-1	Marble, not further manufactured than sawn, when imported by manufacturers of tombstones to be used exclusively in the manufacture of such articles, in their own factories	free	15	20
30700-1	Marble, nop	17½	17½	40
30705-1	Manufactures of marble, nop	17½	17½	40
30710-1	Granite, nop	17½	17½	40
30715-1	Manufacturers of granite, nop	17½	17½	40
30800-1	Manufacturers of stone, nop	17½	17½	35
30905-1	Granules, whether or not coloured or coated, for use in manufacture of roofing, including shingles and siding	free	free	25
30900-1	Roofing slate, per square of 100 square feet	free	free	75¢

United States

Item No.		On and After January 1 1970	1971	1972
513.61	Granite, not manufactured, and not suitable for use as monumental, paving or building stone	free	free	free
514.11	Limestone, crude, not suitable for use as monumental, paving or building stone, per short ton	14¢	12¢	10¢
		(%)	(%)	(%)
513.21	Marble chips and crushed	7	6	5
514.91	Quartzite, whether or not manufactured	free	free	free
515.11	Roofing slate	17	15	12.5
515.14	Other slate	7	6	5
515.41	Stone, other, not manufactured and not suitable for use as monumental, paving or building stone	free	free	free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Tariff Schedules of the United States, Annotated (1972) T.C. Publication 452.
Note: Varying tariffs are in effect on the more fabricated stone categories.
nop Not otherwise provided for.

Sulphur

G. H. K. PEARSE

Sulphur, one of the most important and versatile industrial raw materials, is widely distributed throughout the world in both elemental and combined states. It has been used by man since antiquity and today all industries use sulphur in some form, principally as a processing and manufacturing reagent. More than half of the world's sulphur output is in elemental form, nearly all obtained from native sulphur deposits and sour natural gas. The remainder is recovered from pyrite and smelter stack gases principally as sulphuric acid, in which form 87 per cent of all sulphur is consumed. Fertilizer manufacture accounts for about half of all sulphur consumed, followed by chemicals, pigments and pulp and paper as the next largest consuming sectors.

World sulphur production in all forms increased 8.4 per cent to 49.1 million metric tons in 1973. Western world production rose to 34.7 million metric tons and consumption increased 5 per cent over 1972 to 32.4 million metric tons, largely as a result of sustained vigour in the world fertilizer industry. Canada's total elemental sulphur sales in 1973 were 23 per cent more than in 1972. Notwithstanding this, sulphur stockpiles on the prairies increased by 3.0 million tons*.

Prices, which had been declining since mid-1968 under the pressure of oversupply, recovered during the year as strong demand, beginning in late 1972, continued throughout 1973.

The Canadian sulphur industry

Canadian sulphur is obtained from three sources: elemental sulphur derived from sour natural gas and petroleum; sulphur recovered from smelter gases in the form of sulphuric acid; and sulphur contained in pyrite concentrates used in sulphuric acid manufacture. Minor tonnages of elemental sulphur are recovered as a byproduct of electrolytic refining of nickel sulphide matte, and a small quantity of liquid sulphur dioxide is produced from pyrites and smelter gases. Eighty-four per cent of Canadian sulphur shipments in 1973 were in elemental form, nearly all from sour natural gas in western Canada.

Dramatic growth over the last ten years in the Canadian sulphur industry is due almost entirely to expanded exploitation and treatment of sour natural gas, principally in Alberta. Canadian production of sulphur in all forms in 1960 was one million tons, elemental sulphur making up only one quarter of the total. In 1973, total sulphur production is estimated at 7.8 million tons, some 7.2 million tons in elemental form. Since 1968, Canada has been the world's largest supplier of elemental sulphur. Canadian sulphur shipments in all forms in 1973 were 4,730,358 tons valued at $32,418,000; a tonnage increase of 21 per cent and a value increase of 29 per cent.

Hydrocarbon sources

Hydrocarbons contain sulphur in some form in at least minute amounts. Where the sulphur content is unacceptably high, as it is in many gas reservoirs in western Canada, it must be removed. Sulphur produced from hydrogen sulphide (H_2S), the dominant sulphur compound occurring in sour natural gas, is presently the most important source in Canada. Because of the need to strip high corrosive and toxic hydrogen sulphide from gas prior to marketing, the elemental sulphur produced is, therefore, an involuntary byproduct of natural gas operations.

Sulphur recovery in Canada from Athabasca oil sands and crude oil is comparatively minor at present

Table 1. Canada, sulphur production and trade, 1972-73

	1972		1973[p]	
	(long tons)	($)	(long tons)	($)
Production				
Pyrite and pyrrhotite[1]				
Gross weight	112,408		19,643	
Sulphur content	61,204	456,157	9,822	147,000
Sulphur in smelter gases[2]	606,110	5,118,483	662,500	9,641,000
Elemental sulphur[3]	3,246,099	19,587,807	4,058,036	22,630,000
Total sulphur content	3,913,413	25,162,447	4,730,358	32,418,000
Imports				
Sulphur crude or refined				
United States	20,181	566,000	35,143	972,000
France	–	–	51	6,000
Other	4,910	104,000	–	–
Total	25,091	670,000	35,194	978,000
Exports				
Sulphur in ores (pyrite)				
United States	. .	501,000	. .	659,000
Total	. .	501,000	. .	659,000
Sulphuric acid and oleum (contained sulphur)				
United States	31,000	2,533,000	40,230	3,513,000
Other	20	11,000	10	4,000
Total	31,020	2,544,000	40,240	3,517,000
Sulphur crude or refined nes				
United States	893,970	8,035,000	937,844	8,427,000
Australia	281,212	3,514,000	479,321	7,499,000
Belgium and Luxembourg	40,500	567,000	223,561	3,832,000
People's Rep. of China	188,121	2,229,000	272,822	3,506,000
Italy	89,141	1,122,000	253,270	3,198,000
Taiwan	181,182	1,760,000	214,344	3,164,000
New Zealand	158,853	2,328,000	178,161	2,642,000
South Africa	6,799	36,000	160,454	2,375,000
South Korea	93,075	794,000	121,549	1,729,000
Netherlands	71,766	1,038,000	104,712	1,485,000
Brazil	123,045	1,321,000	156,613	1,478,000
India	194,416	2,080,000	89,870	1,279,000
Other	220,816	2,713,000	244,782	3,734,000
Total	2,542,896	27,537,000	3,437,303	44,348,000

Source: Statistics Canada, Mineral Development Sector.

[1] Producers' shipments of byproduct pyrite and pyrrhotite from the processing of metallic sulphide ores.

[2] Sulphur in liquid SO_2 and H_2SO_4 recovered from the smelting of metallic sulphides and from the roasting of zinc-sulphide concentrates.

[3] Producers' shipments of elemental sulphur produced from natural gas; also included are small quantities of sulphur produced in the refining of domestic crude oils and from the treatment of nickel-sulphide matte.

[p] Preliminary; – Nil; . . Not available; nes Not elsewhere specified.

and from coal is virtually nil. However, with ever-increasing energy requirements, and with stringent air pollution regulations coming into force, these vast sources of sulphur will, in the future, contribute substantially to world supply.

Sour natural gas. Although the H_2S content of sour gas fields ranges as high as 87 per cent by weight of the total raw gas in place, most of the producing fields contain from 1 to 20 per cent H_2S. The modified Claus process in one of its variants is used to recover sulphur from the sour natural gas. Briefly, the method is as follows: H_2S is extracted by absorption into a solution of one of the following: diethanolamine, monoethanolamine, hot potassium carbonate, or sulfinol. The solution is then heated in a stripper tower where H_2S is evolved. The H_2S passes into a furnace where a controlled air flow results in partial oxidation of H_2S to permit the following reactions:

$$2H_2S + 3O_2 \rightarrow 2H_2O + 2SO_2$$
$$2H_2S + SO_2 \rightarrow 2H_2O + 3S$$

Gas from this furnace enters a condenser-converter series and a portion of liquid sulphur is removed from the vapour in each unit. Overflow gases then pass through another reaction furnace and the process is repeated until 95 per cent or more of the original sulphur has been removed. The tail gases are incinerated and released to the atmosphere, and liquid sulphur is fed into an underground storage pit for pumping to outside storage blocks where it cools and solidifies. Alternatively, the liquid is fed into a slating plant where it is quenched in water on a special belt subsequently breaking up into "slates". Slated sulphur is claimed to be superior to bulk because it is dust-free and easier to handle. All offshore shipments are now in slated form.

Canada's first sour natural gas sulphur recovery plant came on stream in Alberta in 1951, and sulphur output in 1952 amounted to 8,000 tons. In 1973, 45 plants were operating, including one in Saskatchewan and two in British Columbia with a combined daily capacity of 25,512 tons, up slightly from the previous year as a result of expansions to four existing plants. No new plants were built during 1973. Production of elemental sulphur in Alberta as reported by the Alberta Energy Resources Conservation Board was 6,990,725 tons, an increase of 7 per cent over 1972. Production in British Columbia was 72,807 tons and in Saskatchewan was 3,186 tons in 1973; a total for the year of 7,066,718 tons of elemental sulphur derived from sour gas.

Alberta sulphur sales were 3,867,191 tons in 1973, up 25 per cent from 1972. Value of sales increased 24 per cent to $21,982,501 in 1973 reversing a downward trend in value which had persisted since 1969. Alberta inventories stood at 11,637,846 tons at year-end. Elemental sulphur sales from British Columbia and Saskatchewan were 54,147 tons and 2,815 tons, and inventories were 113,765 tons and 8,437 tons, respectively, in 1973.

Canadian elemental sulphur productive capacity, having doubled between 1968 and 1972, has reached a plateau. No significant sour gas find has been made in recent years and, with a lag of three to four years between discovery and plant start up, a major increment in sulphur capacity cannot be expected before the late 1970's. Additional capacity scheduled for 1974 includes two new plants, the 15-ton-a-day Bonnie Glen plant of Texaco Exploration Canada Ltd. and Westcoast Transmission Company Limited's second plant at Fort Nelson rated at 450 tons a day, as well as expansions to Gulf Oil Canada Limited's Nevis plant (278 to 292 tons a day) and Hudson's Bay Oil and Gas Company Limited's Sturgeon Lake South plant (62 to 96 tons a day). Anticipated daily rated capacity by year-end 1974 is 26,048 tons.

The above expansions and others to be completed in early 1975 are in response to more stringent pollution abatement guidelines laid down in November 1971 by the Alberta government. The guidelines include: mandatory stack cleanup facilities and recovery efficiencies between 97 and 99 per cent, depending on acid gas quality, for plants rating over 1,000 tons a day; minimal stack cleanup or equipment with efficiency between 94 and 98 per cent for plants rated between 400 and 1,000 tons a day; at least a three-stage Claus unit or equivalent with efficiency between 92 and 96 per cent for 100- to 400-ton plants and for smaller plants, a two-stage Claus unit with recovery efficiency between 90 and 94 per cent. All plants must comply with this requirement by December 31, 1974.

Sulphur destined for offshore markets is currently railed to loading terminals at Vancouver, some 650 miles from processing plants. In mid-1970, unit-train movement of sulphur was inaugurated, resulting in substantial savings in transportation costs.

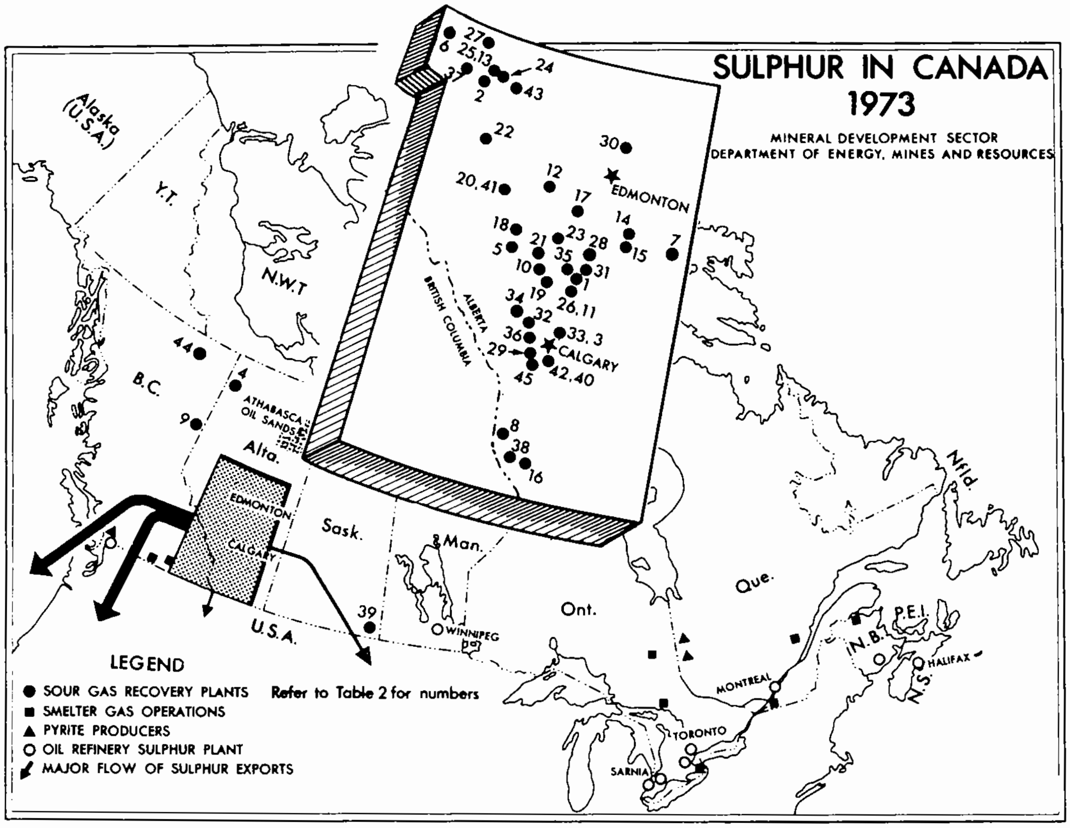
Constraints to marketing Canadian sulphur include prohibition of non-slated sulphur handling in Vancouver port, strained slating capacity, costs of breaking and slating vatted stocks, limited storage capacity at Vancouver Harbour and shortage of rail cars. This situation has resulted in the effective freezing of over 12 million tons of stockpiled sulphur supply at current prices. Expansions to slating capacity and to Vancouver harbour storage capacity are scheduled for completion towards the end of 1974 but rail transport will likely continue to be a problem for some time.

Athabasca oil sands. The Athabasca oil sands constitute a vast deposit of relatively unconsolidated sandstone impregnated with bitumen, covering some 30,000 square miles of northeastern Alberta. The 300 billion barrels of recoverable oil contains 2 billion tons of sulphur.

Table 2. Canada, sour gas sulphur extraction plants, 1973

Operating Company	Source Field or Plant Location	H_2S in Raw Gas	Daily Capacity
	(Alberta, except where noted)	(%)	(long tons)
1. Amerada Hess Corporation	Olds	11	383
2. Amoco Canada Petroleum	Bigstone Creek	19	376
3. Amoco Canada Petroleum	East Crossfield	34	1,710
4. Aquitaine Company of Canada	Rainbow Lake	4	137
5. Aquitaine Company of Canada	Ram River	9-35	4,100
6. Atlantic Richfield	Gold Creek		20
7. Canadian Industrial Gas	Kessler		7
8. Canadian Occidental	Savannah Creek	13	377
9. Canadian Occidental	Taylor Flats, B.C.	3	325
10. Canadian Superior Oil	Harmattan-Elkton	53	482
11. Canadian Superior Oil	Lonepine Creek	12	151
12. CanDel Oil	Minnehik-Buck Lake		32
13. Chevron Standard	Kaybob South	19	3,050
14. Chevron Standard	Nevis	7	258
15. Gulf Oil Canada	Nevis	3-7	278
16. Gulf Oil Canada	Pincher Creek	10	196
17. Gulf Oil Canada	Rimbey	1-3	327
18. Gulf Oil Canada	Strachan	10	955
19. Home Oil	Carstairs	1	58
20. Hudson's Bay Oil and Gas[1]	Brazeau River	1	89
21. Hudson's Bay Oil and Gas	Caroline	1	20
22. Hudson's Bay Oil and Gas	Edson	2	285
23. Hudson's Bay Oil and Gas	Hespero (Sylvan Lk)	1	15
24. Hudson's Bay Oil and Gas	Kaybob South (1)	17	1,070
25. Hudson's Bay Oil and Gas	Kaybob South (2)	17	1,020
26. Hudson's Bay Oil and Gas	Lonepine Creek	10	279
27. Hudson's Bay Oil and Gas	Sturgeon Lake South	10	62
28. Imperial Oil	Joffre		27
29. Imperial Oil	Quirk Creek		286
30. Imperial Oil	Redwater	3	26
31. Mobil Oil Canada	Wimborne	14	331
32. Petrofina Canada	Wildcat Hills	4	174
33. Petrogas Processing	Crossfield (Balzac)	31	1,840
34. Shell Canada	Burnt Timber Creek	8-5	187
35. Shell Canada	Innisfail	14	158
36. Shell Canada	Jumping Pound	3-5	500
37. Shell Canada	Simonette River	15	209
38. Shell Canada	Waterton	18-25	3,016
39. Steelman Gas	Steelman, Sask.	1	7
40. Sun Oil	Black Diamond		13
41. Tenneco Oil & Minerals	Nordegg		41
42. Texasgulf Inc.	Okotoks	33	419
43. Texasgulf Inc.	Windfall	16	1,940
44. Westcoast Transmission	Ft. Nelson, B.C.		250
45. Western Decalta	Turner Valley	4	26
Total daily rated capacity – December 31, 1972			25,512

[1]Plants increased capacity in 1972.



In late 1967, Great Canadian Oil Sands Limited (GCOS) completed the first commercial oil-sand extraction plant at a cost of $240 million. The ancillary sulphur recovery plant is designed to produce 300 tons of sulphur daily. Operating problems which the plant has experienced since start-up have been alleviated following modifications and installation of new equipment. Sulphur production has consequently increased from 47,000 tons in 1970 to 95,000 tons in 1973. In December 1971, Syncrude Canada Ltd. obtained approval from the Alberta Energy Resources Conservation Board to increase the previously proposed production rate of 80,000 b/d to 125,000 b/d of synthetic crude oil and products. This project is scheduled to be under construction in 1974 with completion date in 1978. Annual recovery of sulphur from this plant should be about 175,000 tons. Proposed development of the tar sands to 1985 indicates a synthetic crude production of 500,000 barrels a day. This would result in the production of 1 million tons of sulphur a year. Annual output by 2000 A.D. could reach 5 million tons.

Oil refineries. Some crude oils contain as much as 5 per cent sulphur either as hydrogen sulphide or in other compounds. Domestic crudes generally contain less than 1 per cent sulphur. The sulphur may either be removed in the form of H_2S or treated to form nondeleterious disulphides. Recovery techniques employed during oil refining are similar to those used in the removal of sulphur from sour gas.

In Canada, sulphur is recovered from imported crudes at oil refineries in Nova Scotia, New Brunswick and Quebec. Output from these refineries was 61,000 tons in 1972. Sulphur, recovered from domestic crudes at oil refineries near Toronto, Sarnia, Winnipeg, Edmonton and Vancouver, amounted to about 74,700 tons in 1972. More rigid regulations designed to combat air pollution will undoubtedly result in increased sulphur recovery from this source in the years ahead. Refinery installations and expansions proposed to 1975 will increase capacity by about 15 per cent and total sulphur produced from Canadian oil refineries will exceed 150,000 tons per year.

Coal and oil shales. Coke oven gases generally contain some hydrogen sulphide, the quantity dependent upon the sulphur content of the coal being carbonized. Ordinarily, the H_2S is removed in "iron oxide boxes", but it can also be recovered and converted to elemental sulphur.

In response to the demand for increasing amounts of clean fuel, a research agreement between the United States Department of the Interior and the American Gas Association was entered into in July 1971; $300 million will be spent over an eight-year period with the aim of developing an optimum process for the commercial production of high-quality, pollution-free gas from coal by 1980. Escalation of the energy crisis, particularly in the United States and Europe, brought about by Middle East oil supply cutbacks near the end of the year has given further impetus to gasification projects and oil shale studies. Annual sulphur recovery from these sources could reach 2 million tons during the 1980's and 10 million tons by the end of this century. Although coal in western Canada is low in sulphur (less than 0.5%), coal from the Maritimes is notably sulphurous. With more stringent pollution regulations coming into force, coal gasification may become the only way in which this energy source can be utilized in the future.

Table 3. Proposed new plants and expansions for 1974

Operating Company	Location	Proposed Daily Rated Capacity
	(Alberta)	(long tons)
Gulf Oil Canada[1]	Nevis	292
Hudson's Bay Oil and Gas[1]	Sturgeon Lake	96
Texaco Exploration[2]	Bonnie Glen	15
Westcoast Transmission[2]	Fort Nelson (2)	450
Anticipated daily rated capacity end of 1974		26,048

[1]Expansions.
[2]New plants.

Metallic sulphide sources

In Canada, the use of metallic sulphides for their sulphur content dates back to 1866. Early operations consisted essentially of roasting pyrite for the direct manufacture of sulphuric acid. In the 1920's the use of base-metal smelter gases for the manufacture of byproduct H_2SO_4 began near Sudbury, Ontario, and at Trail, British Columbia. Virtually all Canada's sulphur production was from metallic sulphides prior to 1951 when the first sour gas sulphur recovery plant was built. In 1973, metallic sulphides provided 672,322 tons of contained sulphur and accounted for 9 per cent of Canada's total sulphur production.

Smelter gases. Effluent gas from smelting of sulphide ores contains from 1 to 12 per cent sulphur dioxide (SO_2). Recovery of SO_2 includes processes for cleaning, purifying, cooling and concentrating. Concentrated SO_2 is then used directly for the manufacture of H_2SO_4 via the contact-acid process. Occasionally, the SO_2 is compressed to liquid sulphur dioxide and in some cases is used for the manufacture of oleum (fuming sulphuric acid, $H_2S_2O_7$). Production in 1973 was 662,500 tons of contained sulphur, an increase of 10 per cent from 1972.

The largest sulphuric acid plant complex in Canada is that of Canadian Industries Limited (CIL) at Copper Cliff, Ontario. The company operates three acid plants that have a combined daily capacity of 2,160 tons of H_2SO_4 based on SO_2 gas from The International Nickel Company of Canada, Limited's iron ore recovery plant. Expansions in 1974 will raise capacity to 2,440 tons a day. In addition, CIL operates a liquid sulphur dioxide plant at Inco's nearby Copper Cliff smelter. Much of the acid produced at Copper Cliff is shipped by unit-train about 475 miles to CIL's fertilizer works near Sarnia, Ontario. The company completed a new sulphuric acid depot and storage centre at Niagara Falls, Ontario, in 1972. The $1.5-million facility consists of a 60,000 short-ton storage tank with equipment for unloading unit-trains and loading tank-cars and trucks. Acid from Copper Cliff is shipped directly to the new facility via 56-car unit-trains.

Sulphuric acid is also produced from smelter gases by Belledune Acid Limited at Belledune, New Brunswick. This company, a subsidiary of Brunswick Mining and Smelting Corporation Limited, supplies acid to the adjacent plant at Belledune Fertilizer Division of Canada Wire & Cable Limited. These companies are all owned by Noranda Mines Limited.

Cominco Ltd. operates a sulphuric acid plant at Trail, British Columbia, based on its lead-zinc smelter. The pyrrhotite roasting facility at Kimberley closed down in 1972, thereby reducing the company's smelter acid capacity from 750,000 tons to 435,000 tons. Much of the acid produced is utilized by Cominco in the manufacture of fertilizers.

Allied Chemical Canada, Ltd. and Canadian Electrolytic Zinc Limited at Valleyfield, Quebec produce sulphuric acid from the roasting of zinc concentrates. Canadian Electrolytic Zinc is currently expanding its operations at Valleyfield and acid capacity will increase 50 per cent to 210,000 tons a year in 1975.

The pyrrhotite roasting facility at Falconbridge Nickel Mines Limited, at Falconbridge, Ontario, and

Table 4. Canada, principal sulphur operations based on metallic sulphides, 1973

Operating Company	Plant Location	Raw Material	Annual Capacity 100% H_2SO_4	Annual Capacity Approx. S equiv.
			(long tons)	
Smelter gases				
Belledune Acid	Belledune, N.B.	SO_2 lead-zinc	225,000	75,000
Allied Chemical	Valleyfield, Que.	SO_2 zinc conc.	145,000	48,000
Canadian Electrolytic Zinc	Valleyfield, Que.	SO_2 zinc conc.	120,000	40,000
Canadian Industries[1]	Copper Cliff, Ont.	SO_2 pyrrhotite	670,000	223,000
Cominco	Trail, B.C.	SO_2 lead-zinc	435,000	145,000
Ecstall Mining	Timmins, Ont.	SO_2 zinc conc.	205,000	68,000
Gaspé Copper Mines	Murdochville, Que.	SO_2 copper	450,000	150,000
			Product	
Pyrite and pyrrhotite				
Noranda Mines	Noranda, Que.	Sulphide ore	Pyrite concentrate	
Normetal Mines	Normetal, Que.	Sulphide ore	Pyrite concentrate	

[1]Includes sulphur content in liquid SO_2 production.

the associated elemental sulphur recovery unit of Allied Chemical closed in January 1973 after a year of operation plagued by technical problems.

Ecstall Mining Limited's, Timmins, Ontario zinc plant, which started up in April 1972, has a sulphuric acid capacity of 230,000 short tons a year. Expansion slated for completion in 1975 will raise annual capacity to 290,000 short tons. Gaspé Copper Mines, Limited, a subsidiary of Noranda Mines Limited expanded its facilities at Murdochville, Quebec in 1973. A sulphuric acid plant with an annual capacity of 500,000 short tons was brought on stream near year-end. Half the acid production will be used to leach low-grade oxide ore at the mine, some will be shipped to the Belledune, New Brunswick fertilizer plant and the remainder to other markets.

Shipments of acid and oleum to the United States in 1973 were 40,230 tons contained sulphur, up 30 per cent from 1972. Small amounts were shipped elsewhere, mainly to the West Indies.

Pyrite and pyrrhotite. Pyrite and pyrrhotite concentrates produced as a byproduct of base metal mining operations are sometimes marketed for their sulphur content. The distinction between the category of sulphur in pyrite and pyrrhotite and that in smelter gases used in this review is based upon this concept. For example, although most of the acid production at Copper Cliff, Ontario is dependent upon the roasting of iron sulphides, the sulphur production is reported as smelter gases. In other instances, however, the iron sulphide concentrates are sold and shipped for roasting elsewhere and is reported as pyrite and pyrrhotite production.

Noranda Mines Limited and Normetal Mines Limited have, over the years, shipped pyrite to acid plants principally in the northeastern United States. Recent conversion to elemental sulphur feed resulted in drastic reductions in pyrite usage. Noranda discontinued pyrite sales in 1973. Other companies are stockpiling pyrite concentrates pending development of future markets for this material. In 1973 Canada's pyrite and pyrrhotite shipments amounted to 19,643 long tons of concentrates (9,822 long tons contained sulphur) valued at $147,000. This tonnage is 16 per cent of that of 1972.

Canadian consumption and trade

Canadian consumption of sulphur in all forms as reported by consumers in 1973 amounted to 1.27 million tons, 770,000 tons of which was elemental sulphur. This latter amounts to 19 per cent of producers' shipments, clearly demonstrating that Canada relies heavily upon export markets for sulphur sales. In addition to elemental sulphur from western Canada, pyrite concentrates, sulphuric acid and oleum are exported, largely to the United States.

Canada is the world's largest supplier of elemental sulphur to world markets, exports in 1973 reaching 3.4 million long tons. This is an increase of 35 per cent over the previous year.

Because of its highly competitive nature, involuntary byproduct sulphur from western Canada has, over the years, penetrated much of the United States market. The closure of several marginal United States Frasch sulphur mines and shrinking profits over the last few years as a result of declining prices, led to antidumping proceedings being launched against Canadian and Mexican sulphur producers in February 1972. Subsequent hearings during 1973 culminated in dumping determinations against Canada and Mexico.

Because of these political pressures, as well as growing byproduct sulphur production in the United States, Canada's sales to this market diminished to about 15 per cent below the 1970 record high. Nonetheless, the United States remains the largest market for Canadian sulphur, accounting for 30 per cent of total exports and indications from 1974 figures available are that sales will increase by about 50 per cent. Canada's sales increased to all-time highs in offshore market areas, reflecting strong world-wide demand for sulphur. Shipments to Europe, which had declined in 1972, increased 82 per cent, Asian sales rose 13 per cent, Australasian 51 per cent, Latin American 25 per cent and shipments to Africa increased from 25,000 to 258,000 tons. Major sulphur consuming countries which have increased their purchases of Canadian sulphur by 50 per cent or more in 1973 include Belgium and Luxembourg, Italy, South Africa, Peoples' Republic of China, and Australia. Only France, India, and the United Kingdom reduced imports of Canadian sulphur, the latter having purchased none in 1973.

Table 5. Canada, sulphur production and trade, 1964-73

	Production				Imports	Exports	
	Pyrites[1]	In Smelter Gases	Elemental Sulphur	Total	Elemental Sulphur	Pyrites	Elemental Sulphur
				(long tons)		($)[2]	
1964	154,617	395,910	1,596,474	2,147,001	133,534	878,545	1,155,807
1965	166,918	397,080	1,846,662	2,410,660	144,813	978,828	1,337,367
1966	144,901	446,702	1,822,676	2,414,279	129,871	981,000	1,249,113
1967	162,826	528,568	2,231,290	2,922,685	111,404	1,067,000	1,583,533
1968	139,136	594,935	2,304,090	3,038,161	67,688	1,056,000	1,884,821
1969	152,858	603,702	2,654,746	3,411,306	40,630	1,105,000	2,005,480
1970	156,707	630,206	3,167,931	3,954,844	47,725	1,226,000	2,668,072
1971	138,421	552,185	2,811,677	3,502,283	27,482	1,074,000	2,364,039
1972	61,204	606,110	3,246,099	3,913,413	25,091	501,000	2,542,896
1973^p	9,822	662,500	4,058,036	4,730,358	35,194	659,000	3,437,303

Source: Statistics Canada.
[1] See footnotes for Table 1. [2] Dollar value of pyrite exports, quantities not available.
^{p} Preliminary.

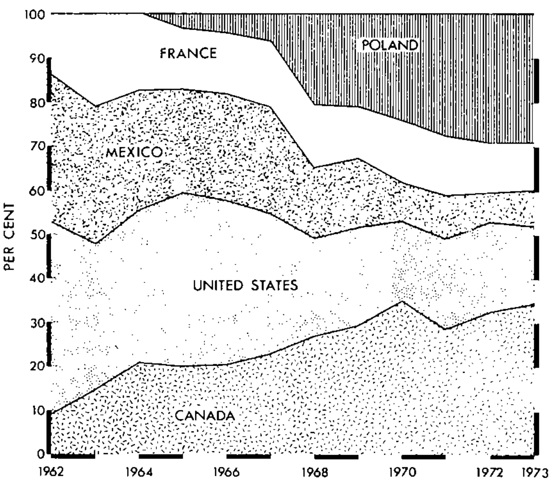
World review

Although world sulphur production in 1973 exceeded demand for the sixth consecutive year, consumption increased an estimated 6 per cent. The surge in demand–significantly above the historical growth rate–is a result of continued vigour in consuming industries, particularly the fertilizer industry. Elemental sulphur exports by major suppliers increased 16.3 per cent in 1973, following a 14.9 per cent jump in the previous year. This growth was aided by conversion of pyrite acid facilities to elemental sulphur burners.

Tight supply conditions created largely by constraint to marketing sulphur from western Canada, i.e., limited slating capacity, limited Vancouver port storage capacity, shortage of rail cars, and a rail strike during the summer resulted in a firming trend in prices. However, with ocean freight rates having increased substantially during the year, transportation costs remained the major component of delivered prices.

Unit-train rates between Alberta and Vancouver are currently $6.40 a long ton, and handling and loading costs at the ocean terminal are around $2.50 a ton. A recently quoted figure for ocean freight from Vancouver to India for cargoes up to 25,000 tons is $29.25 a ton, making total transportation costs from Alberta to this destination $38.15 a ton, about double 1972 rates. By comparison, Iraqi ocean transportation costs to India were quoted as $8.75 per ton, a considerable advantage over Canada, which, undoubtedly, accounts for reduced sales of Canadian sulphur to this destination in 1973.

PERCENTAGE OF ELEMENTAL SULPHUR
EXPORTS TO WORLD MARKETS
BY
MAJOR WORLD SUPPLIERS
(CUMULATIVE)
MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES



SOURCE: BRITISH SULPHUR CORPORATION TO 1971
MINERAL RESOURCES BRANCH ESTIMATE FOR 1972 AND 1973

Other fixtures quoted near year-end included 45,000 tons Port Sulphur (United States)/Antwerp at \$12 and 30,000 tons Vancouver/Rotterdam at \$15.

Consumption of sulphur in the western world amounted to 31.9 million tons. Western world production in all forms was 34.2 million tons. Polish sales to western markets amounted to 1.9 million tons slightly below that of 1972 and shipments to the Peoples' Republic of China from Canada, Mexico and the Persian Gulf totalled 400,000 tons in 1973. Additions to western stockpiles were 3.4 million tons, 3.0 million tons of which was vatted in Canada and the remainder accounted for by United States and Iraq.

The world's largest producer of sulphur in all forms is the United States, with the majority of production derived from Frasch mines located in the Gulf Coast area. These deposits, when first developed in the early 1900's made large tonnages of low-cost sulphur available to world markets and established the United States as the world's foremost supplier of elemental sulphur. In 1973, Frasch production increased 4 per cent to 7.61 million tons and recovered elemental sulphur, principally from sour natural gas, increased 20 per cent to 2.32 million tons. However, shipments of elemental sulphur advanced only 3 per cent over 1972 resulting in a 130,000 ton increase in stocks to 3.92 million tons. Exports decreased 4 per cent to 1.77 million tons, imports rose 6 per cent to 1.21 million tons and domestic consumption of elemental sulphur grew 5 per cent to 9.22 million tons in 1973.

Texasgulf's Bully camp mine, which was closed down in 1972 because of natural gas fuel cuts by the Federal Power Commission, reopened during the first half of 1973 having secured an adequate gas supply at considerably higher prices.

Mexican Frasch production increased approximately 500,000 tons in 1973 as a result of intensive development of the Jaltipan dome deposits by Azufrera Panamericana SA (APSA). Domestic shipments which have grown at an average rate of 25 per cent over the last five years in response to growth in the fertilizer industry reached an estimated 480,000 tons in 1973. Under the influence of a vigorous marketing program initiated by APSA, exports increased 50 per cent in 1973 to 750,000 tons reversing a five year decline.

Production of elemental sulphur from sour natural gas from the Lacq field in France in 1973 was 1.6 million tons, marginally lower than in 1972. However, exports increased by 14 per cent to 1.1 million tons in 1973. Imports also rose markedly to meet both the deficit in domestic shipments and an overall stronger demand.

Table 6. Canadian export markets, 1973

Country	Exports	Per Cent of Total
	(millions of long tons)	
United States	.94	27.3
Europe	.59	17.2
India	.09	2.6
Taiwan	.21	6.2
Australia	.48	13.9
New Zealand	.18	5.2
Korea	.12	3.5
Others	.83	24.1
Total	3.44	100.0

Source: Mineral Development Sector.

Polish shipments increased sharply in 1973, exports rising 15 per cent to 2.83 million tons. Total sales to western countries were marginally lower in 1973 whereas sales to eastern Europe virtually doubled to 930,000 tons. Production in 1973 was 3.70 million tons.

Table 7. Canada sulphur consumption, 1964-1973

	From Pyrites and Smelter Gases[e]	Elemental Sulphur[1]	Total[e]
	(long tons)		
1964	433,551	486,033	920,000
1965	438,166	659,978	1,098,000
1966	461,478	725,053	1,187,000
1967	590,185	752,963	1,343,149
1968	669,763	741,155	1,410,919
1969	680,438	688,211	1,368,649
1970	682,992	751,543	1,434,535
1971	562,500	718,443	1,280,907
1972	562,946	879,098	1,442,044
1973[e]	501,071	768,750	1,269,821

Source: Statistics Canada.
[1]As reported by consumers.
[e]Estimated by Mineral Development Sector.

Iraq became a significant producer of elemental sulphur in 1973 with output from the Mishraq dome rising to 400,000 tons. Capacity is reported to have reached 1 million tons a year, but inadequate rail transport capacity restricted deliveries to the Persian Gulf port of Umm Qasr, 450 miles south of Mishraq. The port itself is apparently too shallow to accommodate cargo vessels greater than 10,000 tons.

Table 8. Canada, consumption of elemental sulphur by industry

	1971	1972
	St tons ~~(long tons)~~	
Chemicals	237,185	254,621
Pulp and paper	394,085	363,084
Rubber products	3,682	3,979
Fertilizers	139,025	276,852
Foundry	7,507	8,557
Other industries[1]	23,224	41,497
Total	804,708	948,590

Source: Statistics Canada. Breakdown by Mineral Development Sector.
[1]Includes production of titanium pigments, pharmaceuticals and medicinals, starch, soaps and detergents, explosives, food processing, sugar refining and other minor uses.

Table 9. Canada, sulphuric acid production, trade and apparent consumption, 1964-1973

	Production	Imports	Exports	Apparent Consumption
	(short tons – 100% acid)			
1964	1,941,000	4,209	67,409	1,877,800
1965	2,165,000	3,075	57,113	2,110,962
1966	2,500,000	6,948	54,948	2,452,000
1967	2,749,279	3,626	84,280	2,668,625
1968	2,852,027	2,606	125,971	2,728,662
1969	2,396,535	60,746	103,386	2,353,895
1970	2,728,298	10,966	142,559	2,596,705
1971	2,933,000	4,952	101,094	2,836,858
1972	3,030,182	70,112	104,227	2,996,067
1973[p]	3,284,714	72,451	135,210	3,221,955

Source: Statistics Canada.
[p]Preliminary.

Table 10. Canada available data on consumption of sulphuric acid by industry, 1971

	(short tons–100% acid)
Iron and steel mills	46,124
Other iron and steel	14,187
Electrical products	6,224
Leather tanneries	2,936
Pulp and paper mills	119,345
Processing of uranium ore	93,046
Manufacture of mixed fertilizers[1]	35,193
Manufacture of plastics and synthetic resins	27,910
Manufacture of soaps and cleaning compounds	20,795
Other chemical industries	58,346
Manufacture of industrial chemicals[2]	1,655,542
Petroleum refining	31,656
Mining [3]	50,000[e]
Nonferrous smelting and refining	256,035
Miscellaneous[4]	22,221
Total	2,439,560

Source: Statistics Canada.
[1]Includes consumption for production of superphosphate in this industry.
[2]Includes consumption of "own make" or captive acid by firms, classified to these industries.
[3]Includes metal mines, nonmetal mines, mineral fuels and structural materials.
[4]Includes synthetic textiles, explosives and ammunition and other petroleum and coal products, mineral wool, starch and glucose, vegetable oils, sugar refining and textile drying and finishing.
[e]Estimated.

Following technical and economic feasibility studies into potential uses for sulphur – a project initiated by the National Research Council – the Sulphur Development Institute of Canada (SUDIC) was formed in February 1973. Its purpose is to promote research and development of new uses, monitor current research, fund approved projects, and to liaise with other institutions elsewhere in the world where research is being carried on. New uses investigated over the last few years which show promise include: an asphalt-sand-sulphur mixture for road and airstrip paving; sulphur cement and other construction materials; and pipeline insulation. The Canadian initiative was followed by a similar project undertaken by the United States Bureau of Mines.

Table 11. World production of sulphur in all forms, 1972

	Elemental	Other[1]	Total
	(thousands of metric tons)		
United States	9,366	1,483	10,849
Canada	6,884	750	7,634
U.S.S.R.	2,360	5,030	7,390
Poland	3,115	249	3,364
Japan	496	2,125	2,621
France	1,747	186	1,933
Spain	4	1,134	1,138
Mexico	945	35	980
West Germany	220	710	930
Italy	101	777	878
Iran	564	–	564
Finland	119	394	513
Norway	3	410	413
East Germany	105	274	379
South Africa	24	287	311
Others	1,031	4,425	5,456
Total	27,084	18,269	45,353

Source: British Sulphur Corporation, November/December 1973.
[1]Sulphur in other forms includes sulphur contained in pyrites and contained sulphur recovered from metallurgical waste gases mostly in the form of sulphuric acid.
– Nil.

Outlook

Growth in elemental sulphur production from sour natural gas in western Canada has, within the past decade, substantially altered the pattern of international sulphur supply. In 1960, Canada accounted for only 3.4 per cent of the world export market. In 1968, with a market share of 27.4 per cent, Canada became the world's largest exporter. In 1973, export sales increased 35 per cent to 3.44 million tons in response to continued strong world demand for sulphur in all forms

Demand for fertilizers under the stimulus of world food shortages and the expansion of modern agricultural practice in Asia, Africa and Latin America should sustain annual sulphur consumption growth in the 6 to 7 per cent range throughout the present decade. Indeed, a current shortage of phosphate rock, the raw material for phosphatic fertilizers prevented sulphur demand growth from rising by as much as 10 per cent in 1973. The People's Republic of China, which entered the sulphur scene as a buyer during 1972, has become a major market, imports reaching 450,000 tons in 1973 and indications are that its requirements will continue to expand at a healthy rate over the next few years at least. Industrial development in these areas will add further to sulphur demand.

Canadian elemental sulphur sales for 1974 are expected to reach 4.8 million long tons. Further sales growth in the near- to medium-term is predicated on solutions to logistic bottlenecks. Expansions to slating capacity and West Coast port storage capacity are expected to be completed by late 1974 and evaluations of the alternate ports, Churchill and Thunderbay, are being undertaken by Amoco Canada Petroleum Company Ltd. and Shell Canada Limited respectively.

For the longer-term, Canada's impact on world sulphur markets is expected to decline. Production of elemental sulphur from sour natural gas peaked in 1973 at just over 7 million long tons. In comparing monthly output with corresponding months of the previous year, a consistent reduction was evident from September on into the early months of 1974, indicating a 3 per cent decline for 1974. Several of the major plants are recycling operations, i.e., sulphur is stripped from the gas and the gas returned to the reservoir. Output from these plants is now tapering off and considering the reservoir life of the others, a reduction to about one half of the current output from existing plants is expected by 1985. Replacement of part of this capacity through new discoveries remains a possibility but, given the fact that no significant sour gas finds have been made in the last few years and considering a lag time between discovery and production of three or four years, no major increment in output is likely before the end of the decade. Sulphur recovery from the Athabasca tar sands, of course, depends on the rate of exploitation of this source of oil. Current estimates in the order of 500,000 barrels a day by 1985 are less than earlier projections by one half and assume acceptable costs and adequate technology.

Sulphur from metallic sulphides, produced largely in the form of sulphuric acid, could double by 1985. However, it is unlikely that new sour gas discoveries and growth in output of metallurgical and tar sands sulphur will be adequate to offset the decline in Canadian production before the late 1980's.

United States' Frasch producers improved sales modestly in 1973 over the previous year, itself a record year. In spite of this showing and the favourable outlook for sulphur, a new restraint has begun to exert pressure on the industry. Ironically, the natural gas industry, which has become the Frasch industry's principal competitor in sulphur production, supplies the essential fuel – natural gas – for production of sulphur by the Frasch process. Energy shortages over the last two years, especially serious towards the end of 1973 because of the oil embargo imposed by the Middle East producers, have resulted in restricted supplies of home and plant fuel, gasoline, petrochemical feedstocks and other hydrocarbon products particularly in the United States. In addition to fuel prices rising radically in response to the shortage, considerable attention has been focussed on current natural gas usage. At best, Frasch producers will have to face the problem of markedly higher costs of production (natural gas accounts for about one fifth of production costs) and fuel supply cuts remain a distinct possibility.

Iraq, being favourably located for sales to the large Far Eastern market has already made its presence felt and with alleviation of transport difficulties could considerably erode Canada's share of sulphur trade in that area in the near future.

French production has reached a plateau and will likely decline slowly during the 1980's.

Pollution abatement sulphur is growing in importance. However, it appears that its impact will be more gradual than earlier predictions suggested for several reasons: for sulphur removal from electric utility stack gases, the largest source of pollution-sulphur, economic and technologic considerations weigh in favour of a scrubbing process which will result in an inert waste product to be discarded; a number of smelters are located in areas lacking adequate markets for sulphuric acid which will likely result in a similar disposal of surplus acid; in light of energy supply considerations, attention has been focussed on conservation which will moderate growth in fossil fuel consumption, the major source of sulphur emissions.

Under the influence of these factors, and coupled with demand pressures for fertilizers from the agricultural sector generated by world food shortages, sulphur inventories should peak in the next few years and supply and consumption will tend toward a balance, perhaps reaching that point before the middle of the next decade.

Prices

After declining for four straight years, a firming trend, evident in the latter months of 1972, manifested itself in 1973. Price increases to North American customers posted in January, August and September raised fob Alberta plant prices by $9 a ton to the $15 range. Additional increases during the early months of 1974 have elevated prices to near record levels. Overseas prices similarly have advanced as surging fertilizer requirements tightened sulphur availability. Although phosphate rock demand remains high, supply is now limited by mine output and phosphoric acid capacity. This situation is expected to prevail beyond 1975 with the result that high sulphur demand pressures will moderate somewhat and prices should tend to stabilize during 1974. However, expansion in the fertilizer industry, scheduled for completion in 1975-76, will renew demand pressures and further price increases are likely at that time.

Canadian sulphur prices quoted in Canadian Chemical Processing, December 1973.

Sulphur, elemental, fob works	($)
contract, carload, per long ton	15.00
Sulphuric acid, fob plants, east,	
66° Be, tanks, per short ton	
December	35.00

United States prices in U.S. currency, quoted in Engineering and Mining Journal, December 1973

Sulphur elemental	($)
U.S. producers, term contracts	
fob vessel at Gulf ports,	
La. and Tex., per long ton (nominal)	
Bright	26
Dark	25
Export prices, fob Gulf ports	
Bright	33 – 34
Dark	32 – 33
Mexican export fob vessel	
per long ton	
Bright	26
Dark	25

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
92503–1	Sulphur of all kinds, other than sublimed sulphur, precipitated sulphur and colloidal sulphur	free	free	free
92802–1	Sulphur, sublimed or precipitated, colloidal sulphur	free	free	free
92807–1	Sulphur dioxide	free	free	free
92808–1	Sulphuric acid, oleum	10%	15%	25%
92813–4	Sulphur trioxide	free	free	free

Tariffs (cont'd)

United States

Item No.			Item No.		(%)
418.90	Pyrites	free	422.94	Sulphur dioxide	
415.45	Sulphur, elemental	free		On and after Jan. 1, 1970	8.5
416.35	Sulphuric acid	free		On and after Jan. 1, 1971	7
				On and after Jan. 1, 1972	6

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), T.C. Publication 452.

Talc, Soapstone and Pyrophyllite

G.H.K. PEARSE

Talc is a hydrous magnesium silicate $H_2Mg_3(SiO_3)_4$ formed by the alteration of rocks rich in magnesia (most commonly ultrabasic igneous rocks and sedimentary dolomite) within which it occurs as veinlets, tabular bodies, or irregular lenses. It is a soft flaky mineral with a greasy feel or "slip"; it is readily ground to a fine white or nearly white powder, has a high fusion point, low thermal and electrical conductivity and is relatively chemically inert. Most of the uses of talc depend on individual physical properties or combinations of these properties.

Talc is produced in various grades which are usually classified by end use, such as cosmetic grade, ceramic grade, pharmaceutical grade and paint grade. A special high-quality block talc used in making ceramic insulators and other worked shapes is designated steatite grade.

Soapstone is an impure talcose rock generally occurring in massive, compact deposits from which blocks can be sawn. Soapstone has been used since early times in many parts of the world for carving ornaments, pipes, cookware, lamps and other utensils, an art which has survived among the Eskimos up to the present era. Present uses include metalworker's crayons, refractory bricks, and blocks for sculpturing.

Pyrophyllite is a hydrous aluminum silicate $H_2Al_2(SiO_3)_4$ formed by hydrothermal alteration of acid igneous rocks, predominantly lavas which are andesitic to rhyolitic in composition. It resembles talc in physical properties and for this reason finds uses similar to talc – notably in ceramic bodies and as a filler in paints, rubber and other commodities.

In Canada, talc is produced in two provinces, Quebec and Ontario; pyrophyllite is produced only in Newfoundland. In 1973 the value of talc and soapstone shipments increased to $1,710,000 from $902,497 in 1972. The value of pyrophyllite production decreased from $560,010 in 1972 to $452,000 in 1973.

Production and developments in Canada

Talc, soapstone. The earliest recorded production in Canada was in 1871-72 when 300 tons of cut soapstone valued at $1,800 were shipped from a deposit in L 24, R 6, in Bolton Township, southern Quebec, by Slack and Whitney. In 1896 a deposit in Huntingdon Township, in the Madoc district in Ontario was opened up, and over the next few years numerous deposits in this area were discovered and mined intermittently.

Several deposits in southern British Columbia and one in southwestern Alberta were discovered prior to 1920 and some of these were worked in a small way. At present, talc is mined by three companies, two in Quebec and one in Ontario.

Baker Talc Limited produces talc and soapstone from an underground mine in South Bolton, Quebec, 60 miles southeast of Montreal. Ore from the mine is trucked 10 miles south to the company's mill facilities at Highwater. In former years, Baker Talc has produced a relatively low-grade, low-cost product suitable for use primarily as a dry-wall joint filler, asphalt filler and dusting compounds for asphalt roofing. Tests conducted in 1967-68, employing a Jones High Intensity Wet Magnetic Separator, were successful in upgrading talc products for use in the paint, cosmetic and paper industries and this process was added to the mill circuit in 1969. This project was supported by the federal Department of Industry Trade and Commerce. In 1972, seven paper mills were using the upgraded product and additional ones placed orders in 1973, raising output of the company's improved product to over 5,000 tons, about double that of 1972. Expansions and modifications to the mill, in order to raise output and diversify specialty grades, were completed during the year. Minor shipments have also been made for use as a filler in plastics and paints.

Table 1. Talc, soapstone and pyrophyllite production, trade and consumption, 1972-73

	1972		1973p	
	(short tons)	$	(short tons)	$
Production (shipments)				
Talc and soapstone				
Quebec[1]	..	484,769	..	1,180,000
Ontario[2]	..	417,728	..	530,000
Total	..	902,497	..	1,710,000
Pyrophyllite				
Newfoundland	..	560,010	..	452,000
Total production	80,946	1,462,507	110,000	2,162,000
Imports (talc)				
United States	39,206	2,069,000	32,828	1,945,000
Italy	1,277	50,000	172	21,000
Other countries	22	2,000	33	4,000
Total	40,505	2,121,000	33,033	1,970,000
	1971		1972p	
Consumption[3] (ground talc, available data)				
Ceramic products	6,190		6,764	
Paints and wall joint sealers	7,469		8,096	
Roofing	6,412		7,074	
Paper and paper products	4,157		4,363	
Rubber	2,629		2,171	
Insecticides	266		302	
Toilet preparations	666		782	
Cleaning compounds	645		889	
Pharmaceutical preparations	163		214	
Linoleum and tile	1,474		1,239	
Other products[4]	8,587		5,588	
Total	38,658		37,482	

Source: Statistics Canada.
[1]Ground talc, soapstone, blocks and crayons. [2]Ground talc. [3]Breakdown by Mineral Development Sector. [4]Chemicals, foundries, gypsum products and other miscellaneous uses.
pPreliminary; . . Not available.

Along with talc output, from time to time the company markets soapstone blocks as an artistic medium to schools and art shops.

Broughton Soapstone & Quarry Company, Limited, quarries talc and soapstone from deposits near Broughton Station in the Eastern Townships of Quebec, where the same geological conditions are evident as in the South Bolton area. Several low-priced grades of ground talc are produced and soapstone is sawn to produce metalworker's crayons and blocks for sculpturing.

Canada Talc Industries Limited produces talc from underground workings at Madoc, Ontario. The deposits at Madoc are extensive and were formed by the alteration of dolomitic marble. Impurities in the deposit consist of tremolite and dolomite, which limit the use of some ground products. A high-quality product suitable as a filler material in the paint industry is produced.

Numerous deposits of talc and soapstone occur in other parts of Canada. A soapstone deposit on Pipestone Lake in Saskatchewan was worked by Indians for the manufacture of pipes and various utensils. Reserves are reported to be considerable. In the Northwest Territories, a few occurrences of soapstone are known, from which Eskimos obtained material for carving. Showings of minor importance occur at several localities in Nova Scotia and Newfoundland.

Table 2. Production and trade, 1964-73

	Production [1]			
	Talc and Soapstone	Pyrophyllite [2]	Total [3]	Imports Talc
	(short tons)			
1964	25,316	32,816	58,132	31,598
1965	22,703	30,134	52,837	27,858
1966	29,596	40,548	70,144	24,918
1967	. .	. .	60,665	26,482
1968	. .	. .	80,589	28,244
1969	. .	. .	75,850	34,910
1970	. .	. .	72,055	33,068
1971	. .	. .	65,562	33,752
1972	. .	. .	80,946	40,505
1973^p	. .	. .	110,000	33,033

Source: Statistics Canada.
[1]Producers' shipments; [2]Producers' shipments of pyrophyllite, all exported; [3] From 1967, breakdown of producers' shipments not available for publication.
^{p}Preliminary; . . Not available.

Table 3. World production of talc, soapstone and pyrophyllite, 1971-73

	1971	1972^p	1973^e
	(short tons)		
Japan	1,731,827	1,661,114	1,500,000
United States	1,037,297	1,107,404	1,209,000
U.S.S.R.	420,000	430,000	450,000
France	279,579	280,000	250,000
South Korea	234,185	259,867	. .
India	208,094	209,189	. .
People's Republic of China	165,000	165,000	. .
Italy	151,973	163,607	150,000
Brazil	143,000	143,000	. .
North Korea	99,000	110,000	. .
Finland	110,979	99,568	100,000
Austria	100,995	91,725	. .
Canada	65,562	80,946	. .
Norway	78,000	78,000	. .
Romania	65,000	65,000	. .
Australia	62,186	62,000	. .
Other countries	254,093	246,073	1,500,000
Total	5,206,770	5,252,493	5,159,000

Source: U.S. Bureau of Mines, *Minerals Yearbook*, Preprint 1972; U.S. Bureau of Mines, Commodity Data Summaries, January 1974; Statistics Canada.
^{p}Preliminary; ^{e}Estimated; . . . Not available.

Pyrophyllite. Newfoundland Minerals Limited, a subsidiary of American Olean Tile Company, Inc. produces pyrophyllite from an open-pit mine near Manuels, 12 miles southwest of St. John's, Newfoundland. Ore is crushed, sized and hand-cobbed at the mine site prior to trucking a short distance to tidewater. Continuous chemical analyses and physical tests are run on all material delivered from the mine to the loading dock. Blended ore is shipped in bulk to the parent company's operation at Lansdale, Pennsylvania, where it is used in the manufacture of ceramic tile. Annual production varies between 30,000 and 40,000 tons. Production declined in 1973 to an estimated 30,000 tons. The pyrophyllite deposit at Manuels appears to be a hydrothermal alteration of sheared rhyolite. Altered zones are associated for the most part with extensive fracturing near intrusive granite contacts. Reserves are extensive.

Other known pyrophyllite deposits in Canada include an extensive area of impure pyrophyllite near Stroud's Pond in the southern part of Burin Peninsula, Newfoundland; a deposit near Ashcroft, British Columbia; and three deposits in the Kyuquot Sound area, 200 miles northwest of Victoria, British Columbia. The Vancouver Island deposits were worked on a limited scale in the early part of this century.

Trade and markets

Most talc and soapstone produced in Canada is consumed domestically while all pyrophyllite produced is exported. Imported talc, most of it from the United States, is high-quality, high-value material suitable for use in the paint, ceramics, paper and cosmetic industries. Production of these superior grades of talc in Canada began in 1970 with the new beneficiation techniques incorporated into Baker Talc's mill and, in 1971, a product acceptable to the pulp and paper industry was marketed. It is anticipated that imported high-quality talc will soon be displaced to some extent in other industries by this domestic product. Imports in 1973 amounted to 33,033 tons valued at $1,970,000; down 15 per cent from 1972. Of this, 32,828 tons were imported from the United States and the remainder predominantly from Italy. Average value of imports in 1973 was $60 a ton while domestic production sells in the range of $10-75 a ton, depending upon quality.

Uses

Talc is used mostly in a fine-ground state although soapstone is used in massive or block form. There are many industrial applications for ground talc, but major consumption is limited to less than a dozen industries.

Talc is used as a filler material in the manufacture of high-quality paper where it aids in dehydration of the pulp, improves sizing characteristics, reduces the tendency of papers to yellow and assures a well-bonded surface to promote ease of printing. For use in the paper industry, talc must be free of chemically active compounds such as carbonates, iron minerals and manganese; have a high reflectance; possess high retention characteristics in the pulp; and be free of abrasive impurities. Micronized material provides a high-gloss finish on coated papers.

The ceramic industry utilizes very finely ground talc which increases the translucence and toughness of the finished product and aids in promoting crack-free glazing. For use in ceramics, talc must be low in iron, manganese and other impurities which would discolour the fired product.

High-quality talc is used as an extender pigment in paints. Specifications for a talc pigment, as established in ASTM Designation D605-69, relate to the chemical composition, colour, particle size, oil absorption and consistency of, and dispersion in, a talc-vehicle system. A low content of carbonates, a nearly white colour, a fine particle size with controlled particle size distribution and a specific oil-absorption are important. However, because of the variety of paints, precise specifications for talc pigments are generally based on agreement between consumer and supplier. Paint characteristics influenced by the use of talc as an extender are gloss, adhesion, flow, hardness and hiding power.

Talc is well known for its use in pharmaceutical preparations and cosmetics. It is the major ingredient in face, baby and body powders. Finely ground, high-purity material is used as a filler in tablets and as an additive in medical pastes, creams and soaps. Material used for these purposes should be free of deleterious chemical compounds, abrasive impurities and fibrous minerals such as tremolite and asbestos, which are believed to be injurious to health when inhaled or ingested.

Lower-grade talc is used as a dusting agent for asphalt roofing and gypsum board; as a filler in dry-wall sealing compounds; as a filler material in floor tiles; in asphalt pipeline enamels; in auto-body patching compounds; as a carrier for insecticides; and as a filler or dusting compound in the manufacture of rubber products.

Other applications for talc include use in cleaning compounds, polishes, electrical cable coating, plastic products, foundry facings, adhesives, linoleum, textiles, and in the food industry.

Particle-size specifications for most uses require the talc to be minus 325 mesh. The paint industry demands from 99.8 to 100 per cent minus 325 mesh. For rubber, ceramics, insecticides and pipeline enamels, 95 per cent minus 325 mesh is usual. In the wall-tile industry 90 per cent minus 325 mesh is generally required. For roofing grades the specification is about minus 80 mesh with a maximum of 30 to 40 per cent minus 200 mesh.

Soapstone has now only very limited use as a refractory brick or block, but, because of its softness and resistance to heat, it is still used by metalworkers as marking crayons. The ease with which it can be carved makes it an excellent artistic medium.

Pyrophyllite can be ground and used in much the same way as talc, but, at present, the use of the Canadian material is confined to ceramic tile. It must be minus 325 mesh and contain a minimum of quartz and sericite, which are common impurities.

World review

Deposits of talc are widely distributed throughout the world, but have been commercially developed only in the more industrialized countries. Because talc is of relatively low unit value, only a very small proportion of world production is traded internationally. The majority of international trade takes place within Europe, in the Far East between Japan, the People's Republic of China and Korea, and in North America between Canada and the United States. However, talc of exceptional purity is able to withstand the cost of transportation over much greater distances. For example, high-grade French, Italian, Indian and Chinese talcs are shipped throughout the world.

Prices

United States talc prices according to Oil, Chemical Marketing Reporter, December 31, 1973.

	($ per ton)
Canadian	
Ground, bags, carlot, fob mines	20-35
Vermont	
Domestic, ordinary, off-colour, ground, bags, carlot, fob works	22.25
California	
Domestic, ordinary off-colour, bags, carlot, fob works	34-39.50
New York	
Domestic, fibrous, ground, bags	35.50

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
71100-3	Talc or soapstone	10	15	25
71100-8	Micronized talc	free	5	25
29655-1	Pyrophyllite	free	free	25
29645-1	Talc for use in manufacturing of ceramic tile (expires Feb. 28, 1974)	free	free	25
29646-1	Talc for use in manufacture of pottery (expires Feb. 28, 1974)	free	free	25

United States
Talc, steatite, soapstone

Item No.			
523.31	Crude and not ground	0.02¢ per lb	
		On and After Jan. 1, 1971	On and After Jan. 1, 1972
523.33	Ground, washed, powdered, or pulverized	7%	6%
523.35	Cut or sawed, or in blanks, crayons, cubes, discs, or other forms	0.2¢ per lb	0.2¢ per lb
523.37	All other, not provided for	14%	12%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 452.

Tin

G.S. BARRY

Canada is an important consumer but a small producer of tin. The only producing company is Cominco Ltd., which recovers cassiterite (SnO_2) as a by-product from milling lead-zinc ores at Kimberley, British Columbia. The concentrate is exported to Britain, Mexico and the United States for smelting. In addition, Cominco obtains a lead-tin alloy from the treatment of lead bullion dross in the indium circuit of the Trail smelter in British Columbia. The company also produces, from purchased commercial-grade metal, small quantities of Tadanac brand high-purity tin (99.9999 per cent) and special research-grade (99.999 per cent).

Canadian production in 1973 of tin in concentrate and lead tin alloy was 132* tons valued at $569,890.

Canadian industrial requirements of tin are met mainly by imports that in 1973 totalled 5,465 tons valued at $23,819,000. In addition M. & T. Products of Canada Limited, Hamilton, Ontario, recovers a secondary tin product by de-tinning industrial and municipal scrap. The product is potassium stannate used mainly in electroplating applications. An equivalent of about 120 to 140 tons of tin is thus recovered annually. Canada also imports tinplate and exports tin metal, tin metal scrap and tinplate scrap, mainly to the United States. In 1973, 64 per cent of Canadian metal imports came from Malaysia, mainly as high-quality Straits brand, 19 per cent from the United States and 9 per cent from the People's Republic of China. This is the second year that Canada imported tin on a regular basis from China.

Brunswick Tin Mines Limited, a subsidiary of the Sullivan Mining Group Ltd., continued exploration and metallurgical testing on its multimineral deposit in southwestern New Brunswick. Revised reserves for the Fire Tower Zone reported in 1973 are 29.5 million tons with an average grade of 1.20 per cent tungsten, 0.09 per cent molybdenum, 0.08 per cent bismuth, 0.04 per cent tin, 0.07 per cent copper, 0.35 per cent zinc, 0.08 per cent lead, 4 per cent fluorspar and about one ounce of indium per ton. In addition, diamond drilling completed in 1973 on the North Zone, a little more than half a mile north of the Fire Tower deposit indicated over 1,000,000 tons grading approximately 0.5 per cent tin with higher grade in deeper holes. Diamond drilling from underground to test this deeper zone is planned for 1974.

* Metric tons of 2,205 pounds are used throughout.

Fine-grained cassiterite is a mineralogical component of sulphide ores of several Canadian mines but cannot be economically recovered except at the Sullivan mine of Cominco and, starting in the first quarter of 1974, at Ecstall Mining Limited's mine near Timmins. Ore grades at these mines are between 0.15 and 0.25 per cent SnO_2. Tin is present in small quantities in the zinc-lead orebodies of Brunswick Mining and Smelting Corporation Limited, New Brunswick and in the South Bay mine, Ontario, of Selco Mining Corporation Limited.

By December 1973, Ecstall Mining Limited, a subsidiary of Texasgulf Inc. had almost completed construction of a tin-circuit at its base metals concentrator at Timmins. The capital cost of this installation is estimated at $5.5 million. Production is scheduled to commence in early 1974 at an annual rate of approximately 1,600,000 pounds, or slightly more, of contained tin. Concentrates are expected to average 54 per cent tin; they will be sold to U.S. or European smelters.

The principal use of tin in Canada, accounting for over 50 per cent of the total consumption, is in the production of tinplate. There are two producers: Dominion Foundries and Steel, Limited (Dofasco) and The Steel Company of Canada, Limited (Stelco), both at Hamilton, Ontario. Canadian output of tinplate is all electrolytic; hot-dip production ceased in 1966. It is estimated that in 1972 approximately 2,650 tons of tin were used to produce 483,700 tons of tinplate, and in 1973, approximately 2,750 tons were used to produce 552,700 tons of tinplate, which indicates that further economies were made by the application of thinner coatings of tin.

Dofasco and Stelco each operate three electrolytic tinplate lines. Stelco's third line, with a capacity of 175,000 tons of tinplate a year was commissioned in November 1971. It can be converted to produce steel with other types of coatings, notably chrome-coated steel. Dofasco's third line is also dual purpose, and was commissioned in March 1972. It doubled the company's tinplate manufacturing capacity.

The second largest use for tin is in the manufacture of solders. Between 1,800 and 2,000 tons of tin are used annually for this product. Important Canadian users of unmanufactured tin for this application are The Canada Metal Company, Limited, Federated Genco Limited, Kester Solder Company of Canada Limited, Toronto Refiners and Smelters Limited, Tonolli Company of Canada Ltd., Metals & Alloys Company Limited, and Cramco Alloy Sales Limited. Bronze, a copper-zinc-tin alloy is also produced in Canada, chiefly by The Noranda Copper Mills Limited and Anaconda Canada Limited.

Table 1. Canada, tin production, imports and consumption 1972-73

	1972		1973^p	
	(metric tons)	($)	(metric tons)	($)
Production				
Tin content of tin concentrates and lead-tin alloys	160	473,908	132	569,890
Imports				
Blocks, pigs, bars				
Malaysia	3,966	14,400,000	3,483	14,972,000
United States	621	2,336,000	1,020	4,805,000
People's Republic of China	575	2,086,000	500	2,081,000
Netherlands	–	–	285	1,149,000
Thailand	300	1,106,000	–	–
Australia	165	590,000	73	338,000
Nigeria	105	370,000	61	249,000
Britain	89	317,000	22	124,000
Other Countries	85	340,000	21	101,000
Total	5,906	21,545,000	5,465	23,819,000
Tinplate				
United States	1,709	481,000	2,187	599,000
Britain	204	87,000	159	84,000
Total	1,913	568,000	2,346	683,000
Tin, fabricated materials, nes				
United States	42	122,000	121	349,000
Britain	1	3,000	4	9,000
Total	43	125,000	125	358,000
Exports				
Tin in ores and concentrates and scrap				
Britain	91	161,000	102	234,000
Mexico	–	–	46	90,000
United States	51	49,000	170	15,000
Total	142	210,000	318	339,000
Tinplate scrap	12,761	377,000	7,052	253,000
Consumption				
Tinplate and tinning	2,626^r		2,896	
Solder	1,638^r		1,818	
Babbit	204^r		188	
Bronze	194		214	
Galvanizing	6		–	
Other uses (including collapsible containers, foil, etc.)	92^r		119	
Total	4,760^r		5,235	

Source: Statistics Canada.
^{p} Preliminary; ^{r} Revised; – Nil.

World developments

Tin is the only metal for which there is formal cooperation between producer and consumer interests and among governments to rationalize problems of supply and demand and attenuate, to a certain extent, excessive price variations. The large mine producers of tin are developing countries with little consumption, and the largest consumers are the major industrial countries. A common interest in market stability in the post-war period led first to a study group and then to the First International Tin Agreement in 1956 under the auspices of the United Nations. The International Tin Council was formed to implement it.

The First International Tin Agreement was in force from July 1, 1956 to June 30, 1961 and the Second from July 1, 1961 to June 30, 1966. The Third and Fourth International Tin Agreement came in force, respectively, on July 1, 1966 and on July 1, 1971. The current agreement will expire on June 30, 1976, but renegotiating procedures will begin in mid-1975.

The main objective of The International Tin Council is the consideration of short-term problems of supply and demand and pricing. Decisions that affect supply and price, however, are made with regard to long-term trends. Consumer and producer members have an equal number of votes in the governing body, The International Tin Council. Canada is a signatory to the Agreement and, in proportion to its consumption, has 41 out of the total of 1,000 votes allocated to consumers. The 22 consumer members in 1973 accounted for 62 per cent of recorded world consumption. The total does not include U.S.S.R. consumption, as its data is not available even though the U.S.S.R. is a member country. United States is the main nonmember country among Western consuming countries. Its consumption in 1973 was 58,697 tons.

Producer members are Australia, Bolivia, Indonesia, Malaysia, Nigeria, Thailand and The Republic of Zaire. Counted together, producer and consumer members of the Council account for 92.8 per cent of the noncommunist production of tin in concentrate, of which the seven producer members account for 89.7 per cent.

Members of The International Tin Council established a buffer stock which currently has resources equivalent to 20,000 tons of tin. The operation of the stock to which until recently only producer members contributed, is vested in a manager appointed by the Tin Council, and responsible to the Executive Chairman of the Council. The ranges of permissible prices are set by the Tin Council and within this framework the manager of the buffer stock may use discretionary judgment to buy or sell tin metal, but not concentrates, on major markets to modify price fluctuations and ease supply problems.

Council may impose export controls to curtail metal supply if tin in the buffer stock exceeds 10,000 tons and other conditions appear to warrant such action. Financial resources of the buffer stock, until recently wholly the responsibility of the producer members, were significantly bolstered by voluntary

Table 2. Canada, tin production, exports, imports and consumption, 1963-73

				Consumption[3]	
Year	Production[1]	Exports[2]	Imports[3]	Recorded	Unrecorded
			(metric tons)		
1963	421	813	4,260	5,021	
1964	160	334	4,927	4,899	
1965	171	219	5,073	4,910	
1966	322	342	4,322	5,052	
1967	198	331	4,621	4,889	
1968	163	119	4,369	4,319	
1969	131	313[e]	5,024	4,349	450
1970	120	272[e]	5,111	4,554	500
1971	144	296[e]	5,104	4,056	800
1972	160	379[e]	5,906	4,760[r]	700
1973[p]	132	127[e]	5,465	5,235	100

Source: Statistics Canada.
[1] Tin content of tin concentrates shipped, plus tin content of lead-tin alloys produced.
[2] Tin in ores and concentrates and tin scrap.
[3] Tin metal.
[p] Preliminary; [r] Revised; [e] Estimated.

contributions from the Netherlands since 1971 and France since 1973 in proportion to their consumption and votes on the Council.

The buffer stock manager operates within price ranges designated as the lower, middle, and upper sector as shown in the accompanying tabulations. Under the first three agreements, the buffer stock manager was directed to buy only in the lowermost sector and sell only in the uppermost sector with no action in the middle sector except under special instruction which was rarely granted. Under the Fourth Agreement, however, the buffer stock operations are much more effective since under a much more flexible system the manager was given authority to both buy and sell in the lower and upper sectors as long as he remains a net buyer in the lower sector and a net seller in the upper sector. The manager was also given permission to operate temporarily in the middle sector under special provisions.

Despite the fact that buoyant economic activity characterized the later part of 1972, improvements in demand were more than offset by increases in new production, thus forcing the buffer stock manager to support the market until early 1973. As of December 31, 1972 the buffer stock contained 12,479 tons of tin metal. This deteriorating situation in the balance between supply and demand prompted the consideration of export controls, first during the October 1972 meeting of the Council in Jakarta, and then during the London meeting in January 1973 when controls were finally imposed. A 72-day freeze went into effect on January 19 and continued to March 31, 1973. The export control level was set at 1972 levels, thus during the control period exports were fixed at a maximum of 35,040 tons. The buffer stock manager's operational price ranges remained unchanged, but the manager has been allowed to operate temporarily in the "middle sector" provided he acts as a net seller in the upper half of this sector. The Council imposed this measure as a safeguard to prevent prices from skyrocketing because of export controls. The Council found it necessary to prolong export controls for the periods of April 1 to June 30 and July 1 to September 30, 1973. The maximum export quota was set at 42,644 tons for each quarter. For all three periods of export control actual exports were below the permissible amount. In retrospect, export controls were imposed for too long a period, and coincided with a period of rapid expansion in demand and a decline in mining output that was not caused by the controls. The general apprehension that impending potentially massive releases from the U.S. stockpile would depress the market was another factor in continuing with export controls beyond the originally agreed period of 72 days.

An important stockpile of tin in the world is that held by the United States in their stockpile of Strategic and Critical Materials. This stockpile originally held 369,000 long tons of tin in 1962, before disposals began. By July 1, 1968, when all commercial U.S. stockpile sales were suspended, these stocks were down to 257,524 long tons.

The stockpile objective was raised on March 28, 1969, from 200,000 to 232,000 long tons, leaving

Table 3. Price ranges in the tin agreements

Period of operation	Floor price	Lower	Sector Middle	Upper	Ceiling price
			(£/long ton)		
1 July 1956-22 Mar. 1957	640	640-720	720-800	800-880	880
22 Mar. 1957-12 Jan. 1962	730	730-780	780-830	830-880	880
12 Jan. 1962-4 Dec. 1963	790	790-850	850-910	910-965	965
4 Dec. 1963-12 Nov. 1964	850	850-900	900-950	950-1000	1000
12 Nov. 1964-6 July 1966	1000	1000-1050	1050-1150	1150-1200	1200
6 July 1966-22 Nov. 1967	1100	1100-1200	1200-1300	1300-1400	1400
22 Nov. 1967-16 Jan. 1968	1283	1283-1400	1400-1516	1516-1633	1633
16 Jan. 1968-2 Jan. 1970	1280	1280-1400	1400-1515	1515-1630	1630
			(£/metric ton)		
2 Jan. 1970-21 Oct. 1970	1260	1260-1380	1380-1490	1490-1605	1605
21 Oct. 1970-4 July 1972	1350	1350-1460	1460-1540	1540-1650	1650
			(M $/picul)		
4 July 1972-21 Sept. 1973	583	583-633	633-668	668-718	718
21 Sept. 1973-	635	635-675	675-720	720-760	760

In the light of changes in exchange rates occasioned by the 'floating' of the £ sterling, the price range has been expressed in terms of the ex-works price of tin on the Penang market in Malaysian dollars per picul since 4 July 1972. This price range was revised upwards on 21 September 1973.

25,524 long tons authorized and available for disposal. Releases totalled 2,046 long tons in 1969; 3,069 in 1970; 1,736 in 1971; and 361 long tons in 1972, all under the program of the United States Agency of International Development (AID). At the end of 1972, the U.S. stockpile held 18,521 long tons of uncommitted excess stock authorized for disposal.

Following a general policy decision to drastically reduce U.S. stockpile objectives in all commodities, the strategic reserves objective for tin was reduced to 40,500 long tons on April 16, 1973. Commercial sales were resumed again on June 8, 1973. These sales were part of the remaining balance then reported as available for disposal of 18,521 long tons; this balance was later reported to have been much higher – 49,897 long tons. Total sales for 1973 were 17,327 long tons leaving 32,570 long tons of tin still authorized by Congress for disposal at the end of the year. The release of the remaining surplus 160,126 long tons has to wait Congressional authorization, which ran into major delays.

More than 75 per cent of world tin mine output is derived from dredging and hydraulicking operations. Lode mines account for most of the output of Bolivia, Australia, Britain and South Africa. Concentrating processes for alluvial or lode tin are chiefly based on relatively simple gravity separation methods that produce concentrates ranging from 50 to 76 per cent tin. Typical concentrates as delivered, for example, to Indonesia's Mentok smelter in 1973 graded 65 to 72 per cent tin. Lode mining tin companies have recently installed flotation plants to complement gravity separation and improve the recovery of other metals as well as some very fine tin.

During the last five years *Australia* has overtaken the Republic of Zaire and Nigeria to become the fifth largest tin producer in the world, excluding the People's Republic of China. The main increase in mine production has come from three principal hard rock deposits: Renison and Mount Cleveland in western Tasmania and Ardlethan in central New South Wales. These three mines collectively produced 6,958 tons in 1973 compared with 7,570 in 1972. The small decrease was due to labour problems. Further expansion plans, particularly at Renison will raise total output of these three mines to about 10,000 tons by 1976.

As part of a five-year expansion program, Associated Tin Smelters Pty. installed a new smelting furnace and ancillary equipment at their Alexandria tin smelter in 1972 at a cost of A$400,000. This increased the smelter's handling capacity to 15,000 tons of concentrates a year against 9,450 tons in 1971. Australia exports its surplus concentrates for smelting mainly to Britain and Malaysia.

Mine production in *Britain* increased to 3,783 tons in 1973 from 3,327 tons in 1972. Production was only 1,816 tons in 1971. Wheal Jane Ltd. produced 1,610 tons and South Crofty Ltd. 1,554 tons. The latter includes output of the Pendares mine, brought into production by the parent company, St. Piran Mining

Table 4. Estimated world[1] production of tin-in-concentrates, 1963, 1972-73

	1963	1972	1973
	(metric tons)		
Malaysia	60,909	76,830	72,260
Bolivia	22,603	32,405	28,568
Thailand	15,835	22,072	20,921
Indonesia	13,155	21,766	22,492
Australia	2,906	12,081	10,633
Nigeria	8,869	6,731	5,828
Republic of Zaire	7,166	5,892	5,542
Total including countries not listed	143,568	196,500	185,300

Source: International Tin Council, Statistical Bulletin for 1966-73.
[1] Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary; it should be noted that China (People's Republic) and U.S.S.R. are large tin producers.

Table 5. Estimated world[1] production of primary tin metal, 1963, 1972-73

	1963	1972	1973
	(metric tons)		
Malaysia	89,081	91,001	82,468
Thailand	–	22,281	22,927
Britain	18,499	21,333	20,404
Indonesia	212	12,010	14,632
Bolivia	2,610	6,528	7,038
Australia	2,785	7,027	6,904
Nigeria	9,598	6,744	5,983
U.S.A.	1,591	4,000	5,500
Spain	1,596	4,100	4,257
Brazil	2,175	3,583	3,198
Belgium	7,470	3,923	3,669
South Africa	989	1,560	1,800
Republic of Zaire	1,378	1,400	1,158
Total including countries not listed	145,295	190,000	184,900

Source: International Tin Council, Statistical Bulletin.
[1] Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary.
– Nil.

Co. Ltd. on July 1973. At Wheal Jane, deepening and re-equipping of the principal shaft was completed and consideration is being given to doubling the current output by additions to the existing treatment plant. By year-end, development work on the new Mount Wellington mine, located next to Wheal Jane was well underway. The property should be in production in early 1975 at a rate of about 1,600 tons a year, tin in concentrate. Williams Harvey, one of two British tin smelters went into voluntary liquidation in June 1973. Production, however, was kept up until December 20 as unsuccessful attempts were made to find a buyer that would be willing to continue operations. Since Williams Harvey supplied 75 per cent of the LME's standard tin, a gradual build-up to shortage conditions for "physical" tin, led to premiums for standard tin over Straits brand at the end of 1973 and early 1974. The Williams Harvey closure posed serious problems for the Bolivians since it handled about 35 per cent of all Bolivian concentrates. Arrangements were made for the treatment of Bolivian tin by Rio Tinto Zinc Corporation (RTZ) at their Capper Pass smelter, North Ferriby, near Hull, U.K. British metal production in 1973 was 20,404 tons, or slightly lower than in 1972.

The largest lode tin mines are in *Bolivia* from which concentrates were exported mainly to Britain, with smaller amounts to the United States, West Germany and the U.S.S.R. In addition the country's German-built Vinto smelter commissioned in January 1971 by Empressa National de Fundiciones (ENAF) produced 7,038 tons of metal and operated near its initial rated capacity of 7,500 tons a year by the end of 1973.

In December 1973 ENAF reached an agreement with the West German government for the financing of the second stage of the Vinto tin smelting complex that would raise capacity to 20,000 tons. The expanded smelter is scheduled to come on stream in early 1976; work will almost certainly be undertaken by Klockners, who built the original smelter.

Production of tin in concentrates in Bolivia decreased considerably in 1973 mainly due to recurrent labour problems and rapid cost escallations in a country which is the highest cost producer in the world. Banco Minero de Bolivia, the body governing Bolivia's medium and small mines claimed that the break-even price for this sector was U.S. $2.86 a pound, considerably above the average N.Y. price of $2.27 a pound of tin in 1973. The insolvency of some small mining enterprises was due primarily to high taxes. The Bolivian industry pays taxes (royalties) on tonnage exported rather than profits, and for tin the royalty in 1973 was about 25 per cent. In addition, "other" taxes accounted for 8 per cent of the quoted price. Banco Minero cited an average cost of U.S. $1.26 a pound for treatment charges, freight expenses and duties, and an average mining cost of U.S. $1.60 a pound.

Bolivia is still experiencing major problems in recovery and beneficiation. The country produces concentrates grading 20 to 60 per cent tin, with recoveries that range from less than 50 per cent to 72 per cent. Significant improvements will be made in the next few years with the planned installation of Soviet-built volatilization plants for Unificada Potosi (at Potosi), Machacamara (at Oruro) and San Jose y Queschisla (at Queschisla). Construction of the Potosi plant, for which the U.S.S.R. granted a 10-year credit of $6.4 million, began at year-end and will be completed in 1976. The material extracted from the mine grades approximately 0.80 per cent tin. It will be upgraded in a preconcentrator plant to 3-3.5 per cent, will then go to the volatilization plant which will upgrade it to 50 per cent and the product will be sent to the Vinto plant for smelting. The main advantage is an expected increase in recovery from 50-60 per cent to over 90 per cent. Future volatilization plants will also process low-grade tailings, upgrading this material to about 50 per cent tin which is suitable for smelting. Corporacion Minera de Bolivia (Comibol), estimates that some 272,000 tons of tin lie in waste material in Bolivia's state-owned mines alone, more than the country's past 10 years of production. These tailings grade between 0.07 and 3.0 per cent fine tin.

Brazil has the potential of becoming an important producer of tin, because of its large resource base, mainly in the western state of Rondonia. Brazil's Ministry of Industry and Trade puts measured reserves of tin in four areas at 168,100 tons. The national plan calls for an investment of about $17 million on tin prospecting over the next two years. According to the new government study, it is expected that by 1980 production of tin will be 7,500 tons a year. This is only slightly above expected domestic demand. The country's production for 1973 was 3,286 tons up from 2,813 tons in 1972. Brazil has two tin smelters which operate partly on imported ores. The 1973 metal production is estimated at 3,719 tons.

Burma, currently producing 600 tons of tin a year compared with 6,000 tons annually prior to World War II, has begun a planned program of mineral exploration and extraction, with foreign aid. The U.S.S.R. has agreed to revive the Mawchi tin-tungsten lode mine, formerly a major producer. The country has a better potential, however, in developing some of its placer deposits, and on a longer term basis offshore tin. Canadian and West German aid in prospecting and obtaining equipment has also been made available.

Indonesia began a long-term program of expansion of its tin industry. Mine production in 1973 was 22,492 tons compared with 21,766 tons in 1972. The Indonesia State Tin Enterprise, P.N. Timah, began construction on the expansion of the Peltim smelter. It was commissioned in 1967 with a designed capacity of 15,000 tons per year but achieved operational capacity only in 1973 when Indonesia shipped to markets 14,632 tons. Difficulties still persist and on a longer term basis the rotary furnaces are not expected to produce much more than 12,000 to 13,000 tons per year. The addition of three stationary furnaces will increase capacity to about 30,000 tons. Trial runs in the expanded section of the smelter should start in early 1975. This expansion will be greatly facilitated by the completion of the nearby Mentok Harbour to accommodate 19,000 ton dwt vessels in 1973. Almost all of the Indonesian output comes from dredging and hydraulic mining on and off Bangka Island (71 per cent), Belitung Island (23 per cent) and Singkeg Island (6 per cent).

Production in *Laos* is recorded at about 747 tons in 1973 compared with 787 tons in 1972. It is believed however that production is somewhat higher but is not adequately reported. The country has potential to produce more, but this potential is not likely to be realized until political conditions improve.

Malaysia, the largest world tin producer, had a production of tin in concentrates of 72,260 tons, considerably below last year's level of 76,830 tons. The record Malaysian production was 79,400 tons in 1941. At the end of 1973 Malaysia recorded production from 974 mining units, including 58 dredges and 873 gravel pump operations. The labour force in tin mining was 41,744, a decrease from 45,500 at the end of 1972. The Selangor Dredging Berhad Company completed construction of the largest inland-based dredge in the world in July 1973 at a cost of $5 million. This dredge has an annual capacity of 10,300,000 cubic yards and was built to operate profitably a low grade deposit which averages only 0.008 per cent tin (0.20 katis per cubic yard). Malaysian dredging operations are on inland properties but offshore dredging is planned for the second half of current decade. Malaysia has two tin smelters that jointly produced 82,468 tons of tin metal in 1973 from domestic and imported concentrates.

Tin output in *Nigeria,* now all from alluvial deposits, declined to 5,828 tons in 1973 from 6,731 tons in 1972. As a result, tin metal production at the Makeri smelter at Jos, which operates only on domestic resources, declined to 5,983 tons in 1973. This level is less than half of its designed capacity. The decline in concentrate output from alluvial deposits may be compensated by production from a lode mine at Liruie'n Kano that could be developed in the late 1970's. Although the principal reason for the decline in mining is a decrease in grade combined with a minimum of new investment, the high tax or royalty levied by the government is a source of great concern. During 1973 the royalty was approximately 17 per cent levied on gross realization on tin at the time of sales to the Makeri Smelting Company.

The Republic of *South Africa* increased tin output from 2,126 tons in 1972 to 2,628 tons in 1973 and plans further increases principally based on the Rooiberg mine. *South-West Africa* produced about 800 tons in 1973. About half of the combined output of the two countries is smelted at the Zaaiplaats, Potgietersrust smelter and the remaining is exported in concentrates, mainly to Britain.

Thailand's output of tin in concentrates decreased from 22,072 tons in 1972 to 20,921 tons in 1973 partly due to flooding and partly to a much lower output from sea dredging operations than originally expected. Thailand's metal production was 22,927 tons slightly higher than in 1972. It comes from the Thaisarco smelter on Phuket Island.

Table 6. Estimated world[1] tin position, 1971-73

	1971	1972	1973
		(metric tons)	
Ore supply			
Production of tin-in-concentrates	185,900	195,300	185,300
Stock at year's end	10,574	9,108	9,645
Primary metal supply			
Smelter production of tin metal	185,900	190,000	184,900
Net sales to centrally planned countries	2,800	1	1,900
Government stockpile sales	1,764	367	17,600
Buffer stock, net bought	5,400	5,800	–
net sold	–	–	11,500
Commercial stocks at year's end	46,200	40,300	37,400
Primary metal consumption	188,700	191,100	212,100

Source: International Tin Council, Statistical Bulletin.
[1] Excludes countries with centrally planned economies except Czechoslovakia, Poland and Hungary.
– Nil.

Uses

Tin metal is unequalled as a protective, nontoxic hygienic coating on steel. The manufacture of tinplate represents the largest market for tin. Approximately 85 per cent of tinplate is used by the can-making industry. Available world data indicate that 81,700 tons of tin were used in 1973 for the production of 13.7 million tons of tinplate compared with 74,700 tons used to produce 12.3 million tons in 1972. The tin coating on steel varies with the product mix of tinplate plants, from 0.25 pounds per base box (5.6 g/m^2) for electrolytic tinplate up to 1.25 pounds (28 g/m^2) for the hot-dip process. Tinplate is sold by the base box (31,360 square inches).

Tin International reports in their January 1974 issue that at the end of 1973, 110 electrolytic tinning lines were in operation in the world which include all 27 important producing countries other than the U.S.S.R. and the People's Republic of China. Total finishing capacity is some 21 million tons of which almost 98 per cent is now electrolytic. Three new electrolytic tinplate producers began commercial operations during 1973: Venezuela in May, Thailand in July and Bulgaria in November, and one plant was closed in West Germany.

The technology of can making is changing with better and more economic uses being made of coiled tinplate. Other developments include the use of double-reduced tinplate and of jet soldering techniques for can side seams. A tin coat also imparts an inherent lubricity to tinplate, an important characteristic for the recently introduced deep-drawn and wall-ironed can-making process (D&I). Seamless cans could compete in the beer and beverage can market in which chrome-plated steel (TFS) or aluminum have already acquired a strong foothold, increasingly replacing glass containers. Crown Cork & Seal Corporation in the United States was the first to achieve commercial production of one-piece D&I tinplate cans in 1971; in 1972 American Can Company brought into production a similar line at Edison. In Britain, The Metal Box Company started commercial production of D&I cans in 1973. There is currently no substitute for tinplate in most container applications involving food processing and the expansion of this market will continue, particularly in less developed countries. Despite yearly increases in absolute quantities of containers, the utilization of tin in tinplate has remained static in the past few years mainly because of more economical, thinner application of tin coatings. In the United States the tinplate industry, for example, utilized 5.176 kg. of tin per ton of tinplate in 1971, 4.849 kg. in 1972 and 4.504 kg. in 1973. This can be compared with the utilization of 5.961 kg. per ton of tinplate for the world average in 1973. While most processed food products are now packed in cans manufactured from electrolytic tinplate, demand for hot-dipped (H.D.) tinplate material for canning highly corrosive foods such as fish remains strong in some countries. In the developed countries, H.D. tinplate is being increasingly replaced by electrolytic, particularly by differential tinplate, which carries a heavier coating on one face than on the other.

After tinplate, solders are the second largest tonnage users of tin; estimated at 27 per cent in the U.S.A., 34 per cent in Japan and 20 per cent in Britain in 1973.

Uses for tin solder (60-63 per cent Sn) in the electronic industry, are growing rapidly; tin remains unchallenged as the means for interconnecting components given utmost reliability. Newer applications are the mass-production of 'tailor-made' preforms based on discs and washers punched from foil and the use of a tin-lead powder and flux mixture that fuses on heat applications. Tin and tin-rich coatings are also widely used to ensure highest solderability.

Soft solders are used to join side seams of cans (2-3 per cent Sn) and as lead-rich body-filling solders (2 per cent Sn) in the automotive industry. Motor-car radiator cores are another important application. This market could run into some stiff competition with the announcement by some large European radiator manufacturers that they have solved the problems of mass-producing aluminum radiators. Use of solders in plumbing is important but is not increasing in proportion to gains in the construction industry because of the increased use of PVC (polyvinyl chloride) plastics.

The alloy applications of tin have a long tradition. Babbitt and white metal alloys are used for bearings and so are aluminum-tin alloys, which have a higher fatigue strength. Newer bearing materials include chromium- and beryllium-inoculated tin-base alloys offering markedly improved mechanical properties. Copper-tin alloys such as bronze and gunmetal (up to 12 per cent Sn) have an average tin content of about 6 per cent and account for about 7 per cent of the world primary tin consumption or for about 12,000 tons of primary tin plus about 28,000 tons of secondary tin. The gunmetals contain copper, tin and zinc and sometimes lead to improve machinability. Continuous casting of standard shapes has reduced fabrication cost and caused renewed interest in bronze as an engineering material. A heat-treatable tin-bronze has now been developed, giving added strength.

Titanium-tin alloys bearing 2-11 per cent tin are used increasingly in the aerospace industry, especially in supersonic jets. For example the British-French Concorde utilizes these alloys. Terneplate, an alloy of 80-88 per cent lead and 20-12 per cent tin, has a three-century tradition as a most durable roofing material. It shows signs of revival in the United States. Other applications for terneplate are in automotive car and oil filters and some fixtures and in critical body parts, for example the undersides of electric golf carts. A possible future use with large tonnage potential would be as a replacement of copper in radiator cores.

A new product introduced by Hoesch in West Germany in 1973 is Galvo-Terne. It is a cold-rolled sheet, electrolytically coated with an 88 per cent lead-12 per cent tin alloy, offering attractions for corrosion resistant parts of cars (gasoline tanks). It is resistant to a number of chemicals, suggesting potential uses in chemical plant applications.

Pewter is again becoming popular; for instance, pewter plate and beaker castings commemorated the Munich 1972 Olympics. Modern methods of making pewterware from rolled sheet have recently been introduced. Pewter is pure tin that has been hardened by the addition of copper and antimony; representative compositions range from 91 per cent tin, 2 per cent copper and 7 per cent antimony to 95 per cent tin, 1 per cent copper, and 4 per cent antimony. Lately, the Association of British Pewter Craftsmen drew up plans for guaranteeing a minimum of 90 per cent tin in British pewter articles. Some pewters are lead-free, but many pewterers favour the addition of up to 0.5 per cent lead.

Fusible alloys of tin, bismuth, lead, cadmium and, sometimes, indium are used in safety devices such as heat fuses. Diecasting alloys of tin, antimony and copper have applications in jewelry.

Tin is widely used as a minor alloying agent in other metals; for example, alloy AP (antipollution) bronze is a corrosion-resistant copper-tin-aluminum alloy for condenser tubes in power stations operating in polluted waters. Tin accounts for 5.5 to 9.0 per cent of this alloy. Tin is a constituent in superconductive alloys such as intermetallic Nb_3Sn. Tin is also used in special protective coatings, particularly as a tin-nickel alloy electroplate which has excellent corrosion resistance, high hardness and the power of retaining an oil film.

A relatively new application is the use of small quantities of tin (approximately 0.1 per cent) in cast iron for engine blocks. Adding tin assures a uniformly hard, wear-resistant and thermally stable perlitic structure in the castings. Current consumption for this usage is estimated at 1,000 tons a year. Tin has also an application in powder metallurgy primarily for sintered bronze bearings (sealed, self-lubricating). A new application is powder-sintered bronze-teflon bearings. Tin plus copper is replacing other metallic additions to iron powders to improve the quality of conventional sintered iron alloys, but only a substantial reduction in the price of tin powder could lead to a large market expansion for such products. Some encouragement in this field is provided by recent experiments in West Germany on the use of water-atomized powder directly from tinplate scrap.

Pure tin is used in collapsible tubes, especially for pharmaceutical products. It is used as a molten bath in the float-glass process for making perfectly flat glass sheet. Tin is also marketed as tin oxide for polishing applications; a newer use of tin oxide is in the manufacture of conductive glass and glass resistors.

Tin is used widely in organotin compounds and inorganic tin compounds. Chemicals, however, account for consumption of 5,000-10,000 tons, much of which comes from secondary tin. Growth potential from this modest base is excellent. The main uses of organotins are as: dioctyltin stabilizers for PVC; triphenyltin fungicides in agriculture; and tributyltin in industrial biocides and disinfectants. Inorganic compounds stannous chloride and stannous sulphate as well as sodium stannate and potassium stannate are used as electrolytes in the tin-plating process. The chloride also stabilizes the colour and perfume of soap. Stannic oxide is an opacifier in enamels. Stannic chloride is a basic chemical in the manufacture of the organotin compounds. Under development is the use of organotin chemicals as biocidal compounds to combat tropical diseases: for example, schistosomiasis (blood flukes) by eliminating the main carrier, a water snail.

Tin chemicals are used as highly efficient catalysts in polyurethane foam technology and in the construction industry, and as catalysts in silicone elastomers, also known as semiplastic sealants, a rapidly expanding application. Organotins have outstanding stabilizing properties for the production of PVC compounds and roofing materials, as well as in the packaging industry.

The high-purity tin produced in Canada by Cominco, 59 grade (5-9's) (99.999 per cent) and 69 grade (6-9's) (99.9999 per cent) is used mostly in metallic form in the electronics industry. Some is used to produce semiconductors such as a tin-lead telluride for advanced solid-state radiation detection devices. Tin reclaimed by M & T Products of Canada Limited is in the form of potassium stannate and is used directly in electro-plating.

Outlook

The unprecedented 10 per cent consumption rise from 191,100 tons in 1972 to 210,400 tons in 1973 was not foreseen and export controls instituted during the year were more in response to a predicted theoretical surplus caused by normal supplies from mine sources plus expected releases from the U.S. stockpile. As it turned out, mine output decreased by 5 per cent and the gap between supply and demand was bridged by the depletion of the Buffer Stock account and, indeed, an almost providential availability of GSA tin. The price of tin escalated rapidly from the £1,700 per ton price level in January to £2,800 level in December. However, the increase did not pave the way for additional mine supplies, as costs escalated just as rapidly, and new taxation measures imposed by the developing producing countries tended to discourage investment. The outlook for 1974 and 1975 is the continuation of a bottleneck on the mine-supply side with metal from U.S. stockpile accounting for much of the difference. If price stability at new high levels persists, China may again enter the market with increased exports. Of the main producing countries only Indonesia has the potential of increasing output next year. Price stability therefore is not likely to be achieved in the short-term, but in the long-term much will depend on the intentions of the United States on the disposal of the large stockpile reserve currently considered as surplus.

Monthly Tin Prices in 1973

	London Metal Exchange			New York			Penang		
	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average
	Cash–£ per metric ton			Prompt–¢ per lb.			Ex-works–M$ per picul		
Jan.	1,622.0	1,593.0	1,611.5	180.00	177.75	179.05	636.50	625.13	629.46
Feb.	1,746.5	1,606.5	1,658.2	202.50	181.25	192.00	643.00	625.00	634.79
Mar.	1,787.5	1,674.0	1,736.1	210.00	201.00	205.10	655.50	619.00	636.99
Apr.	1,740.0	1,707.5	1,722.1	204.00	199.00	202.44	633.00	615.50	623.53
May	1,746.5	1,700.5	1,717.9	214.00	202.00	209.11	638.50	620.13	628.98
June	1,812.0	1,727.0	1,764.2	218.75	207.50	212.27	671.00	634.13	652.65
July	2,053.5	1,810.0	1,950.6	247.75	218.00	237.55	706.00	655.13	690.52
Aug.	2,062.5	1,982.5	2,025.4	248.50	239.00	243.45	706.00	685.00	694.76
Sept.	2,155.0	1,984.0	2,068.0	241.75	238.75	240.30	699.13	680.00	688.35
Oct.	2,272.5	2,149.0	2,213.2	252.00	239.00	245.91	726.88	687.50	704.99
Nov.	2,647.5	2,231.5	2,349.8	284.75	252.00	262.44	863.00	730.00	788.55
Dec.	3,182.5	2,375.0	2,788.5	345.00	274.25	301.85	1,026.00	720.13	853.11

Tariffs

Canada

Item No.		Most Favoured Nation
		(%)
32900-1	Tin in ores and concentrates	free
34300-1	Tin in blocks, pigs, bars, or granular form	free
34400-1	Tin strip waste and tin foil	free
33910-1	Collapsible tubes of tin or lead coated with tin	17½
38203-1	Sheet or strip, iron or steel, corrugated or not, coated with tin	12½
33507-1	Tin oxides	15
34200-1	Phosphor tin	7½
43220-1	Manufactures of tin plate	17½

United States

Item No.		
601.48	Tin ore and black oxide of tin	free
622.02	Unwrought tin other than alloys of tin	free
622.04	Unwrought tin, alloys of tin	free
622.10	Tin waste and scrap	free

Tariffs (concl'd)

United States

Item No.		After January 1 1970	1971	1972
608.91	Tinplate and tin-coated sheets	8.5% valued at not over 9.4¢/lb	8% valued at not over 10¢/lb	8% valued at not over 10¢/lb
608.92	Tinplate and tin-coated sheets	0.8¢ per lb valued over 9.4¢/lb	0.8¢ per lb valued over 10¢/lb	0.8¢ per lb valued over 10¢/lb
644.15	Tin foil	24%	21%	17.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1972) TC Publications 452.

Titanium and Titanium Dioxide

R. GOODMAN and M. BOUCHER

In 1973, Canada remained the world's premier producer of ilmenite concentrates, in the form of titania slag, with Quebec Iron and Titanium Corporation (QIT) producing 841,700 long tons, valued at \$40,828,421. Approximately 89 per cent of QIT's titania slag is exported to over fifty countries; the remaining 11 per cent is consumed by the two Canadian pigment producers. Total production of TiO_2 pigment in 1973, by Canadian Titanium Pigments Limited at Varennes, Quebec, and Tioxide of Canada Limited at Sorel, Quebec, was 63,000 tons, each plant consuming approximately 45,000 tons of titania slag.

Estimated world production of ilmenite in 1973 was 3.74 million short tons compared with 3.59 million tons in 1972, with Australia, Canada, United States and Norway continuing to contribute over 80 per cent of total world supply. The residual 20 per cent of titanium was derived from rutile production, which increased by an estimated 2 per cent in 1973 from 356,853 short tons of rutile concentrates in 1972 to 365,000 short tons in 1973. Australia accounted for 95 per cent of the world's rutile production. World demand for titanium metal increased by over 15 per cent in 1973, after three consecutive years in the doldrums, and world demand for titanium dioxide pigments continued to exhibit a healthy growth trend of 7 per cent in 1973.

Controversy continued throughout 1973 regarding the merits of the chloride and sulphate processes of TiO_2 pigment manufacture which, essentially, was an argument of pollution abatement costs as opposed to raw material costs. The chloride process is particularly advantageous from the viewpoint of nonpollution, as no deleterious waste products are produced but, until recently, the chloride process was entirely dependent on high-grade rutile as a raw material source. This raw material remains in relatively tight supply, with only limited known world reserves. In 1973, however, E.I. du Pont de Nemours & Co. Inc. appeared to make a significant breakthrough by using 50-60 per cent TiO_2 as a feedstock in its chloride process instead of the conventional 97 per cent TiO_2 for rutile. This has permitted du Pont to include a large proportion of ilmenite in its feed; du Pont and other major TiO_2 pigment producers are now convinced the chloride process is the most economical in a modern environmentally conscious society.

Minerals and Canadian deposits

Titanium is the ninth most abundant element in the lithosphere, with an average content of approximately 0.50 per cent. It occurs predominantly in rocks of basic affiliations, especially gabbroic and anorthositic rock complexes. Ilmenite ($FeTiO_3$) and rutile (TiO_2) are usually the only two titanium minerals of economic significance. Ilmenite theoretically contains 52.66 per cent TiO_2 and 47.34 per cent iron oxide (FeO). It occurs extensively throughout rocks of igneous origin, but is only concentrated in economic deposits in gabbroic and anorthositic rock complexes, where it occurs as massive lenses of ilmenite intergrown with hematite or magnetite. Ilmenite is also found as a heavy mineral constituent in beach or placer deposits which have been derived from igneous rocks by mechancial disintegration.

Rutile is essentially pure TiO_2 but, in nature, it may contain up to 10 per cent impurities, mainly iron and vanadium oxides. Rutile is a widespread accessory mineral in many types of igneous, metamorphic and sedimentary rocks. It is only of economic significance when it is concentrated in reworked beach or placer deposits in association with other heavy minerals especially ilmenite and zircon and occasionally cassiterite, columbite and tantalite.

Other titanium minerals such as brookite (TiO_2), anatase (TiO_2), perovskite ($CaTiO_3$), sphene ($CaTiSiO_5$) and leucoxene (an ilmenite alteration product) are often common accessories in many ilmenite or rutile ore deposits but, as yet, have never attained sufficient concentrations individually to acquire economic significance. The only possible exception is a newly discovered titanium deposit in Minas Gerais state in Brazil, which appears to contain almost exclusively anatase, a polymorph of rutile.

Commercial ilmenite concentrates typically contain between 44 and 60 per cent TiO_2, and rutile concentrates normally average 95 per cent TiO_2.

The Canadian Shield, especially that part situated in the province of Quebec, is favourably endowed with titaniferous deposits. Under existing technology and prevailing economics, only the high-grade ilmenite-hematite or ilmenite-magnetite deposits attract widespread exploration activity. Ultimately the largest potential may lie in the vast low-grade titaniferous magnetite deposits. These deposits occur extensively in Quebec and have an average content of 20 per cent iron and 5 per cent titanium, and known reserves alone total many billions of tons. However, current production is restricted to one high-grade deposit in the Lac Tio-Lac Allard area of eastern Quebec. The ilmenite deposit is mined by open-pit methods, and constitutes one of the world's largest with reserves exceeding 100 million tons grading 35 per cent TiO_2 and 40 per cent iron. In addition the surrounding area has potential reserves of billions of tons of low-grade titaniferous magnetite disseminated throughout the gabbroic-anorthosite massif. The Lac Tio deposit occurs as a high-grade sill-like structure in which the ilmenite forms intimate intergrowths with hematite. Another high-grade titanium deposit located at St. Urbain, 75 miles northeast of Quebec, is expected to come into production in the near future if titanium markets continue to exhibit their present strength. This deposit is a high-grade massive dyke-like structure of ilmenite-hematite containing 20 million tons grading 38 per cent TiO_2 and 40 per cent total iron.

Table 1. Canada, titanium production and trade, 1972-73

	1972		1973p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
Titanium dioxide slag	. .	40,828,421	. .	46,318,000
Imports				
Titanium dioxide pure				
United States	2,308	1,130,000	2,069	1,110,000
Belgium and Luxembourg	1,632	651,000	152	67,000
West Germany	915	450,000	1,325	623,000
United Kingdom	879	372,000	1,185	505,000
Japan	159	55,000	–	–
Other countries	–		11	6,000
Total	5,893	2,658,000	4,742	2,311,000
Titanium dioxide extended				
Britain	–	–	181	92,000
West Germany	–	–	124	50,000
United States	1,192	224,000	117	50,000
Total	1,192	224,000	422	192,000
Titanium metal				
United States	209	1,788,000	228	1,703,000
Japan	9	49,000	44	261,000
France	–	–	3	53,000
Britain	4	55,000	3	40,000
Netherlands	. . .	3,000	. . .	3,000
Total	222	1,895,000	278	2,060,000
Exports[1] to the United States				
Titanium metal, unwrought, incl., waste and scrap	12	8,746	120	116,486
Titanium metal, wrought	82	439,107	87	450,075
Titanium dioxide	17,385	7,353,452	14,065	6,831,043

Source: Statistics Canada, except where noted.
[1]U.S. Department of Commerce Imports for Consumption, Report F.T. 135; no identifiable classes are available from Canadian export statistics.
pPreliminary; – Nil; . . Not available; . . . Less than 1 ton.

Canadian production and developments

Quebec Iron and Titanium Corporation (QIT) is the only company in Canada mining and processing ilmenite for the production of titania slag for use in the manufacture of TiO_2 pigments by the sulphate process. The ilmenite is mined by open-pit methods in the Lac Tio-Lac Allard area of eastern Quebec. The ilmenite is crushed at the minesite to minus 3 inches, transported 27 miles by rail to the port of Havre-St. Pierre and shipped up the St. Lawrence River to the company's beneficiation plant and smelter at Sorel near Montreal. The crushed ilmenite is upgraded from about 86 per cent to about 93 per cent of total titanium and iron oxides by means of heavy media separation, spirals and cyclones. The upgraded product is calcined in rotary kilns to lower the sulphur content, cooled, and mixed with powdered anthracite. Electric arc smelting of the calcine-coal mix yields titania slag and molten iron. Pigment-grade slag contains 70 to 72 per cent TiO_2 and is a product experiencing exceedingly strong demand in world markets.

In 1973, QIT treated 2,050,000 long tons of ilmenite in producing 841,700 long tons of titania slag and 579,000 long tons of coproduct pig iron. These production figures represented a 1-2 per cent increase over the comparable 1972 values. Canada's titania slag output in 1973 was valued at $40,828,421 compared with $41,105,000 in 1972 when production was reported at 821,800 long tons.

In 1973, QIT announced plans of a $11.4 million expansion program which will increase capacity at its Sorel and Havre-St. Pierre operations by 5 per cent to 2,200,000 long tons of ilmenite treated annually. The major improvements will include the addition of a third pig casting machine, a coal dryer and an upgrading of a rotary kiln and a cooler unit at its Sorel operation and additional production trucks and drilling equipment at its Lac Tio minesite. Of the approved investment $2.6 million has been allocated for pollution control equipment. Construction is scheduled for commencement in 1974 and completion by mid-1975.

Tioxide of Canada Limited, a subsidiary of British Titan Products Company Limited, operates a 33,000-tons-a-year sulphate process titanium-dioxide pigment plant at Sorel, Quebec. The plant uses QIT titania slag as its raw material and, in addition to providing pigment for the Canadian market, significant quantities are exported to Britain, United States, and Europe.

Canadian Titanium Pigments Limited, a subsidiary of N.L. Industries, Inc., New York, produces 30,000 tons a year of titanium pigment using the sulphate process at its plant at Varennes, Quebec. The company utilizes TiO_2 slag from QIT as its raw material source. The company formerly operated a 10,000-tons-a-year capacity chloride process TiO_2 pigment plant at Varennes, but this was closed in 1972 due to difficulties experienced in obtaining rutile and chlo-

Table 2. Canadian titanium production trade and consumption 1964-73

	Production		Imports			Consumption	
	Ilmenite[1]	Titanium Dioxide Slag[2]	Titanium Dioxide Pure	Titanium Dioxide Extended[3]	Total Titanium Dioxide Pigments	Titanium Dioxide Pigments[4]	Ferro-titanium[5]
	(short tons)						
1964	1,387,960	544,721	1,839	10,443	12,282	41,539	42
1965	1,318,352	545,888	1,565	9,534	11,099	39,682	65
1966	1,264,704	524,720	1,627	9,774	11,401	43,579	49
1967	1,442,224	602,448	1,616	9,763	11,379	43,447	54
1968	1,619,408	672,896	2,387	9,697	12,084	45,470	22
1969	1,824,144	749,280	2,504	8,651	11,155	47,418	34
1970	2,085,888	844,704	2,781	8,174	10,955	44,408	27
1971	2,087,008	852,992	5,941	5,725	11,666	..	21
1972	2,258,480	920,416	5,893	1,192	7,085	..	147
1973[p]	2,295,216	942,704	4,742	422	5,164	..	..

Sources: Statistics Canada, and company reports.
[1]Ore treated at Sorel from company reports: [2]Gross weight of 70-72 per cent TiO_2 slag produced, from company reports; [3]Approximately 35 per cent TiO_2; [4]Includes pure and extended TiO_2 pigments; [5]Ti content.
[p]Preliminary; . . Not available.

rine at economic prices.

Canadian Tiron Chemical Corporation is nearing completion of the construction phase at its pilot plant at Pointe-aux-Trembles, Quebec. Production is scheduled to commence by mid-1974 with an ultimate processing capacity of 20,000 tons a year of upgraded ilmenite. The ilmenite will be obtained from a high-grade ilmenite-hematite deposit at St. Urbain, northeast of Quebec City. The company expects to produce intermediate titanium dioxide products and an unfinished high-grade anatase-grade material.

Table 3. Titania slag and iron production, Quebec Iron and Titanium Corporation, 1968-73

	Ore Treated	Titania Slag Produced	Iron Produced
		(long tons)	
1968	1,445,900	600,800	410,100
1969	1,628,700	669,000	496,100
1970	1,862,400	754,200	531,200
1971	1,863,400	761,600	535,300
1972	2,016,500	821,800	572,800
1973	2,049,300	841,700	579,000

Source: QIT.

United States production and consumption

The United States is the world's third largest producer of ilmenite, with an estimated production of 760,000 short tons in 1973. Production was obtained from seven major mining operations based on placer deposits in Florida, Georgia and New Jersey and a lode deposit in the Sanford Lake area of New York. In 1973, one additional ilmenite producer supplemented the previous six major producers, as the American Smelting and Refining Company (ASARCO) plant near Lakehurst, New Jersey came on stream. The operation will have an eventual planned capacity of 185,000 tons a year, of which 125,000 tons have already been committed to du Pont on a ten-year contract. Development work also commenced in 1973 in Nelson County, Virginia, where Titanium Minerals, Inc. intend to mine rutile and ilmenite contained in placer deposits. A pilot plant operation is scheduled for completion by 1974.

Production of titanium metal in the United States increased substantially in 1973, after three years in the doldrums. Ingot production increased 42 per cent in 1973 from 40.5 million pounds in 1972 to 57.0 million pounds in 1973. Mill product shipments reached the second highest level in the industry's 23-year history, increasing by 17 per cent from 25.3 million pounds in 1972 to 29.5 million pounds in 1973. The United States continued to produce approximately 75 per cent of its titanium sponge requirements with most of the balance being imported from Japan (6 million pounds) and Russia (4.1 million pounds).

In 1973 the United States continued to import almost its entire consumption of rutile, estimated at 200,000 short tons. Eight pigment manufacturers using the chloride process accounted for 84 per cent of rutile consumption, a further 7 per cent was used in welding rod coatings and the remaining 9 per cent was used in the titanium metal industry. United States imports of rutile accounts for over 50 per cent of Australian exports of the TiO_2 raw material. Over 20 per cent of the United States consumption of ilmenite concentrate is also imported, with 95 per cent of this total being imported as QIT titania slag containing 70-72 per cent TiO_2.

The United States consumption of titanium products showed renewed strength in 1973, with TiO_2 pigment-plants working at absolute capacity in an attempt to meet spiralling demand for TiO_2 pigments. Total United States TiO_2 pigment production in 1973 exceeded 700,000 short tons. The year 1973 also heralded an overdue increase in demand for titanium metal. United States consumption of titanium sponge was estimated to be 39.5 million pounds, an increase of 50 per cent compared with 1972 and ingot consumption was 52.5 million pounds, an increase of 35 per cent over 1972. Accelerated demand in the aerospace and military industries, which account for 85 per cent of metal sales, was largely responsible for the increased consumption in 1973.

Other world developments

Australia. Australia is the world's largest producer of rutile and the world's second largest ilmenite producer. Current Australian rutile production is derived entirely as a coproduct of zircon production from beach sands scattered along 600 miles of the eastern coast of Australia extending from Northern Queensland to New South Wales. Additional supplies of rutile are expected to emerge in 1974 from new titanium operations in Western Australia. Estimated Australian production of rutile in 1973 was 365,000 short tons compared with 356,853 short tons in 1972.

Present Australian ilmenite production is confined to the beach sands of Western Australia, where four major companies have controlled production since 1968 producing ilmenite as the major product, with substantial recovery of byproduct zircon. Estimated 1972 production of ilmenite in Australia was 781,324 short tons. However, recent developments in the Eneabba area of Western Australia could totally revolutionize productive capacity and, already, some sources believe the Eneabba deposits alone could eventually produce 150,000 tons a year of rutile and 450,000 tons a year of ilmenite. Four companies have substantial holdings in the Eneabba area, but the plans of Allied Eneabba Pty. Limited are the most advanced, with a pilot plant already operating at the rate of 7,000 tons a year rutile, 28,000 tons a year ilmenite and 15,000 tons a year zircon. Allied Eneabba intends to proceed with construction of a full-scale plant in 1974 capable of producing 75,000 tons a year rutile, 250,000 tons a year ilmenite and 125,000 tons a year zircon. Allied Eneabba is owned 75 per cent by Allied Minerals Limited and 25 per cent by E.I. du Pont de Nemours & Co. Inc., and it is especially of interest from the viewpoint of TiO_2 pigment manufacture that du Pont has already contracted to buy 200,000 tons a year of the ilmenite output.

Another company, A.V. Jennings Limited is also firmly committed to pilot-scale production in 1974 with an envisaged eventual production of 40,000 tons a year of rutile, 120,000 tons a year of ilmenite, 40,000 tons a year of zircon and 35,000 tons a year of altered ilmenite and leucoxene. Other companies with extensive holdings in the Eneabba area are Western Titanium N.L. and West Coast Rutile Pty. Limited, both of whom are currently conducting feasibility studies.

Sierra Leone. Large reserves of rutile estimated at 30-100 million tons exist in Sierra Leone, but formidable mining problems and high operating costs have

Table 4. Salient titanium statistics, United States, 1972-73

	Ilmenite		Rutile		Titanium[1]	
	1972	1973[e]	1972	1973[e]	1972	1973[e]
			(short tons)			
Production	740	839	–	–	. .	. .
Imports	317[2]	365[2]	204,000	212,000	4,078	6,700
Consumption	1,050[2]	1,150[2]	243,000	250,000	13,068	19,300
Price/pound	. .	. .	. .	. .	$1.32	$1.42
Price/ton	$23[3]	$26[3]	$175[4]	$180[4]	. .	. .

Source: U.S. Bureau of Mines, Commodity Data Summaries, January 1974.
[1]Short tons sponge metal. [2]Includes titania slag from Canada. [3]54 per cent TiO_2, fob Atlantic seaboard, long ton. [4]fob Atlantic and Great Lakes ports, short ton.
[e]Estimated; . . Not available or not applicable; – Nil.

Table 5. Consumption of titanium concentrates in United States, by products, 1972

	Ilmenite[1]		Titania Slag		Rutile	
Product	Gross Weight	Estimated TiO_2 Content	Gross Weight	Estimated TiO_2 Content	Gross Weight	Estimated TiO_2 Content
			(short tons)			
Pigments	775,618	453,248	264,095	187,608	208,704	199,894
Welding-rod coatings	(2)	(2)	(3)	(3)	11,022	10,392
Alloys and carbides	(2)	(2)	(3)	(3)	(2)	(2)
Miscellaneous[4]	10,766	8,174	–	–	23,032	21,945
Total	786,384	461,422	264,095	187,608	242,758	232,231

Source: U.S. Bureau of Mines, *Minerals Yearbook* Preprint 1972.
[1]Includes mixed product containing rutile, leucoxene and ilmenite.
[2]Included with miscellaneous to avoid disclosing confidential data.
[3]Included with pigments to avoid disclosure.
[4]Includes ceramics, glass fibers, and titanium metal.
– Nil.

resulted in protracted exploitation of these deposits. Recently a joint venture of Nord Resources Corporation and Bethlehem Steel Corporation announced the formation of a company, Sierra Rutile Limited, in conjunction with the Sierra Leone government to exploit the rutile deposits. It is anticipated a full-scale operation producing 20,000 tons a year will be completed by mid-1975. It also appears that a German company, Bayer-Preussag, also may be commencing pilot-scale production of rutile in 1974.

Sri Lanka. Ceylon Mineral Sands Corporation, a state-owned company, is currently expanding the production capacity of its heavy mineral recovery facilities at Pulmoddai on the northeast coast of Sri Lanka. The expansion, due to be completed in 1975, will increase production to 140,000 tons a year of ilmenite, 12,000 tons a year of rutile, 8,000 tons a year zircon and minor monazite. Feasibility studies involving smelting the ilmenite to produce titania slag and pig iron are currently in progress.

Brazil. In December 1973, Cia Vale do Rio Doce signed an agreement with Isihara Industry and C. Itoh Company of Japan to jointly develop a titanium deposit in Minas Gerais state. The deposit is unique in that the predominant titanium mineral is high-grade anatase, and reserves have been estimated at 1.6 billion tons grading 10 per cent TiO_2. The development contract will include construction of a TiO_2 pigment plant, with anticipated commencement of production scheduled for late 1976.

Table 6. Production of ilmenite concentrates by countries, 1971-73

	1971	1972	1973^e
	(thousands of short tons)		
Canada[1]	853	920	942
Australia	914	781	700
United States	683	682	839
Norway	707	671	700
Malaysia	172	168	}
Finland	154	150	}
Sri Lanka	102	102	}
India	73	76	} 550
Spain	26	25	}
Japan	9	6	}
Brazil	11	4	}
Portugal	1	1	}
Total	3,705	3,586	3,731

Source: U.S. Bureau of Mines, *Minerals Yearbook* Preprint 1972; Commodity Data Summaries, January 1974.
[1] Titania slag containing 72% TiO_2.
^{e}Estimated.

Table 7. Production of rutile concentrates by countries, 1971-73

	1971	1972	1973^e
	(short tons)		
Australia	404,233	349,899	357,000
Sierra Leone	13,153	–	. .
India	3,200	3,400	. .
Sri Lanka	3,100	3,100	. .
Brazil	129	454	. .
Other free world	–	–	8,000
Total	423,815	356,853	365,000

Source: U.S. Bureau of Mines, *Minerals Yearbook* Preprint, 1972 and Commodity Data Summaries, January 1974.
^{e}Estimated; – Nil; . . Not available.

Manufacturing of TiO_2 pigments

Traditionally, titanium dioxide pigments have been manufactured using either the sulphate process or the chloride process. Since 1960 no new sulphate plants have been constructed in the United States, mainly due to the environmental problems encountered in the disposal of sulphuric acid and byproduct ferrous sulphate (called "copperas"). Hence, the United States have constructed only chloride plants in recent years. Recently, chloride plants have also encountered problems, with escalating costs and greater difficulty in obtaining the rutile raw material. Australia is the world's largest rutile producer and also has the largest proven reserves, but these are deemed only sufficient to last until 1985. This has resulted in renewed interest in sulphate plants, with increased incentive towards solving the disposal problem. The other alternative is to continue to operate with the chloride process using upgraded ilmenite or artificial rutile. Many processes are presently available to upgrade ilmenite, but they fall into three major categories:

1. electric arc furnace smelting for the production of pig iron and a titanium dioxide rich slag;
2. acid leaching of ilmenites to remove iron oxides and other contaminants; and
3. reduction of the iron oxides contained in the ilmenite, to either ferrous oxide or metallic iron, followed by mechanical or chemical processing of the reduced ore.

In the United States, E.I. du Pont de Nemours & Co. Inc. recently announced the use of a large proportion of ilmenite in its feed material for the chloride process.

Until very recently the chloride process had traditionally used rutile as its raw material source and in the initial phase of the process rutile reacts with chlorine gas to give titanium tetrachloride ($TiCl_4$). The $TiCl_4$ is then oxidized at elevated temperatures, with air or oxygen, and the resultant TiO_2 is then calcined to remove any residual chlorine or hydrogen chloride. The process is especially attractive from the environmental standpoint, because the oxidation of $TiCl_4$ liberates chlorine, which is recycled for use in the chlorination of the rutile.

The sulphate process is more complex and produces large quantities of waste byproducts. The starting material is ilmenite, which is dried and ground to a fine grain size prior to dissolution in sulphuric acid at 106°C. The resultant sludge contains a mixture of titanium and iron (ferrous and ferric) sulphates which are dissolved in water in the presence of added scrap iron to keep all the iron in the ferrous state, then clarified to remove all the insoluble residues. By cooling the solution to 10°C most of the iron is precipitated as hydrated ferrous sulphate (copperas) which is later discarded as a waste byproduct. The titanyl sulphate solution is then boiled to precipitate TiO_2 in fine colloidal form. The precipitate is then filtered, washed and calcined at 900-1000°C in a rotary kiln to produce crystalline TiO_2. The TiO_2 is then dried, ground to pigment size and classified for shipment.

Table 8. Canada, consumption of titanium dioxide and titanium dioxide pigments

	1969	1970	1971
	(short tons)		
Refined titanium dioxide			
Paint and varnish	27,841	27,281	29,297
Paper	4,986	4,894	5,208
Linoleum	1,564	1,786	1,053
Rubber	2,123	1,910	1,879
Miscellaneous non-metallic products	866	739	999
Plastic and synthetic resins	226	498	498
Toilet preparations	44	37	34
Industrial chemicals	79	71	63
Other chemicals	877	538	462
Extended titanium dioxide pigments			
Paint and varnish	8,812	6,654	6,496

Source: Statistics Canada.

Current technology and uses

The single largest application of an expanding titanium industry is the manufacture of titanium dioxide pigments, which accounts for about 90 per cent of world titanium consumption. The outstanding characteristics of titanium dioxide as a white pigment are based on its high refractive index, lack of absorption of visible light and its crystalline properties imparting maximum opacity. Two main grades of TiO_2 pigments are marketed commercially – rutile and anatase. Both these grades have a purity of 95-99 per cent, but rutile has a somewhat superior hiding power and chalking qualities because of differences in crystal structure and refractive index. By reason of its favourable characteristics and also its great durability, over 50 per cent of TiO_2 pigments is used in paints, varnishes and lacquers. Other important applications are as a filler in high-grade paper, rubber, plastics, linoleum and coated fabrics.

Apart from pigment applications, TiO_2 is used in vitreous enamels applied to iron-base containers, due to improved acid resistance and high opacity. It is also used in high-dielectric ceramics for electrical condensers, in high-speed titanium and tungsten carbide cutting tool tips and in the coating of electric arc-welding electrodes.

Titanium metal is endowed with many favourable properties much sought after in today's aerospace and chemical process industries. These include its lightness, strength, fracture toughness, low thermal conductivity, corrosion resistance and fatigue resistance. Aerospace applications now account for 91 per cent of titanium consumed in the form of the metal in the United States, with about 54 per cent being consumed in jet engines, 34 per cent in airframes, and 3 per cent in space and missile crafts. Non aerospace applications account for the residual 9 per cent of current titanium metal consumption predominantly in the chemical process industry, where its high resistance to corrosion is an invaluable property. The metal exhibits long-term resistance to many of the extremely corrosive liquids such as powerful oxidants and strong acids; and is used extensively as a construction material in the manufacture of chlorine, calcium and sodium hypochlorite and organic acids, particularly in such components as tanks, centrifuges, agitators, pumps, piping and valves. Miscellaneous uses of titanium metal are ordnance applications such as helmets, armoured vests and vehicle armoured plate, and also marine applications such as desalination processing plants.

Future trends

The imminent rutile supply crisis continues to plague the titanium industry, despite some developments destined to alleviate the problem to some degree. The unveiling of large rutile deposits in Western Australia, the discovery of a large anatase deposit in Brazil and the initiation of development work in Sierra Leone has potentially at least, doubled world reserves of high-grade TiO_2. No supply problems are foreseen for ilmenite, as known deposits have immense potential, especially if one includes the extensive low-grade titaniferous magnetites of many Shield areas such as Canada, South Africa and Scandinavia.

The rutile supply situation will continue to exert pressure on technological development in the pigment manufacturing industry as debate continues regarding the relative merits of the chloride and sulphate processes. Essentially it is an argument of pollution costs versus raw material costs. Du Pont has already committed itself to the chloride process and is now using a low-grade feedstock of mixed ilmenite and rutile, as opposed to the conventional high-grade (95 per cent or greater) rutile feedstock. However, such a process also begins to run into an effluent problem with ferric chloride, as well as increased chlorine consumption costs. On the other hand, the sulphate process is coming under increased scrutiny from environmental protagonists who object to the disposal methods used for the effluent.

Increased construction of titanium oxide pigment plants should remain strong in the seventies, especially in North America, Europe, and certain Latin American countries such as Mexico, Argentina, and Brazil. However, economies of scale in production will dictate that future plants will probably operate with a minimum of 30,000-tons-a-year capacity, and closure or expansion of smaller plants is envisaged as operating costs escalate to untenable levels. In addition, monopolistic elements will increasingly dominate the industry as large multinational corporations alleviate titanium dioxide supply problems by gaining financial interests in strategic sources of raw materials to supply their pigment plants. Already the increased role of companies such as du Pont, Titanium Metals Corporation of America and Bayer A.G. in the development of raw material supplies can be seen and this will lead to increased barriers of entry into the TiO_2 pigment industry.

The demand for titanium metal will probably continue to grow by about 5 per cent in the long run, but inelastic demand caused by prime reliance on the aerospace industry will continue to impart severe short-run cyclical trends in titanium metal consumption.

An important new market for titanium metal in the long-run may be the marine environment, as man increasingly turns to abundant food and mineral resources offered by the oceans. Construction materials for deep-sea mining and oil drilling rigs on continental shelves may offer a potential use for titanium metal.

Prices

Prices in the United States published in Metals Week of December 28, 1973

	(U.S. $)
Titanium ore fob cars Atlantic ports, Great Lakes ports	
Rutile, 96% per short tons delivered within 12 months	310
Ilmenite, 54% per long ton, shiploads	38
Slag 70% per long ton, fob shipping point	60
Titanium metal, sponge, per lb fob mine or mill max. 115 Brinell, 99.3%, 500 lb	1.42-1.43
Mill products per lb delivered, 4,000-lb lots	
Billet, Ti-6AL-4V (8″ diam. random lengths)	3.19
Bar, Ti-6AL-4V (2″ diam.)	4.89

Table 9. United States, titanium metal data, 1968-72

	1968	1969	1970	1971	1972
			(short tons)		
Sponge metal					
Imports for consumption	3,349r	5,745r	5,931r	2,802r	4,078
Industry stocks	2,600	1,909	2,516	2,724	1,816
Government stocks (DPA inventories)	20,711	20,385	19,994	19,994	19,994
Consumption	14,237	20,124	16,414	12,145	13,068
Scrap metal consumption	4,701	7,566	7,242	6,149	7,802
Ingot[1]					
Production	19,234	28,490	24,331	18,387	20,267
Consumption	18,323	27,082	23,687	17,058	19,499
Net shipments of mill products[2]	11,900	15,940	14,480	11,241	12,627

Source: U.S. Bureau of Mines, *Minerals Yearbook* Preprint 1972.
[1]Includes alloy constituents. [2]Bureau of the Census and Business and Defence Services Administration, Current Industrial Reports Series BDCF-263.
rRevised.

Prices (concl'd)

Ferrotitanium, delivered	
Low carbon, per lb, Ti, 25-40% Ti	
Medium carbon, net ton, 17-21% Ti	1.35
High carbon, net ton, 15-19%	

Titanium dioxide, Canadian prices, quoted in *Canadian Chemical Processing*, of titanium pigments, effective December, 1973.

Anatase, dry milled, bags, car lots, delivered, East, per 100 pounds	25.50

Tariffs

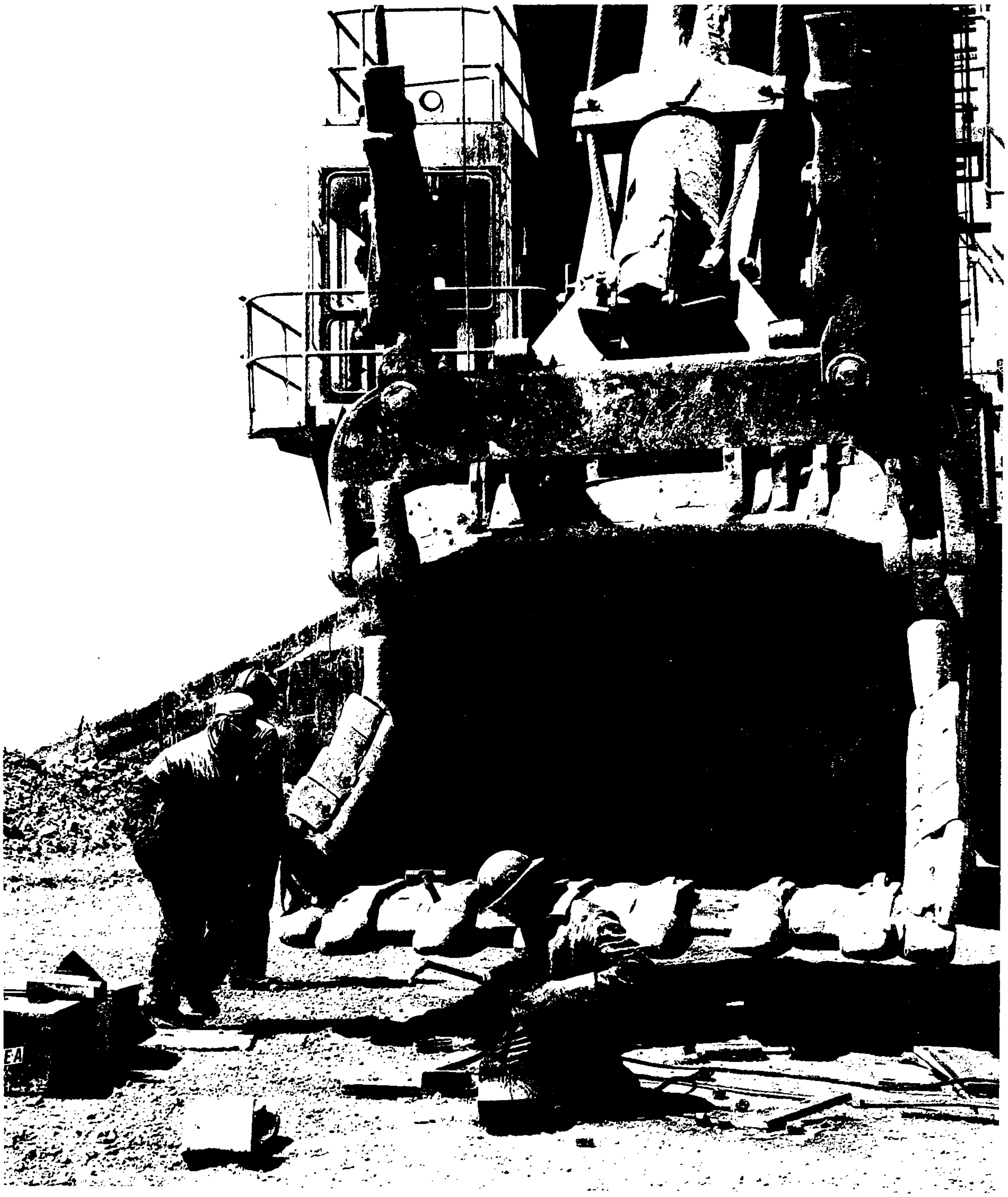
Canada

Item No.		British Preferential	Most Favoured Nation	General
			(%)	(%)
32900-1	Titanium ore	free	free	free
92825-1	Titanium oxides	free	12-1/2	25
34715-1	Sponge and sponge briquettes, ingots,blooms, slabs, billets and castings in the rough, of titanium alloys for use in Canadian manufacturers (expires 31 October 1974)	free	free	25
37506-1	Ferrotitanium	free	5	5
34735-1	Tubing of titanium or titanium alloys for use in Canadian manufactures (expires 28 February 1974)	free	free	25
93207-6	Titanium whites, not including pure titanium dioxide	free	12-1/2	25

United States

Item No.		On or After January 1 1971	1972
		(%)	(%)
601.51	Titanium ore, including ilmenite, ilmenite sand, rutile and rutile sand	free	free
629.15	Titanium metal, unwrought, waste and scrap (duty on waste and scrap suspended on or before June 30, 1973)	18	18
629.20	Titanium metals, wrought	18	18
607.60	Ferrotitanium and ferrosilicon titanium	6	5
473.70	Titanium dioxide	9	7.5
422.30	Titanium compounds	9	7.5

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States annotated (1972) TC Publication 452.



Welders installing new teeth on a 15 cu. yd. dipper on a P & H 2100 electric shovel. (George Hunter photo).

Tungsten

M.A. BOUCHER

Canada's shipments of tungsten as (WO_3) increased by 30 per cent in 1973 over the previous year. The major events that occurred in Canada during the year were the closure of Canex Placer Limited and the discovery of large tungsten reserves by both Canada Tungsten Mining Corporation Limited and Amax Exploration, Inc.

The tungsten industry in the rest of the world was marked by a decrease in the western world supplies and an increase in demand, better prices, and an announced sales plan by the General Services Administration (GSA) of the United States of 500,000 pounds of tungsten per month starting July 1, 1973.

Canada

Production. Canadian shipments in 1973 were 5,793,000 pounds of WO_3 in scheelite concentrates, compared with 4,447,316 pounds of WO_3 in 1972. Canada ranks among the top six leading producers in the noncommunist world.

Mine production comes from two producers – Canada Tungsten Mining Corporation Limited's mine, with a 600-ton-a-day mine, mill and concentrator at Tungsten in the Northwest Territories, near the Yukon border, about 135 miles north of Watson Lake, and Canex Placer Limited's mine, with a 500-ton-a-day mine, mill and concentrator near Salmo, east of Trail in southeastern British Columbia. Canada Tungsten Mining Corporation Limited is owned 42 per cent by American Metal Climax, Inc., and 17 per cent by Dome Mines Limited.

In 1973, Canada Tungsten produced 161,430 short-ton units* of WO_3 which is slightly more than the 1972 production. An overall recovery of 80.2 per cent was obtained during the year.

Trade. Canada Tungsten exports its entire output as concentrate mostly to customers in the United States, Japan and France. A large part of the domestic market is supplied by imports from sources and trading arrangements that were established before Canada Tungsten became a producer.

Consumption. With the exception of 1971, Canadian consumption during each of the last five years has been around 1,000,000 pounds W. About 40 per cent of this is used as tungsten metal and metal powder, with less than 5 per cent consumed as tungsten wire.

Developments. A major new discovery was made during the year by Canada Tungsten near its open-pit mine site in the Flat River area of the Mackenzie District, near Tungsten, Northwest Territories. The deposit consists of a relatively flat-lying scheelite-bearing zone that extends over a length of 1,700 feet and a width of 500 feet or more. Underground drilling by the end of the year indicated 4,242,000 tons averaging 1.68 per cent WO_3 and 0.22 per cent Cu, before dilution. These reserves will provide enough ore to keep the operation active for another 20 years at its current rate of operation of 500 to 600 tons a day.

In August 1973, Canex Placer Limited ceased operations at its mill and concentrator, near Salmo, British Columbia. It had been in operation since The Second World War and produced lead-zinc and tungsten intermittently. The company's reserves of scheelite were depleted and, with the reserves of lead and zinc, the mine and mill equipment, along with the townsite, were disposed of by the end of September.

Amax Exploration, Inc., a wholly-owned subsidiary of American Metal Climax, Inc., has identified a scheelite ($CaWO_4$) deposit in the Yukon-Northwest Territories boundary, some 240 miles northeast of Whitehorse, Yukon and about five miles from the Caron Road. Over 30 million tons, with an average grade of 0.9 per cent tungsten oxide (WO_3), have been indicated. Additional drilling and bulk sampling is necessary before the deposit is fully outlined and more accurate tonnage and grade estimate can be determined.

Foreign developments

The People's Republic of China was represented for the first time at the United Nations Conference on Trade and Development (UNCTAD) Tungsten Committee meeting in Geneva in November 1973. During the year the General Services Administration of the United States (GSA) announced a plan for the sale of 6 million pounds of stockpile tungsten at the rate of 500,000 pounds per month. Due to low prices, the Storeys Creek Mine of Aberfoyle Ltd., Australia was shut down in late summer.

World production

Mine production is almost divided equally between communist countries (China, U.S.S.R., North Korea)

Table 1. Canada, tungsten production, imports and consumption, 1972-73

	1972		1973^p	
	(pounds)	($)	(pounds)	($)
Production[1] (WO_3)	4,447,316	. .	5,793,000	. .
Imports				
Tungsten in ores and concentrates				
United States	–	–	–	–
Australia	221,500	440,000	–	–
People's Republic of China	18,400	38,000	–	–
Total	239,900	478,000	–	–
Ferrotungsten[2]				
United Kingdom	244,000	370,000	172,000	404,000
United States	8,000	15,000	. . .	2,000
West Germany	2,000	7,000	–	–
Total	254,000	392,000	172,000	406,000
Metallic carbide tips or blanks				
United States		159,000		158,000
Sweden		40,000		50,000
Others		14,000		72,000
Metallic carbide inserts				
United States		371,000		566,000
Sweden		169,000		290,000
Others		326,000		428,000
Metallic carbides nonagglomerated				
United States	1,032,700	2,901,000	6,079,100	4,219,000
Sweden	63,500	332,000	89,100	591,000
Others	46,100	99,000	12,700	69,000
Consumption by type (W content)				
Tungsten metal and metal powder	354,796^r	. .	486,245	. .
Tungsten wire	29,229	. .	27,932	. .
Others[3]	792,539^r	. .	505,529	. .
Total	1,176,564^r	. .	1,019,706	. .

Source: Statistics Canada.
[1] Producers shipments. [2] Gross weight. [3] Includes tungsten ore, tungsten carbide.
^{p}Preliminary; ^{r}Revised; . . Not available; – Nil; . . . Less than one pound.

and noncommunist countries. Approximately 75 per cent of reserves are reported to be in the communist countries.

Japan and the United States are the only countries in the noncommunist world that are both major consumers and producers. Other producer nations consume only small amounts and export practically all of their total production. Little information is available regarding production, reserves and trade of any of the countries whose economy has been centrally planned.

Generally, the period from 1966 to 1973 was characterized by supplies, excluding releases from General Services Administration (GSA), being less than consumption. However, shortfalls were made up by sales from the GSA. No large sales from the GSA were made until 1969. However, a sudden release of 38.3 million pounds of tungsten in 1969 created a world oversupply of nearly 25 million pounds, leaving approximately 18 million pounds overhanging the market.

Due to high consumption in 1970, the world cumulative net balance was reduced to about 7 million pounds but a low demand in the recession year of

Table 2. Canada, tungsten production, trade and consumption, 1964-73

	Production[1] WO$_3$ Content	Imports Tungsten Ore[2]	Imports Ferro-tungsten[3]	Consumption W Content
	(pounds)			
1964	1,068,420	389,800	172,000	740,410
1965	3,824,660	357,400	354,000	877,614
1966	4,263,927	523,600	192,000	941,207
1967	267,600	233,600	192,000	891,411
1968	3,584,920	131,700	118,000	1,181,541
1969	4,063,488	426,500	210,000	1,050,824
1970	3,726,800	182,200	200,000	984,777
1971	4,624,208	153,300	222,000	639,765
1972	4,447,316	239,900	254,000	1,176,564^r
1973^p	5,793,000	–	–	1,019,706

Source: Statistics Canada.
[1] Producers' shipments of scheelite (WO$_3$ content). [2] W content. [3] Gross weight.
^{p}Preliminary; ^{r}Revised; . . Not available.

1971 caused the cumulative balance to again increase to approximately 12 million pounds by the end of the year. In 1972, a near balance between supply and consumption prevented any major change. During 1973, due to the cumulative effect of lower supplies and a greater consumption of tungsten in Western Europe, the United States and particularly Japan, the quantities of tungsten overhanging the market were almost reduced to zero. Prices for tungsten started to go up in 1964 following a low in 1963. Increased consumption during 1969 and 1970 combined with speculation pushed prices to a peak of about $80 a short-ton unit in early 1970. This prompted GSA to release large quantities of tungsten and from that time through November 1972 prices fell steadily to $30 a short-ton unit. This downward price trend was finally reversed in late 1972 in response to a clear indication of an increasing rate of consumption.

During 1973, GSA announced a plan for selling 6 million pounds of stockpile tungsten at the rate of 500,000 pounds a month. It became evident that these sales could be absorbed easily in a high-demand world market. Prices continued to rise and, at the end of 1973, tungsten was selling at $47 a short-ton unit.

Table 3. Western world consumption of tungsten ore and concentrate[1], 1966-73

	1966	1967	1968	1969	1970	1971	1972	1973^e
	(millions of pounds of W)							
United States	18.1	13.9	11.0	13.1	16.7	11.6	14.1	16.4
Japan	4.0	5.7	5.0	7.3	9.0	4.6	5.1	8.2
Western Europe	22.6	17.2	19.2	27.7	28.2	20.8	24.2	29.0
Eastern Europe	0.6	4.6	7.3	5.0	12.6	3.3	2.8	3.0
Other	0.9	0.9	0.8	1.8	2.1	2.0	2.0	2.0
Total consumption	46.1	42.2	43.2	54.7	68.6	42.3	48.2	58.5
World supply (ex GSA)[2]	36.8	33.9	36.3	40.9	42.7	45.6	49.4	44.6
Over (under) supply	(9.3)	(8.3)	(6.9)	(13.8)	(25.9)	3.3	1.2	(14.0)
GSA releases	8.1	6.4	3.2	38.3	15.1	1.4	0	1.5
Net world balance	(1.2)	(1.9)	(3.7)	24.5	(10.8)	4.7	1.2	(12.5)
World cumulative net balance	(1.2)	(3.1)	(6.8)	17.7	6.9	11.6	12.8	0.3

Source: Union Carbide Corporation.
[1] Based primarily on USBM and UNCTAD published data. [2] Includes Western World mine production plus imports of Chinese concentrates by Western countries. Russian and Eastern European production is not included because Eastern Europe is a net importer of tungsten.
^{e}Estimated.

Table 4. Principal tungsten mines of the non-communist world

Mine/Company	Country	Mineral
Union Carbide (Bishop California)	United States	S
Korea Tungsten Mining Co. (Sangdong)	South Korea	S
Canada Tungsten Mining Co.	Canada	S
Amax-Climax Colorado	United States	W
King Island	Australia	S
Panasqueira	Portugal	W
Grace-International	Bolivia	W
Barra Verde	Brazil	S
San Cristobal	Peru	W
Aberfoyle	Australia	W
Brejui	Brazil	S

S=Scheelite; W=Wolframite

Table 5. Tungsten production in ores and concentrates, by countries, 1971-73

	1971	1972	1973^e
	(thousands of pounds of contained tungsten)		
U.S.S.R.	15,400	15,900	. .
People's Republic of China	15,400	15,400	. .
United States	6,900	8,150	7,000
Thailand	5,527	7,370	. .
North Korea	4,740	4,740	5,600
Republic of Korea	4,539	4,478	4,480
Bolivia	4,608	4,923	5,000
Canada	4,624	4,447	5,793
Australia	3,411	3,371	3,200
Brazil	3,082	2,750^e	. .
Portugal	2,176	3,049	3,000
Peru	1,698	1,888	. .
Japan	2,332	2,493	. .
Spain	897	648	. .
Other countries	10,034	9,633	56,870
Total	80,744	85,309^e	90,943

Sources: U.S. Bureau of Mines *Minerals Yearbook*, Preprint 1972; Commodity Data Summaries, January 1974. Producers' shipments.
^{e}Estimated.

Factors contributing to instability in the tungsten market

The number of uses for tungsten is restricted mainly to cutting tools and mining equipment. Other applications such as lamp filaments and electrical contacts account only for small quantities. However, even wide price changes do not generally affect demand in any significant amount; year-to-year changes in the use of tungsten concentrates are only a reflection of the highly fluctuating nature of demand for the principal products, i.e., cutting tools and mining equipment such as grader blades teeth for excavator buckets and rock crusher jaws.

Total demand for tungsten concentrates is also affected by commercial and governmental stock-building programs. Information regarding commercial stocks is limited and no clear-cut conclusions regarding their effects on the market can be given. Stocks in the hands of intermediaries are not well known either, but past experience has shown that their effects on the market may be quite important. Government stockpiling was important only in the 1950's and its effect on demand is now relatively small.

The nature of tungsten mining is such that a smooth and rapid adjustment of output to short-term changes in the level of demand is not generally to be expected. Output can rarely be increased rapidly beyond the planned rate, while a significant reduction of output normally involves appreciably higher unit costs. Also, in the case of tungsten the inflexibility of response is influenced by the fact that some mining operations also involve the production of other metals such as tin. Export figures from China to market economy countries can only be roughly estimated.

There are no statistics to show what proportion of trade in tungsten is carried out by merchants; however, there is no doubt that their role in the market is important because vertical integration of tungsten mining and the fabrication of products is nonexistent. Speculative transactions by merchants; i.e., selling short when prices are expected to fall and buying long when prices are expected to rise, are in themselves a factor tending to accentuate price fluctuations. Also, it has been reported that merchants can influence price quotations in which ever direction is favourable to them in respect of larger transactions in which they may have an interest, by carrying out and reporting relatively small transactions.

In order to alleviate price fluctuations three measures have been proposed by the Committee on Tungsten: export controls, buffer stock and price control. Other ways and types of arrangements are also under study.

Consumption forecast

A forecast of tungsten consumption prepared for the Natural Resources Division of the Economic and Social Affairs Department of the United Nations indicated that, by 1980, 75 million pounds of contained tungsten (W) should be consumed, excluding the centrally planned economies. This compares with 48 million pounds in 1972. For the United States, the corresponding forecast for 1980 is 25.0 million pounds compared with 14 million in 1972. The forecast is a composite of three projections: a simple extrapolation of a consumption-time series of the market-economy countries from 1950 to 1969; a modified multiple correlation between tungsten consumption and capital goods production; an end-use evaluation based on the judgments of a group of ferrous and nonferrous metal and ore consumer and producer representatives.

Prices

An almost universal economic downturn is predicted for late 1974; therefore, it is probable that consumption of tungsten will be lower in 1974. If GSA fails to make a corresponding reduction in its sales the world prices will fall again, and mines that have not recovered from the adverse economic effects of 1971 and 1972 will close. At the end of 1973, the U.S. stockpile contained 126.7 million pounds of tungsten, of which only 4.2 million pounds are required for stockpile objective. So, the high degree of responsibility of the GSA policy makers for the health of the tungsten mining industry is evident.

Tungsten prices according to Metals Week for December 1973

	1973 (U.S. $)
GSA Domestic	46.928
GSA Export	47.270
LMB ore	44.065–44.590
Ferrotungsten, per pound W, fob shipping point	
Low-molybdenum	4.60
High-molybdenum	. .
"UCAR" high-purity	. .
Dealer (export)	4.50
Tungsten metal, per pound, cif U.S. ports	
Carbon red, 98.8%, 1,000-pound lots	4.50
Hydrogen red, depending on Fisher No. range	4.97–6.74
Typical Fisher No. 400	. .

. . Not available.

Table 6. Consumption of tungsten by end use in the United States, 1972

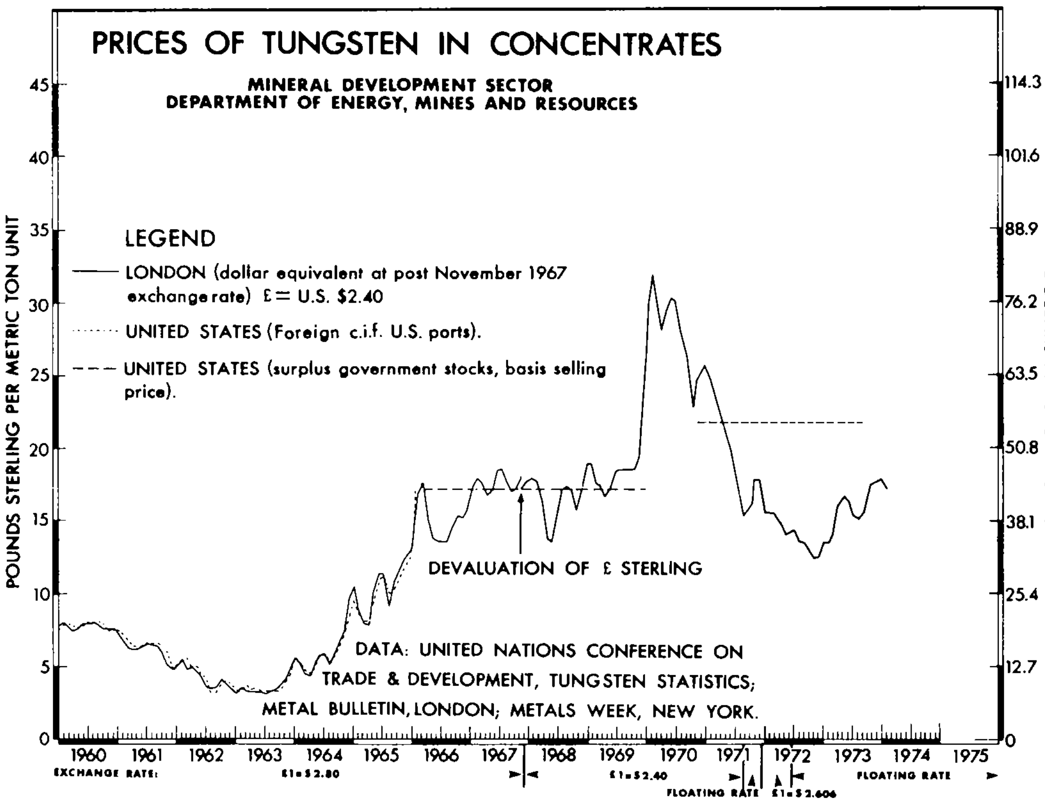
	(thousands of pounds of contained tungsten)	%
Steel		
Stainless and heat resisting	173	1.3
Alloy	157	1.2
Tool	1,451	10.9
Superalloys	429	3.2
Alloys (excluding alloy steel and superalloy)		
Cutting and wear-resistant material	6,657	50.1
Other alloys	1,217	9.1
Mill products made from metal powder	2,525	19.0
Chemical and ceramic uses	179	1.4
Miscellaneous and unspecified	508	3.8
Total	13,296	100.0

Source: U.S. Bureau of Mines *Minerals Yearbook* Preprint 1972.

Table 7. Consumption of tungsten in Canada by use, 1972-73

	1972	1973[p]
	pounds contained tungsten	
Carbides	463,221[r]	594,138
Alloy steels	–	–
Electrical and electronic	29,229	27,932
Other[1]	684,114[r]	397,636
Total	1,176,564[r]	1,019,706

Source: Compiled by Mineral Development Sector from data supplied by Statistics Canada.
[1] Includes nonferrous alloys, chemicals and pigments.
[r] Revised; [p] Preliminary.



Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(%)	(%)
32900-1	Tungsten ores and concentrates	free	free	free
34700-1	Tungsten metal in lumps, powder, ingots, blocks or bars and scrap of tungsten alloy metal	free	free	free
34710-1	Tungsten rod and tungsten wire	free	free	25
35120-1	Tungsten alloys in powder, pellets, scrap, ingots, sheets, strip plates, bars, rods, tubing, wire (expires October 31, 1974)	free	free	25
37506-1	Ferrotungsten	free	5	5
37520-1	Tungsten oxide in powder, lumps, briquettes	free	free	5
82900-1	Tungsten carbide in metal tubes	free	free	free

United States

Item No.		On and After Jan. 1, 1971	On and After Jan. 1, 1972
601.54	Tungsten ore, on pounds W content	30¢	25¢
	Tungsten metal, unwrought other than alloys		
629.28	Lumps, grains, powders on pounds of W content	25¢ + 15% ad val	21¢ + 12.5% ad val
		%	%
629.29	Ingots and shot	12.5	10.5
629.30	Other tungsten unwrought metal	15	12.5
	Tungsten metal waste and scrap		
629.25	Not over 50% tungsten on pounds of W content	25¢ + 7.5%	21¢ + 6%
		%	%
629.26	Over 50% tungsten	12.5	10.5
629.35	Tungsten metal wrought	15	12.5
	Tungsten unwrought alloys		
629.32	Not over 50% tungsten on pounds of W content	25¢ + 7.5%	21¢ + 6%
629.33	Over 50% tungsten	15%	12.5%
		(¢) (%)	(¢) (%)
422.40	Tungsten carbide on pounds of W content	25 + 15	21 + 12.5
422.42	Other tungsten compounds on pounds of W content	25 + 12	21 + 10
607.65	Ferrotungsten on pounds of W content	25 + 7.5	21 + 6

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1972) TC Publication 452.

Uranium

R.M. WILLIAMS

As 1973 drew to a close, there were signs of revival in the uranium industry. The world uranium market grew more active with several contracts being announced, and consumers appeared to be taking more interest in where their next pound of uranium was coming from. Production expansion plans were announced in several countries and there were indications that 1974 might mark the commencement of the much-needed increase in uranium exploration activity on a world-wide basis.

In Canada, while exploration activity remained at a low level, programs were under way to increase production capacity by 1975. Some success was achieved by Canadian producers as a result of their sales efforts, particularly by Denison Mines Limited which announced, late in 1973, that it had reached agreement in principle with a Japanese utility for a large long-term contract beginning in the mid-1980's. Canada's nuclear program took a giant step forward with the announcement in June, by the Ontario government, of plans to install some 8,000 MWe (electrical megawatts) of nuclear power capacity to meet the province's needs to the mid-1980's.

The rate of increase in world demand for uranium in the late 1970's and early 1980's is expected to be some 20 per cent a year, an unprecedented growth rate for any commodity. The challenges which this kind of growth presents are immense and were highlighted in a report published late in 1973 by the Organization for Economic Co-operation and Development (OECD) on world uranium availability and demand. The report concluded that by the end of this decade there could be a deficiency not only in uranium production capacity, but also in the appropriate reserve base required to sustain the production capacity installed at that time.

Production

Uranium production in Canada declined slightly in 1973. Three operations were still producing, two at Elliot Lake, Ontario and one near Uranium City, Saskatchewan. Total production amounted to 4,823 tons of uranium oxide (U_3O_8)* of which 4,664 tons were shipped, about 85 per cent from Elliot Lake.

*Short tons used throughout; 1 short ton U_3O_8 = 769.3 kgms uranium metal.

Table 1. Uranium production in Canada, by province, 1972-1973

	1972		1973^p	
	(pounds)	($)	(pounds)	($)
Production				
(U_3O_8 shipments)				
Ontario	8,428,053	..	7,915,000	..
Saskatchewan	1,334,647	..	1,413,000	..
Total	9,762,700	..	9,328,000	..

Source: Statistics Canada.
^{p}Preliminary; .. Not available for publication.

Denison Mines Limited continued to operate its Elliot Lake mill at about 4,400 tons of ore a day, limited by its present in-service leaching capacity. A total of 1,432,000 tons of ore was treated with an average grade of 2.57 pounds of U_3O_8 a ton to produce 3,424,234 pounds of U_3O_8. Engineering design work for the company's mill expansion was completed and preliminary foundation work had commenced at year-end. The main part of the expansion will consist of the addition of 10 new pachuca tanks to the leaching circuit, although certain modifications to the crushing plant, the steam plant and the power plant will also be required. Actual construction on the $3.7 million project will begin early in 1974 for completion by the end of December 1974; new design capacity will be 7,100 tons of ore a day.

Long-range underground development at Denison also proceeded in 1973; one of the principal projects being the 25-foot diameter, 1,750-foot ventilation air intake being raised to Roman Island in Quirke Lake. During the year, a 3,700-foot extension of the main conveyorway system was completed to serve as a transportation artery for the eastern section of the mine. Significant to the flexibility of Denison's operation in the longer-term was the acquisition, in February 1973, through amalgamation, of the Stanrock property which adjoins Denison's to the southeast. An exploration drive was begun in 1973 which will link the two properties and provide an additional airway to the surface.

Table 2. Uranium production by major producing countries, 1963-73

	Canada	United States	South Africa	Other[1]	Australia	France[2]	Total[3]
				(short tons U_3O_8)			
1963	8,352	14,218	4,532	86[4]	1,200	2,692	31,080
	$136,909,119						
1964	7,285	11,847	4,445	144	370	2,113	27,204
	$ 83,509,429						
1965	4,443	10,442	2,942	179	370	2,210	20,586
	$ 62,361,377						
1966	3,932	9,587	3,286	162	330	2,223	19,520
	$ 54,334,787						
1967	3,738	9,125	3,214	273	330	2,272	18,952
	$ 53,021,936						
1968	3,701	12,570	3,883	289	330	2,234	23,007
	$ 52,284,580						
1969	3,854	12,281	3,979	332	330	2,306	23,082
	$ 53,150,657						
1970	4,104	12,905[r]	4,119	301[r]	330	2,402[r]	24,161[r]
	..						
1971	4,107	12,273[r]	4,189	342[r]	115[5]	3,010[r]	24,036[r]
	..						
1972	4,881	13,667	4,001	436	–	3,454	26,439
	..						
1973[p]	4,664	14,000	3,500[e]	400[e]	–	3,450[e]	26,014
	..						

Sources: Statistics Canada; U.S. Bureau of Mines *Minerals Yearbooks;* U.S. Commodity Data Summaries, January 1974; and South African Chamber of Mines.
[1] Includes Argentina, Portugal, Spain and Sweden; [2] Includes Gabon, Malagasy Republic (until 1967) and Niger (from 1970); [3] Totals are of listed figures only. Other countries are known to have produced small quantities of uranium and estimates have been included in totals for year 1964 and earlier, in tables of this series in previous reviews; [4] Estimate for Spain; [5] Estimate, production ceased April 1971.
[p] Preliminary; [r] Revised; . . Not available for publication; [e] Estimate.

Rio Algom Mines Limited, also in the Elliot Lake area, operated its Quirke mill at an average of 4,260 tons of ore a day, slightly less than its full 4,500 ton-a-day capacity. A total of 1,419,000 tons of ore was treated with an average recovered grade of 3.4 pounds U_3O_8 to produce 4,818,000 pounds of U_3O_8; average mill recovery was 95.5 per cent. Despite the slightly higher grades in 1973, production was less due mainly to a slow-down in underground ore production and the consequent shut-down of the mill for a week in April during labour negotiations. At the company's New Quirke mine, which presently supplies the entire Quirke mill feed, a major $2.5 million project was completed to enlarge the mine ventilation system. The company also began to drive a decline, in which a conveyor haulage system is to be installed, to develop and mine the orebody below the eighth level, which is serviced by the existing shaft. Planning also continued on the feasibility of several expansion options related to the company's inactive properties in the Elliot Lake area.

Near Uranium City, Saskatchewan, the Crown company, Eldorado Nuclear Limited, continued to operate its mill at about 50 per cent of its 1,800-ton-a-day capacity. A total of 204,305 tons of ore was treated to produce 1,402,567 pounds of U_3O_8; the average recovered grade was 6.87 pounds of U_3O_8 a ton. While the major portion of the mill feed came from the Fay mine, significant tonnages continued to come from the Hab mine, located some 7 miles north-east of the main Fay complex; the Hab is expected to be mined out by the fall of 1974. The company's principal project toward the longer-term development of its Uranium City operations was the internal Fay shaft, which bottomed in April, at a depth of 5,500 feet below surface. Most of the equipment was installed and development work commenced on three levels. Raising of a 14-foot diameter, ventilation intake was also completed thereby permitting a complete changeover to a new ventilation system, with a consequent increase in air volumes.

In the Wollaston Lake area of northern Saskatchewan, Gulf Minerals Canada Limited continued on schedule with the $50 million development of its Rabbit Lake deposit in partnership with Uranerz Canada Limited. By year-end, the mill was completely enclosed and installation of equipment had begun. Construction of the 2,000 ton-a-day, acid-leach solvent-extraction mill is expected to be completed by the end of December 1974. Sulphuric acid for the mill will be supplied by an on-site 150 ton-a-day acid plant which will use elemental sulphur as feed stock. Development of the orebody will begin in the fall of 1974, and the ore will be stockpiled pending completion of the mill. The 150-mile highway being built by the Saskatchewan government from Reindeer Lake to Rabbit Lake was in use at year-end; it was to be closed, however, from April to August 1974, for the final upgrading to all-weather standards. Production at Rabbit Lake, at a rate of 4.5 million pounds U_3O_8 a year, is scheduled to begin in April 1975.

With the increase in uranium prices at the end of 1973, re-examination of the viability of other prospective producing properties was also underway. Preston Mines Limited began a reassessment of the economics of its Stanleigh property at Elliot Lake, and Agnew Lake Mines Limited initiated similar studies of its property, located 40 miles east of Elliot Lake. At year-end Federal Resources Corp. had negotiated a sales contract which, subject to approval by the federal government, would enable operations to resume at its Faraday property, near Bancroft, Ontario.

Exploration

Exploration for uranium in Canada continued at a low level in 1973. Although the Atomic Energy Control Board (AECB) issued only six new exploration permits in 1973, there were several revocations, leaving only about 30 per cent of the over 200 permits issued since 1966 still in force. Of these, less than half are still active.

Release of the results of a joint federal-provincial airborne radiometric survey in Quebec's Mont Laurier area, 75 miles northeast of Ottawa, sparked a small staking rush in January 1973; an estimated 15 companies were involved. Although there has been considerable activity in the area, particularly in 1968 and 1969, little of economic significance has yet been found. One of the more successful programs has been carried out by Mont-Laurier Uranium Mines Inc., which has been active in the area since 1971, and has identified several prospects.

Although there were scattered reports of minor uranium exploration in a number of areas of Canada, the most active programs were underway in northern Saskatchewan. Gulf Minerals continued its program of exploration in the area surrounding Rabbit Lake with promising results. The program will be accelerated in 1974, primarily to drill several prospects that have been identified within a few-mile radius of the Rabbit Lake mill; the company plans to spend up to $10 million on this exploration over the next three years.

Amok Ltée* also continued its program at Cluff Lake in the Carswell dome area of Saskatchewan, 90 miles southwest of Uranium City. In addition to the small high-grade orebody announced in 1972, the company has identified two other deposits of more conventional grade in the same area. All are of the pitchblende replacement type, although with complex mineralogy. They are all amenable to open-pit extraction and, if reserves continue to be developed as expected, the deposits could be in production before the end of the decade. Although most of the work in 1973 was associated with evaluating these three deposits, considerable effort was also spent examining other promising targets on the company's holdings in the Carswell area. The company plans to accelerate its total program significantly in 1974. Numac Oil & Gas Ltd. was also active in the southwest area of the Carswell structure near Amok, and reported that several promising showings had been identified.

Numac and Mokta (Canada) Ltée have also been participating with Vestor Explorations Ltd. in the latter's Simpson Islands project in the east arm of Great Slave Lake, Northwest Territories. This uranium prospect occurs in the lower part of the Sosan Group of quartzites and conglomerates and was the object of extensive investigation in 1970 and 1971.

As 1973 drew to a close, it became more and more apparent that the industry must expand its efforts in the search for additional resources of uranium and, subsequently, the federal government made known** its intention to assist and encourage the industry toward this end. As a direct action in this regard, it was announced that the government would provide Eldorado Nuclear Limited with funds to carry out a program of off-property exploration. In addition, and to assist industry generally, the government made known its intention to expand the various technically oriented uranium programs carried out within the Department of Energy, Mines and Resources.

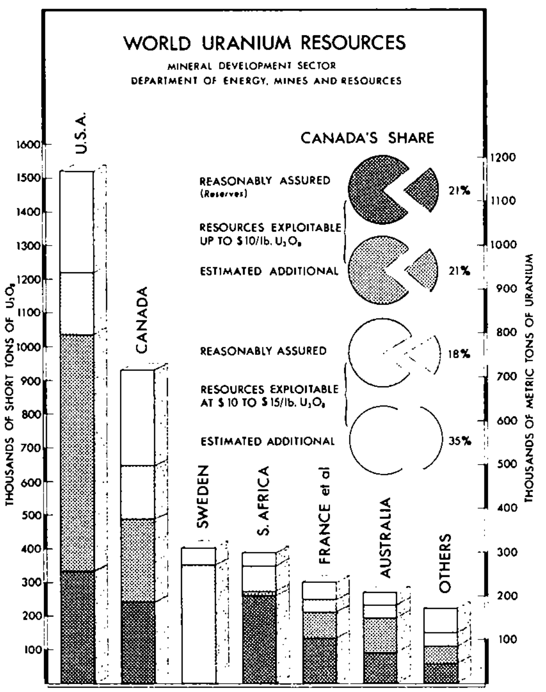
---

*An affiliate of Mokta (Canada) Ltée; Amok is owned by Compagnie de Mokta, Compagnie Français de Minerais d'Uranium, Pechiney Ugine Kuhlmann Development, Inc. and the Commissariat à l'Energie Atomique which is a French state corporation.

**Announced at First Ministers' Conference on Energy, January 1974.

International developments

In October 1973, the OECD released its latest world assessment of uranium supply and demand prepared jointly by the OECD's Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA). The study reported an estimated world total of 1,128,000 tons of U_3O_8 in the category of "reasonably assured resources exploitable at up to $10 a pound U_3O_8" (defined as *reserves*). This is an increase of some 80 per cent over the estimate first published by the OECD in 1965, and represents an average gross annual additional to *reserves* of 85,000 tons U_3O_8 a year. Much of the increase is due to discoveries in Australia, Africa, United States and to a lesser degree in Canada.



Data from NEA/IAEA August 1973

World attention was again focussed on Australia in 1973 where a marked decline in the pace of exploration and development activity was evident, due largely to the announced policies of Australia's new Labour government which took office late in 1972. The government's actions included a freeze on the renewal and granting of exploration and mining leases in Aboriginal reserves in the Northern Territory pending a judicial inquiry into Aboriginal land rights; a similar freeze on leases in an area of the Northern Territory to be designated a National Park; the withdrawal of certain tax exemptions and profit allowance accruing from the mining of several minerals including uranium; steps to stem the inflow of foreign equity capital and to control foreign loans related to the development of energy minerals as well as to control such developments; and a ban on new export contracts for uranium pending formulation of a new energy policy. Finally, at year-end, it was reported that the Australian government was considering a plan to supply all export contracts, which had been approved before it took office, from Mary Kathleen Uranium Limited's deposit and to reserve the newly discovered deposits in the Northern Territory until prices improve in the early 1980's.

Late in 1973 Queensland Mines Limited was preparing to suspend development operations at its Nabarlek deposit, located in an Aboriginal reserve in the Northern Territory, pending a government decision to renew its mining leases which were due to expire at the end of the year. Earlier, the company had announced plans to start production in 1975 at about 1,000 tons of U_3O_8 a year; reserves were reported by the company to be 10,500 tons U_3O_8 at an average grade of 2.35 per cent U_3O_8. Similarly, Western Mining Corporation Limited placed its Yeelirrie deposit, located 280 miles north of Kalgoorlie, Western Australia, on a care and maintenance basis pending clarification of the government's intentions relative to uranium export policy. The company had intended to proceed to production, beginning in 1977, at a rate of 2,000 tons U_3O_8 a year based on its deposit reported to contain 50,700 tons of U_3O_8.

The future of Ranger Uranium Mines Pty. Ltd., a third new Australian prospective producer, was also in doubt at year-end. The Ranger deposits, located in the Northern Territory 140 miles east of Darwin, are being developed jointly by Peko Mines N.L. and Electrolytic Zinc Company of Australia Ltd. Reserves have been reported at 90,900 tons U_3O_8, and production was planned for 1976 at a rate of 3,300 tons of U_3O_8 a year. Although the project was not affected by either the Aboriginal rights or the National Park issue, the government had not approved all of the company's export contracts upon which the production plans were based. (See Markets.)

The two companies directly affected by the National Parks issue were Pancontinental Mining Ltd. and Noranda Australia Ltd. Pancontinental, exploring in partnership with Getty Oil Company, announced the discovery of the Jabiluka deposit in early 1973 in the East Alligator River area; reserves were reported at 3,850 tons U_3O_8. Later in the year, a second discovery was announced just east of Jabiluka, with estimated reserves of 21,600 tons U_3O_8. Noranda continued its program of evaluating its Koongarra deposit, located 12 miles southwest of Ranger, but no reserves or production plans had been announced. Exploration rights for both Pancontinental and Noranda were extended late in 1973, for a further year, while studies on the proposed National Park continue.

As a result of the continued work in the Northern

Territory and of Western Mining's Yeelirrie deposit in particular, the Australian Atomic Energy Commission indicated late in 1973 that Australia's reasonably assured resources, exploitable at up to $10 (US) a pound U_3O_8, had increased from 92,000 to 140,000 tons U_3O_8.

As a measure of exploration activity in the United States, the United States Atomic Energy Commission (USAEC) reported that companies completed 17 million feet of exploration and development drilling in 1973, some 2 million more than in 1972. This was slightly short of that predicted due to poor spring weather conditions in the western United States and to a heavy demand for drill rigs and logging equipment for coal and seismic exploration. An increase in activity is predicted for 1974, when levels are expected to approach those of the peak year 1969. United States uranium *reserves,* available at a maximum *forward cost** of $10 a pound U_3O_8, increased only marginally in 1973, from 337,000 to 340,000 tons U_3O_8. Uranium *potential** in the same *cost* category remained unchanged at 700,000 tons U_3O_8.

Several announcements were made in 1973 of participation by US electric utilities in uranium exploration projects. The Tennessee Valley Authority (TVA) signed two new agreements (bringing its total to three) for exploration and development of uranium properties. The first, with Federal-American Partners, involves uranium rights to 2,500 acres in Wyoming as well as the right to first call on production to 1990 from Federal's existing mill in the Gas Hills area of Wyoming, after Federal's existing commitments are met. The second, with United Nuclear Corp., involves options on 50,000 acres in Wyoming and 80,000 acres in New Mexico, whereby TVA can gain 50 per cent interests by April 1977 and will jointly develop any discoveries. Southern California Edison Company extended for eight years an exploration agreement it held with Union Pacific Mining Corp. in a very promising area of the Powder River Basin of Wyoming.

Sohio Petroleum Company and Reserve Oil and Minerals Corp. announced in mid-1973 their intention of building a $25 million 1,000 ton-a-day uranium mining and milling complex on their deposit 50 miles west of Albuquerque, New Mexico. Sohio expects to begin production in 1976 to supply a 5.75 million-pound-U_3O_8 contract with Gulf Energy and Environmental Systems Company. This was balanced by an announcement, late in the year, that Susquehanna-Western Inc. intended to phase out its two Texas uranium mills (1,000 tons of ore a day each) and withdraw from the uranium business. Finally, of considerable significance to the uranium industry in the Uravan area of Colorado and the neighbouring area of Utah and New Mexico, the United States Atomic Energy Commission (USAEC) announced that it would release uranium rights covering about 25,000 acres of land, much of which had been withheld since the Second World War. The land, estimated to contain some $45 to $50 million of uranium reserves, will be subsequently leased through public bids and will do much to extend the life of producers in the area.

* United States Atomic Energy Commission definitions.

There were two major developments in Niger in 1973. First, the Société des Mines de l'Air (SOMAIR), in which the French Commissariat à l'Energie Atomique (CEA) has a controlling 33.5 per cent interest, began work in July on the planned expansion of its Arlit mill. The capacity of the plant, which began operation in 1971, will be raised from 975 tons to 1,950 tons U_3O_8 a year by 1975. Second, the CEA, the Government of Niger, and Japan's Overseas Uranium Resources Development Company announced, in late 1973, that they would jointly (44, 31 and 25 per cent respectively) develop the Akouta deposit, located about six miles south of Arlit. The CEA will eventually transfer shares equivalent to 10 per cent of the new company, to be named Cie. Minière d'Akouta (COMINAK), to Spain at a later date. Production from the $70 million project is scheduled to begin in 1979, at a rate of 2,600 tons U_3O_8 a year. The uranium will be enriched in France by EURODIF (see Enrichment), and some 43.3 per cent of the enriched product will be acquired by Japan. COMINAK is the first positive result of Japan's intensive efforts to develop uranium production abroad through exploration in various countries.

In South West Africa, Rossing Uranium Limited began construction of basic facilities, including construction camps, offices, temporary power and water systems and road and rail spurs, preliminary to the development of its uranium deposit near Swakopmund. Preproduction work in the open-pit mine will commence late in 1974, and the mill is scheduled to be commissioned late in 1976. The deposit is very large and low grade, reportedly about 0.04 per cent U_3O_8, and initial mining of ore and waste will be at the rate of about 66,000 tons a day. Rio Tinto Zinc Corporation Limited (RTZ), which holds a 60 per cent beneficial interest in Rossing*, reports that financing and sales contracts have been arranged.

Considerable exploration activity was reported in South Africa, in an area from 250 to 275 miles northeast of Cape Town, where a number of companies were prospecting for sandstone-type uranium deposits in the lower part of the Beaufort Group of sediments. The initial discovery of uranium in the sediments was made by a South African affiliate of Union Carbide Corporation during a drilling program in 1972. The sediments in question are widespread, covering some 43 per cent of South Africa and extend from Angola on the west, to Swaziland on the east and to Malawi on the north.

*Canada's Rio Algom Mines Limited acquired a 10 per cent equity position in Rossing in 1973.

Table 3. Uranium hexafluoride capability of world uranium refiners, 1973

Company	Location	Present Capacity	Expansion Planned or Underway
		(short tons U per year)	
Allied Chemical Corporation	Metropolis, Illinois, U.S.A.	14,000	nil
British Nuclear Fuels Limited	Springfields, Lancashire, England	3,300	8,800
Comurhex Company	Malvesi and Pierrelatte, France	3,900	6,600
Eldorado Nuclear Limited	Port Hope, Ontario, Canada	3,200	5,000
Kerr-McGee Corporation	Sequoyah, Oklahoma, U.S.A.	5,000	10,000

Source: Various company brochures and USAEC and OECD publications.

Refining

Activity at Eldorado's uranium refinery at Port Hope, Ontario, continued at a high level. The solvent extraction circuit, which converts mine concentrates to nuclear pure uranium trioxide (UO_3), was started up in 1973 following a four-year-shutdown period.* The production of *natural* ceramic uranium dioxide (UO_2) reached a record level, most of the increase resulting from additional requirements of Ontario Hydro; UO_2 is used for the fabrication of fuel for CANDU reactors. Additional UO_2 capacity was installed late in the year.

Production of uranium hexafluoride (UF_6) continued at a relatively low level due to slippage in customer's nuclear reactor programs. Despite lower volumes than anticipated, the company increased the capacity of its UF_6 plant from a nominal 2,750 to 3,200 tons of uranium a year. Further expansion to 5,000 tons of uranium a year is planned, as soon as markets permit. It is significant to note that Eldorado is, at present, one of only five uranium refiners in the world with the capability of converting uranium concentrates to UF_6, the feedstock for uranium enrichment plants.

The company reactivated and upgraded its metal production facility in 1973 to produce depleted** uranium metal from uranium tetrafluoride (UF_4) of United States origin. Depleted uranium metal castings were made for two very large, spent nuclear-fuel shipping-casks, as well as for a smaller, spent fuel removal-flask, radiographic cameras, components for radioactive isotope equipment, and bits and pieces for shielding applications. Design work proceeded on the Eldorado spent fuel transport-flask, and a licence is expected for the flask from the Atomic Energy Control Board (AECB) early in 1974.

Small volumes of *enriched* UO_2 were produced on a custom basis from enriched uranium of foreign origin, primarily for Canadian research and development purposes. In addition, various high-density uranium compounds were produced in connection with Atomic Energy of Canada Limited's development program for the design and production of more efficient nuclear fuel elements for CANDU reactors. It is pertinent to note that the Port Hope facility completed its first year under the International Atomic Energy Agency Safeguards inspection system, as required in connection with Canada's obligations under the Non-Proliferation Treaty.

Markets

Canadian efforts in the world uranium market met with some success in 1973. Early in the year, Gulf Minerals announced that it had engaged the Japanese trading company, Toyo Menka Kaisha Ltd. (Tomen), as its exclusive agent in Japan. The company also reported that it was nearing the final stages of completing a contract covering a Japanese utility's requirements in the period 1978 to 1980. In August 1973, Uranium Canada, Limited (UCAN) and Denison, announced that 1,000 tons of U_3O_8 would be delivered to Tohoku Electric Power Company Inc. from the Denison-UCAN joint venture stockpile and from the general government stockpile over the period 1977 to 1981. Late in the year Denison announced that agreement had been reached in principle with Tokyo Electric Power Co. Inc. (TEPCO) for the supply of 40 million pounds of U_3O_8 over the period 1984 to 1993. The contract would provide for an advance payment of $10 million and would have a total value of some $800 million. At year-end, the sale

*At Eldorado's refinery, this is the first step in the refining sequence for the conversion of uranium concentrates to all refined products, including UO_2, UF_4, UF_6 and uranium metal.

**Depleted uranium is that having less than the natural (0.7%) content of the easily fissionable isotope U^{235}; e.g., the residue from a uranium enrichment plant or from a nuclear reactor.

was still subject to approval by the boards of both companies as well as by both the Japanese and Canadian governments.

Canadian uranium commitments, made since 1966, to both domestic and export markets totalled over 78,000 tons U_3O_8 by the end of 1973; of this total, some 13,000 tons had been delivered leaving a forward commitment of over 65,000 tons U_3O_8*, about 90 per cent of which is destined for export, primarily to western Europe and Japan. By year-end, Canadian producers were reporting a dramatic increase in numbers of inquiries from potential customers and indications were that negotiations were underway with utilities in a number of countries.

Market activity in the United States seemed particularly brisk during 1973, where it was reported that more than a dozen utilities invited bids totalling as much as 150,000 tons of U_3O_8. The USAEC reported commitments made during the year of 52,000 tons U_3O_8. This was three times that contracted during 1972, making it the largest commercial purchasing activity for a single year. Moreover, utilities reported outstanding bid invitations for 40,400 tons of U_3O_8 at year-end. Nuclear fuel buying in the United States continues to be of a comparatively short-term nature however, illustrated by the fact that fuel arrangements had been made for first cores for only 68 per cent of 171,500 MWe of nuclear power capacity scheduled to come into operation after January 1,1974.

*Not including the Tepco-Denison Agreement, announced in December.

There were positive indications by year-end of rising prices for uranium and an imminent change from a buyer's to a seller's market. Central Area Power Coordination Group (Capco), a group of five north-central United States utilities, for example, invited bids for several million pounds of U_3O_8 for the 1980's from 36 producers and received only five replies. Perhaps the most significant bid invitation was that of TVA which, in October, invited bids from 53 domestic and foreign (including Canadian) uranium producers for some 86 million pounds of U_3O_8 over the period 1979 to 1990. Only three bids were received. Western Nuclear Inc. offered 12 million pounds U_3O_8 in equal amounts over the 12 year period at base prices ranging from $12 per pound in 1979 to $16 per pound in 1990, plus escalation; the company also requested $3 million down payment at the time of contract signing. Kerr-McGee Corporation offered only a little more than 3 million pounds U_3O_8, in the form of uranium hexafluoride (UF_6), over the period 1977 to 1982 at prices ranging from $12.10 per pound U_3O_8 to $15.50 per pound U_3O_8, also with escalation. Urangesellschaft MBH & KG Co. offered 18.2 million pounds over the period 1979 to 1990, but declined to quote prices.

Another example of price trends was embodied in TVA's exploration agreement, with Federal-American mentioned earlier, which requires TVA to pay for all exploration and to reimburse Federal-American for all costs plus a royalty on future production equal to 50 per cent of the difference between costs and the market price for uranium at the time. It will be

Table 4. Exports of uranium concentrates from Canada, 1963-73

	United States[1]	Britain	West Germany	Japan	Others	Total
			(thousands of dollars)			
1963	96,879	40,509	–	130	13[2]	137,531
1964	34,863	39,627	159	4	–	74,653
1965	14,749	38,948	–	–	–	53,697
1966	13,761	22,605	–	–	–	36,366
1967	1,047	22,772	–	55	–	23,874
1968	3	26,064	–	–	–	26,067
1969	477	14,997	5,469	3,564	–	24,507
1970	17,031	8,990	–	–	–	26,021
1971	6,213	11,473	–	1	–	17,687
1972	23,040	16,456	–	–	–	39,496
1973p	46,794	17,356	–	–	–	64,150

Source: Statistics Canada, exports of radioactive ores and concentrates that cleared customs.
[1]For years 1970 to 1973, almost entirely destined for a third country, following enrichment, primarily West Germany and Japan; [2]Brazil.
pPreliminary; – Nil.

recalled that, in 1972, a similar cost-plus arrangement had been discussed between Carolina Power and Light Co. and Federal-American. A Canadian example, of course, was the Tepco-Denison agreement involving a $10 million down payment.

There were various reasons why so few bids were received by TVA including a reluctance of producers to bid where prices were made public, a reluctance of producers to bid due to uncertainty of expected price levels in the 1980's, the inability of some US producers to bid due to full commitments and the refusal of most foreign producers to bid because of the restrictions on the importation of foreign uranium for United States use.

With respect to these restrictions, in November, the USAEC made public its proposal for the gradual removal of its restriction on the enrichment of foreign uranium for domestic use. If adopted, USAEC enrichment customers will be allowed to furnish up to 10 per cent of their uranium feed from foreign sources beginning in 1977; the allowable limit will be raised to 15 per cent in 1978, 20 per cent in 1979, 30 per cent in 1980, 40 per cent in 1981, 60 per cent in 1982, 80 per cent in 1983 and 100 per cent beginning in 1984. Comments on the proposal were to be received by the USAEC until February 24, 1974.

While there was considerable activity elsewhere in the uranium market-place there were few public details. Nuclear Fuels Corporation of South Africa (Pty) Ltd. (NUFCOR) was reported to have sold 20 million pounds of U_3O_8 to EXXON Nuclear Company of the United States for delivery between 1976 and 1984. A second NUFCOR sale of 22 million pounds of U_3O_8 to Westinghouse Electric Corporation for delivery between 1976 and 1985 was also reported. EXXON is in the fuel fabrication business, while Westinghouse normally supplies initial fuel cores and limited fuel reloads with its reactor sales. Australia's Peko Mines announced early in the year an agreement with Italy's AGIP Nucleare (a subsidiary of Italy's State petroleum company) whereby AGIP would acquire a 10 per cent interest in Peko's Ranger deposit and thus be assured of some 10,000 tons of U_3O_8 between 1981 to 1990. The Australian government later voiced exception to the agreement and at year-end it had not been approved. The new Australian labour government announced that it would not approve any new contracts until it formulated a new energy policy.

The industry practice of negotiating uranium contracts in terms of United States dollars presented some unexpected problems to uranium producers in 1973. With the recent parity changes in the US dollar, non-North American producers found their income expectations eroding by as much as 17 per cent. Particularly hard hit were the prospective Australian producers which had negotiated contracts in 1971 and 1972. Mary Kathleen Uranium Limited which had planned to reopen its mine in 1974, made alternate arrangements to meet its contracts in 1975 and was considering approaching its customers for a revision of prices for later years; without such revisions the company indicated that its operation would be marginal.

Nuclear power developments

Nuclear power plant commitments reached new peaks in 1973. In the United States new orders totalled some 43,000 MWe, exceeding the previous peak year by some 5,000 MWe. In the rest of the world the number of reactors committed in 1973 was almost twice that of 1972. Moreover, at year-end, as a result of actions by the OPEC* nations relating to the supply and price of oil, many countries were drawing up plans to accelerate their nuclear programs. As of December 31, 1973, some 42,600 MWe of nuclear capacity was operating in the world, with an additional 300,000 MWe expected to be in operation by the end of 1981. Canada ranked second in the world in terms of nuclear energy output per capita exceeded only by Switzerland.

Canada's nuclear power programs, based on the CANDU-PHW** reactor, set several significant records in 1973. The fourth 508 MWe unit of The Hydro-Electric Power Commission of Ontario's (Ontario Hydro) Pickering Nuclear Generating Station went critical on May 16, 1973 and reached full power an unprecendented twelve days later. With a total capacity of 2,034 MWe, the four-unit station was the largest nuclear power station operating in the world in 1973, producing some 14,279,000 MWh of electrical energy; the average net capacity factor for the four units was 83.4 per cent of the year and 95 per cent for the peak winter season of 1973-74. Nuclear generated electricity in Ontario accounted for 18 per cent of province's total in 1973.

Ontario Hydro's 208 MWe Douglas Point Generating Station, at Kincardine, Ontario, operated in its dual capacity, as a supplier of electricity to the Ontario Hydro grid and as a source of steam to the Bruce heavy water production plant; about 60 per cent of the Douglas Point output is used for the latter purpose. Construction at the four-unit 3,000 MWe Bruce Generating Station, also near Kincardine, continued on schedule. The first unit is expected to produce first electricity in September 1975 with the other units following at yearly intervals. The Nuclear Power Demonstration station (22 MWe), near Rolphton was shut-down for a period while its heavy water inventory was on loan.

In June 1973, the Ontario government announced approval of a nuclear expansion program for Ontario Hydro totalling 8,000 MWe by 1984. The program will consist of a doubling of the Pickering Generating Station, a doubling of the Bruce Generating Station

*Organization of Petroleum Exporting Countries.

**Canadian Deuterium Uranium – Pressurized Heavy Water.

Table 5. Nuclear power reactors in the world as of December 31, 1973

	Operating	Ordered	Planned	Total
		(net electrical megawatts)		
Argentina	319	600	1,200	2,119
Australia	–	–	500	500
Austria	–	692	1,200	1,892
Bangladesh	–	–	200	200
Belgium	10	1,650	–	1,660
Brazil	–	600		600
Bulgaria	–	1,620	–	1,620
Canada	2,528	11,544	1,200	15,272
Czechoslovakia	112	1,520	–	1,632
Denmark	–	–	900	900
Finland	–	1,480	–	1,480
France	2,879	16,048	21,900	40,827
West Germany	2,215	16,011	17,073	35,299
East Germany	70	1,460	–	1,530
Hungary	–	880	–	880
India	582	1,006	–	1,588
Iran	–	–	5,000	5,000
Ireland	–	–	600	600
Israel	–	–	900	900
Italy	547	2,749	1,000	4,296
Japan	2,520	16,191	19,196	37,907
Korea	–	1,164	1,164	2,328
Mexico	–	1,308	–	1,308
Netherlands	52	450	–	502
Norway	25	–	600	625
Pakistan	125	–	–	125
South Africa	–	–	900	900
Spain	1,091	16,041	8,000	25,132
Sweden	450	6,899	7,300	14,649
Switzerland	1,015	4,312	800	6 127
Taiwan	–	3,109	–	3,109
Thailand	–	–	600	600
United Kingdom	5,432	6,439	1,400	13,271
United States	19,745	183,879	16,600	220,224
U.S.S.R.	2,902	5,870	4,811	13,583
Yugoslavia	–	615	800	1,415
Total	42,619	304,137	113,844	460,600

Sources: Nuclear Engineering International April 1974; International Atomic Energy Agency, Power and Research Reactors in Member States September 1973.
– Nil.

and the construction of a new four-unit 3,000 MWe plant near Bowmanville, Ontario, to be designated the Darlington Generating Station. Completion of this program will bring nuclear capacity in Ontario to some 13,000 MWe which will account for about 41 per cent of Ontario's total generating capacity at that time. By 1990, some 65 to 70 per cent of Ontario's electrical energy will be nuclear.

The Quebec Hydro-Electric Commission (Hydro-Quebec) began site preparation late in 1973 for the construction of its 600 MWe Gentilly-2 Generating Station, near Trois Rivières. By the end of the year some 35 per cent of the nuclear equipment had been ordered. Meanwhile, Gentilly-1 was shut down for the

Table 6. Nuclear energy output per capita – 1973

Country	MWh Gross	Population* (million)	KWh/person
Switzerland	6,192,350	6.4	968
Canada	15,343,427	21.7	707
United Kingdom	28,095,581	55.3	508
United States	86,674,526	208.5	415
Sweden	2,110,987	8.1	261
France	11,217,347	51.7	216
Spain	6,545,058	34.4	190
West Germany	11,706,752	61.8	189
Japan	9,438,545	107.5	88
Italy	3,141,991	54.5	58
Netherlands	480,920	13.3	36
Pakistan	458,121	64.9	7
India	1,927,033	571.0	3

Sources: *Nucleonics Week,* McGraw-Hill, New York, *Background Notes,* Department of State, Washington, D.C. *U.S. Statistical Yearbook,* Washington, D.C.

* Population figures are 1972 where available.

whole year due to the loan of its heavy water inventory to Douglas Point under Atomic Energy of Canada Limited's (AECL) "pooling" arrangement. The shutdown period was used to carry out an extensive program of changes and modifications to the 250 MWe prototype CANDU-BLW* reactor.

The New Brunswick Electric Power Commission (NBEPC) continued its studies throughout the year aimed at ordering a nuclear power station for operation in its province by the early 1980's. In December, the Minister of Energy, Mines and Resources announced that the federal government was prepared to provide financing for 50 per cent of the cost of constructing the first nuclear power station in any province. Additional financing would be made available for a second plant if its output is to serve the needs of more than one province; NBEPC was considering taking advantage of this possibility.

Production of heavy water (D_2O) from AECL's heavy water production plant at the Bruce nuclear complex began in April 1973. The 800 ton-a-year, two-unit plant was subsequently purchased by Ontario Hydro in June. Although some difficulty was experienced initially in putting design volumes of gas and liquid through the first stage towers, these problems were largely solved by year-end and the plant proceeded to near full capacity. Canadian General Electric Company Limited's (CGE) 400 ton-a-year plant at Point Tupper, Nova Scotia, also operated at below capacity until about mid-year, after which output increased rapidly. Elimination of the problems at both plants was at the expense of only a small reduction in extraction efficiency. Rehabilitation of the 400 ton-a-year Glace Bay, Nova Scotia, plant by AECL, proceeded on schedule and first production is expected in early 1975.

In 1973 Ontario Hydro decided to double the size of the Bruce heavy water plant. This was followed by a decision in January 1974 to quadruple the size of the existing plant to give a total output at Bruce of 3,200 tons of D_2O a year by mid-1979. In December 1973, the federal government announced that it would finance the construction of a new 800 ton-a-year, $250 million, heavy water plant near the Gentilly nuclear power station in Quebec, for production beginning in 1978. At the same time it was indicated that the next federally-financed heavy water plant would be in Manitoba or Saskatchewan. These plans will satisfy domestic and export requirements until the end of this decade.

Reactors of CANDU design operating in other countries progressed well in 1973. Pakistan's 125 MWe Karachi Nuclear Power Plant, (KANUPP), built by CGE, reached commercial operation in late 1972, and by the end of 1973 most of the initial operating difficulties had been overcome.

Commissioning of India's first 203 MWe unit of the Rajasthan Atomic Power Project (RAPP) continued throughout 1973 and the plant was declared commercial by the end of December. All Canadian personnel

* Canadian Deuterium Uranium-Boiling Light Water.

have now left India, and the remainder of the RAPP II project has been turned over to the Indian Department of Atomic Energy. India will continue its nuclear power development program based on CANDU technology.

The unparalleled success of the Pickering Generating Station gave impetus to AECL's marketing activities abroad. In March 1973, Argentina's Comision Nacional de Energia Atomica (CNEA) accepted the joint proposal of AECL and Italimpianti, an Italian engineering firm, to build a 600 MWe CANDU reactor at Rio Tercero, Cordoba; negotiations were entered into and a contract was signed on December 20. Also, in December, it was announced that the Korea Electric Company (KECO) had submitted a letter of intent to AECL for the purchase of a 600 MWe CANDU and had expressed interest in an option for a second plant. Earlier in the year, AECL and Italimpianti bid unsuccessfully on a 975 MWe plant for Italy's Ente Nazionale per l'Energia Elettrica (ENEL).

At year-end, there appeared to be a growing interest in CANDU reactors in a number of countries. Britain was again considering its Steam-Generating Heavy Water Reactor (SGHWR), a concept similar to CANDU, for its next period of nuclear expansion and the possibility for a renewed technological exchange between Canada and Britain was discussed late in the year.

Uranium enrichment

The world uranium enrichment situation seemed to moderate slightly during 1973, due primarily to a slippage in nuclear plant construction programs and to the 1972 decision of the USAEC to build up its preproduction of enriched uranium by operating its enrichment plants at a tails assay higher than that stipulated in contracts with its customers. In addition, some modifying effect was achieved by the decision of several countries to seek enriching services from the USSR. The result of these factors was to move the date when new enrichment capacity is required from about 1980 to mid-1983. A failure of United States nuclear plants to institute the recycling of plutonium in the late 1970's as scheduled, however, could erode much of this saving.

As of the end of 1973 there were some 18 million

Table 7. Forecast[1] of world nuclear capacity

Country	1975	1980	1985	1990
	(installed nuclear capacity at year-end in net electrical megawatts x 1,000)			
France	3.8	13.4	32.5	67.0
West Germany	4.9	19.0	38.0	75.0
Italy	1.5	6.0	18.0	44.0
Spain	1.1	8.0	12.0	24.0
Sweden	3.2	8.3	16.0	24.0
United Kingdom	8.8	13.8	35.0	75.0
Other Europe	3.2	12.8	32.8	64.0
Total OECD Europe	26.5	81.3	184.0	873.0
Canada	2.5	6.5	15.0	31.0
United States	54.2	132.0	280.0	508.0
Japan	8.6	32.0	60.0	100.0
Others	2.0	12.0	28.0	56.0
Total World				
Mean Power Growth	94.0	264.0	567.0	1,068.0
Low Power Growth	92.0	243.0	487.0	806.0
High Power Growth	97.0	284.0	644.0	1,290.0

[1]Assumes continuation until 1990 of the present heavy reliance on light water reactors (LWR) for installed nuclear capacity.
Source: NEA/IAEA; Uranium Resources Production and Demand, August 1973.

separative work units (SWU)* of annual enrichment capacity in the world, of which some 95 per cent (17.2 million SWU's) was in the United States, operated by the USAEC. The USAEC capacity consists of three plants, which use the gaseous diffusion method of isotope separation and which are operated as an integrated operation. Production is presently below capacity, but is gradually being increased in order that its full 17.2 million SWU capacity (which requires 6,060 MW of electric power) will be operational by 1978. Presently underway are two programs which, together, will upgrade the capacity of these existing plants to 27.7 million SWU a year at a cost of $907 million; at full capacity the expanded complex will require 7,380 MW of electric power.

Significant to the uranium mining industry, is the fact that the USAEC plants are presently being operated with a tails assay** of 0.3 per cent U^{235} while customers are being charged for their separative work on the basis of a tails assay of 0.2 per cent U^{235}; this has been called the "split-tails" concept. Operating at the higher tails assay increases the amount of enriched uranium product that can be produced with a given amount of separative work, thus enabling the USAEC to build up its enriched uranium inventory. The higher operating tails assay also requires the provision of more uranium feed which is being provided by the USAEC from its surplus uranium stockpile, thus removing the stockpile from the open market.

In line with the United States goal of having private industry build its next enrichment plants, a policy which was reaffirmed in the President's Energy Message in April 1973, two programs are underway to provide classified enrichment technology to domestic industry. The first program was designed to permit selected companies to conduct research and development on uranium enrichment processes. Of the seven companies which submitted proposals to the USAEC late in 1972, only six are continuing with the program; significantly, all are interested only in the gaseous centrifugation method of isotope separation. Two of the companies, General Electric Company and Exxon Nuclear Company, joined forces later in 1973 to carry out a three-phase study aimed at constructing a joint enrichment plant for completion in 1981 or 1982.

The second program of access, designed to permit qualified companies to undertake a commercial enrichment venture, was announced in late 1972. At the end of 1973, only one company, Uranium Enrichment Associates (UEA), owned jointly by Bechtel Corporation, Union Carbide Corporation and Westinghouse Electric Corporation, had been granted the appropriate access permits, and was proceeding with an 18-month, $6 million feasibility study of both the gaseous diffusion and centrifugation methods of enrichment. Interestingly, the Japanese Enrichment Study Committee had negotiated a study agreement with UEA.

In February 1973 the USAEC announced an increase in its charges for enrichment services from $32 a SWU to $38.50 a SWU, effective August 14, 1973. At the same time, the USAEC indicated its intention to set a reduced charge of $36 a SWU under its new long-term fixed commitment-type contracts which had been proposed late in 1972. The new charges would be increased by one per cent at six-month intervals, beginning January 1, 1974. The USAEC began contracting under its new-type contracts in September 1973, following a nine-month period when contracting was suspended pending review of its contracting procedures.

Several major steps were taken in Europe toward the establishment of European-based enrichment plants. The Uranium Enrichment Company Ltd. (URENCO), the operating company formed under the 1970 British-Dutch-West German Tripartite Agreement, ordered its first 400,000 SWU a year of commercial centrifuge capacity in August and first construction contracts were issued by year-end. Half of the capacity will be installed at Capenhurst, England and half at Almelo, Holland; completion is scheduled for 1976 or 1977. URENCO plans to have 2 million SWU a year capacity installed by 1980 and as much as 10 million SWU a year by 1985. By year-end the company had received letters of intent from British and West German utilities for some 40 per cent of its planned 1980 capacity and negotiations were underway which, if consummated, would satisfy the remainder. Terms of the URENCO contracts are less stringent than those of the USAEC, particularly in that they require orders only four years in advance of deliveries (versus the USAEC's eight years) and provide for some flexibility in deliveries and product assays up until 180 days before delivery. URENCO's base charge will be 120 Deutchmarks per SWU, plus escalation for labour, material and electricity.

Europe's other major enrichment project, EURODIF, based on French gaseous diffusion technology, took several steps forward in 1973. France has a 47.5 per cent interest in the project, Italy 22.5 per cent and Spain, Belgium and Sweden 10 per cent each. A plant with an ultimate annual capacity of 9.3 million SWU is planned for first production about 1979 at partial capacity. The date of expected full

---

*A measure of effort expended to separate a quantity of uranium of a given assay into two components, one having a higher percentage of uranium 235 and one having a lower percentage. Separative work is generally expressed in kilogram units to give it the same dimensions as material quantities, i.e., kilograms or metric tons of uranium. It is common practice to refer to a kilogram separative work unit simply as a separative work unit or as SWU.

**The assay of the residue from the enrichment process.

capacity wavered from 1981 to 1983 and possibly 1985 as EURODIF and URENCO manoeuvred to attract available customers. Both EURODIF and URENCO made representations to the Commission of the European Communities (EEC), but Commission efforts to seek a unified European strategy made little headway. At the same time, some European utilities grouped to form the Organization des Producteurs Electricité Nucléaire (OPEN) in an effort to coordinate their enrichment needs. OPEN made representations to the USAEC in late 1973 in an attempt to keep this supply option open until the availability of European enrichment services was clarified. Moreover, several European utilities negotiated small contracts for enrichment services with the USSR as a protective measure. In November, the government of France announced that it intended to proceed with the construction of the EURODIF plant, regardless of the final decisions of its partners.

In Canada, Brinco Limited continued to study the possibility of establishing a multinational group to build a uranium enrichment plant, probably based on US gaseous diffusion technology. In August, the federal government outlined its attitude towards the establishment of such a plant in Canada. Basically, such a project is not viewed as essential to the national nuclear power program and therefore cannot depend on government financial sponsorship. It would be, in essence, a secondary industry "whose value would be measured by the extent of Canadian participation through the machinery and equipment industry, the involvement and development of engineering and technology, the employment of Canadians in both the construction and operating process, the possible advantage to Canada's uranium industry, the taxation revenues to the country and the overall benefit." The government indicated further that, should a proposal be considered to be in the national interest (specific factors that the government would consider were also announced), it would be prepared to negotiate with the appropriate foreign governments for access to the required technology.

Australia continued its studies aimed at establishing an enrichment capability in its country based on its newly discovered uranium reserves. Japan was actively pursuing its own development programs as well as studies in partnership with other interests. Finally, a South African pilot plant was nearing completion which will demonstrate the feasibility of a new undisclosed process of isotope separation, speculated to be similar to the jet nozzle technology developed by Steinkohlenelektrizitat AG (STEAG) of West Germany.

Table 8. Annual world requirements for uranium and for uranium enrichment services

A. Uranium Requirements (10^3 short tons U_3O_8 a year)

	Lower Limit	Medium Range		Higher Limit
1975	29.9	32.5	32.5	33.8
1980	66.3	78.0	79.3	85.8
1985	102.7	133.9	140.4	165.1
1990	130.0	202.8	224.9	291.2

B. Uranium Enrichment Services (10^6 SWU a year)

	Lower Limit	Medium Range		Higher Limit
1975	13	14	14	14
1980	26	30	31	33
1985	45	57	58	68
1990	61	91	97	124

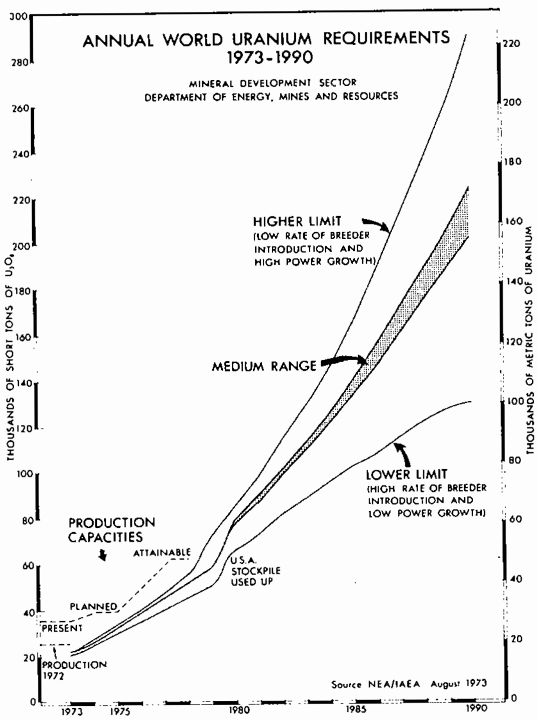
Source: NEA/IAEA; Uranium Resources, Production and Demand, August 1973.

Notes: 1. Assumes plutonium recycling beginning 1978.
2. Split-tails operation in USAEC enrichment plants until 1980, and tails assay of 0.275% U^{235} thereafter.
3. Lower limit assumes rapid introduction of breeders and low nuclear power growth.
4. Higher limit assumes slow introduction of breeders with light water reactors dominant and high nuclear power growth.
5. Medium range assumes reactor strategies as in lower and higher limits, except with medium nuclear power growth.

Outlook

The August 1973 NEA/IAEA report on uranium resources, production and demand predicted that annual world uranium requirements will grow from about 26,000 tons U_3O_8 in 1974 to between 134,000 and 140,000 tons in 1985 and between 203,000 and 225,000 tons in 1990, assuming a moderate rate of power growth. The study examined a number of different cases of world reactor strategies but determined that uranium demand variations due to power growth uncertainties far exceeded those due to different reactor strategy uncertainties. The effects of other variables such as uranium enrichment tails assays and rates of plutonium recycling were also examined and the most likely cases chosen for illustration. The USAEC world forecasts published earlier in 1973 (WASH – 1139/72) were comparable to the NAE/IAEA forecasts.

These forecasts are not significantly different than those that have been published for the last few years. Many of the problems contributing to construction and licensing delays that have beset the nuclear power industry in recent years are gradually being solved and, with the added incentive recently provided by the



world energy crisis, there is every reason to expect that these forecasts will be met; indeed, the forecasts may be exceeded. The rate of growth in demand over the next decade is expected to be about 20 per cent a year, an unprecedented growth rate for any commodity. Translated into demands on the uranium industry it means that, on a world basis, annual additions to reserves must increase from the recent level of about 85,000 tons U_3O_8 a year to some 140,000 tons a year in 1980, 210,000 tons in 1985 and 250,000 tons U_3O_8 in 1990.* In addition to these requirements for exploration, there will be the requirement for the establishment of production capacities which will ultimately match the annual uranium demand figures.

In terms of financial outlays, these requirements are staggering. Unless there are some extraordinary changes from past experiences, some $6,000 million will be required for uranium exploration on a world basis to 1990, plus an additional capital expenditure for new production plants conservatively estimated at anywhere from $4,500 million to $5,500 million, all in terms of 1973 conditions. To meet these challenges many new forms of producer-consumer relationships will likely evolve. Joint-venture exploration agreements of the kind arranged by TVA (see International developments) will become more common, whereby consumers will participate in the financing of exploration programs in return for shares in production; the classic equity type of joint venture may become less common, particularly in countries where governments are becoming more concerned about the ownership of resources; long-term contracts, with substantial down payments to assist established producers in their capital expansions, may become more widely accepted; and, finally, to avoid both the pitfalls of world currency fluctuations so dramatically demonstrated during 1973, and the uncertainties of forecasting prices a decade in advance, new pricing mechanisms will undoubtedly be developed to protect the interests of both consumers and producers.

While the world enrichment situation improved a little during 1973, the outlook in the longer-term continued to present a challenge to those countries depending on enriched uranium for their nuclear fuel. Latest forecasts indicate a world requirement for annual enrichment services approaching 100.0 million separative work units by 1990 and at least 160.0 million separative work units by the year 2000. Translated into more understandable terms, this means that by the year 2000 the world needs 15 new plants, assuming each has a capacity of 8.75 million separative work units a year; each such plant would cost from $1,130 to $1,710 million, depending on the technology used. Clearly, uranium enrichment is a multi-billion dollar business.

As for the Canadian uranium industry, no significant increase in production is expected until 1975 when, with the completion of Gulf's Rabbit Lake project and Denison's expansion, capacity will be increased to a level of about 8,500 tons U_3O_8 a year; actual production in that year could be in the order of 7,000 to 7,500 tons U_3O_8. Developments beyond 1975 will be dependent on markets. Canada does have some additional productive capability based on known lower-cost reserves, part of which is available through producer expansions and rehabilitation of certain past producing operations, but realization of production levels much beyond about 14,000 tons a year of U_3O_8 will be contingent on the discovery of new reserves. While exploration in Canada is now proceeding toward this end, it is far below the level which will bring about the annual rates of additions to reserves that are required. However, with the recent improvement in the outlook for uranium it can be anticipated that exploration activity in Canada will soon be increased and, given Canada's favourable geological potential, discoveries will be made sufficient both to guarantee long-term domestic needs and to contribute significantly to the needs of Canada's trading partners.

---

*This question examined by author in *Northern Miner,* Annual Review November 29, 1973, pp. 62-63, "Requirement for uranium exploration—annual expenditures (Canada) $100 million by 1990?"

Vanadium

R. J. GOODMAN AND M. A. BOUCHER

Vanadium pentoxide was produced by Masterloy Products Limited at its Ottawa plant for the first six months of 1973, but difficulties encountered in obtaining raw material sources resulted in the cessation of this operation in June 1973. As such, there is currently no vanadium production in Canada, though Masterloy continues to process significant quantities of ferrovanadium using imported raw materials.

World production capacity of vanadium in 1973 totalled about 45 million pounds of contained vanadium and, as such, probably exceeded total world consumption in 1973 by about 18 per cent. The bulk of the world's production came from the United States and South Africa, each contributing 42 per cent of the total world production with most of the residual production emanating from Europe. Total world production is soon expected to completely outstrip world consumption, especially as major projects in South Africa, Australia and the United States are destined to commence operations by 1976. In the longer run, additional sources of byproduct vanadium from crude oil and tar sands could supply a significant proportion of future world supplies by 1985, as increased environmental controls increase the availability of fly ash from multivariant fossil fuel residues.

World demand for vanadium in 1973 was strong and increased by 22 per cent, from 31.2 million pounds of vanadium in 1972 to an estimated 38 million pounds in 1973. The major consumer of vanadium is the United States with 32 per cent of the world's total consumption, with Western Europe at 40 per cent and Japan 10 per cent. The United States consumption in 1973 increased from 10.2 million pounds of vanadium in 1972 to 12.0 million pounds in 1973. This was largely due to increased demand for high-strength low-alloy (HSLA) steel for oil and natural gas pipelines and building construction, as well as a sharp increase in demand for tool steels. Demand outside of the United States was also strong with a growth rate of 14 per cent, from 21 million pounds in 1972 to an estimated 24 million pounds in 1973. The large growth rate experienced in 1973 is not expected to continue into 1974, and over the next several years annual growth in the vanadium industry is expected to stabilize around 4.5 per cent. The growth in the demand for vanadium is intimately linked with HSLA steel applications for pipelines and structural steel, and strong growth in this field for vanadium is far from assured, due to the pronounced competition from substitute metals such as columbium. Columbium is, at present, less expensive and in certain applications is deemed to provide a superior HSLA steel product than its vanadium counterpart.

Price quotations in the United States remained very stable throughout 1973 for all marketable vanadium materials, while European markets expressed an overall increase of about 10 to 20 per cent on vanadium materials throughout 1973.

Minerals and world occurrences

Vanadium is one of the most common trace elements, ranking twenty-second in abundance in the earth's crust, with an average distribution of 150 parts per million. Despite its apparent overall abundance, vanadium only rarely obtains levels to be economically significant, and even then it is often mined as a byproduct and not as a primary product. Over one hundred vanadium minerals are known, with patronite, roscoelite, bravoite, carnotite, cuprodescloizite, descloizite, brannerite, titanomagnetite and coulsonite being the most common. Patronite and bravoite are complex sulphides and were an important source of vanadium prior to 1955. These sulphides came from asphalt-coke sediments at Mina Riga in the Peruvian Andes. The most important sources of vanadium are now the vanadium-bearing titanomagnetite and coulsonite deposits of South Africa, Finland and Norway. Similar deposits are known to exist in Canada, Russia and the United States. Vanadium in the form of copper, lead and zinc vanadates, such as carnotite, cuprodescloizite and descloizite is a common constituent in uraniferous sandstone deposits, such as those that occur at the Colorado Plateau in the United States. Vanadium also occurs in certain phosphatic ores, such as those in Wyoming, United States, and also in association with chromite in Quebec and complex sulphide veins in Butte, Montana, and Cornwall, England. The affinity of vanadium for carbonaceous materials, is exemplified by anomalous concentrations in black shales, asphalt, coal, tar sands and graphite.

The bulk of present world production is obtained from the sedimentary sandstone deposits of the Colorado plateau with grades exceeding 1.5 per cent, the lateritic deposits in Arkansas, the phosphatic sediments in Idaho and the titaniferous magnetite deposits predominantly in South Africa, Norway and Finland. The South African deposits contained in the Bushveld Complex are especially rich, grading 1.5-2.0 per cent V_2O_5.

Vanadium is widely distributed in Canada, but as yet no commercial deposits have been found. Most of the ilmenite-magnetite and ilmenite-hematite deposits within gabbro-anorthosite complexes are vanadiferous, notably the ilmenite-magnetite deposit in the Lac Doré complex near Chibougamau, Quebec, with 0.50 per cent V_2O_5, and the ilmenite-hematite deposit from the Lac Allard area, Quebec with 0.34 per cent V_2O_5. Significant vanadium values averaging 150 parts per million are known to occur in the Athabasca tar sands and the imminent development of these tar sands as an important source of oil should precipitate the recovery of vanadium from the coke residue formed during the distillation process.

Canadian developments

Vanadium has not been produced in Canada since Masterloy Products Limited, near Ottawa, Ontario, suspended its production of vanadium pentoxide in June 1973 because of difficulties experienced in obtaining sodium fluorovanadate from the Aluminum Company of Canada, Limited (ALCAN). The recovery of sodium fluorovanadate by ALCAN from its bauxite leaching circuit at Arvida, Quebec, was uneconomical. An attempt by Masterloy to use fly ash from thermal power stations as a raw material proved unsuccessful because of the inconsistency of the feed material. Masterloy continued to produce ferrovanadium by the aluminothermic process in 1973.

Table 1. Canada, vanadium imports and consumption, 1972-73

	1972		1973^p	
	(short tons)	$	(short tons)	$
Imports				
Ferrovanadium				
United States	3	13,000	168	985,000
Austria	60	326,000	–	–
United Kingdom	31	131,000	–	–
Belgium-Luxembourg	22	115,000	–	–
Total	116	585,000	168	985,000
Consumption				
Ferrovanadium				
Gross weight	346	..	..	..
Vanadium content	249	..	..	..

Source: Statistics Canada.
^{p}Preliminary; – Nil; .. Not available.

A feasibility study on the Lac Doré vanadium-bearing titaniferous magnetite deposit has been conducted recently by the Quebec Department of Natural Resources. Its conclusions precluded the development of this deposit in the near future because the magnetite concentrate was deemed to contain an objectionable proportion of titania for the production of a marketable iron ore product; the titania content is insufficient to offer any potential as a titania deposit; and that the operation is not feasible as a vanadium operation.

The prospects of significant Canadian production of vanadium by 1985 was improved appreciably with the development in June 1972 of a pyrometallurgical process by the Department of Energy, Mines and Resources in Ottawa, to recover vanadium and nickel from fly ash derived from the Athabasca tar sands bitumen in Alberta. The fly ash is produced by combustion of petroleum coke obtained from the tar sand bitumen, which is presently being used at the Great Canadian Oil Sands Limited's (GCOS) oil production plant, Fort McMurray, Alberta. The tar sand bitumen itself contains 150 parts per million vanadium, but the resultant fly ash derivative contains over 2 per cent vanadium and 1 per cent nickel. It has been estimated that economic recovery of both nickel and vanadium becomes feasible when total oil production from the tar sands attains 200,000 barrels of synthetic crude oil a day.

Present production of synthetic crude by GCOS, which has a permit to produce 65,000 barrels a day, is about 50,000 barrels a day and Syncrude Canada Ltd. has received authorization to construct a production facility with 125,000-barrels-a-day capacity for commencement of production on January 1, 1978. Two other applications to establish production facilities, one at the rate of 100,000 barrels a day by Shell Canada Limited and one at the rate of 122,500 barrels a day by Petrofina Canada Ltd. are currently under scrutiny by the Alberta Energy Board. Scheduled production dates for these facilities are January 1, 1980, and July 1, 1982. Thus, it appears likely that synthetic crude will be available at a rate of at least 190,000 barrels a day by 1980 and 410,000 barrels a day by 1985. These figures appear to indicate that the early 1980's will be the earliest date for commencement of vanadium production with a fly ash content as low as 1.5% V from the combustion of petroleum coke and, assuming a recovery of 80%, Canada's potential production of vanadium is estimated at nearly 10 million pounds a year by the mid-1980's. This represents 26 per cent of the world demand in 1973.

World developments

In Australia, Agnew Clough Limited announced that a $A12 million development is planned for commencement in January 1974 on its vanadium project at Wundowie, near Perth, Western Australia. Ore reserves have been estimated at 500 million pounds of commercial grade V_2O_5, and the project is scheduled to come on stream by the end of 1975 at a productive capacity of 7 million pounds of contained V_2O_5 annually. The property is owned 60 per cent by Angew Clough, 20 per cent by British Oxygen Limited (England) and 20 per cent by Mitsui Mining & Smelting Co., Ltd. (Japan).

Also, in Western Australia, feasibility studies were initiated by Ferrovanadium Corporation N.L. on its Barrambie vanadium-bearing titaniferous magnetite deposit, 280 miles east of Geraldton. Ore reserves of 400 million tons have been delineated containing an average of 21.5 per cent iron, 10.4 per cent titanium and 0.5 per cent vanadium. The eventual aim of Ferrovanadium Corporation N.L. is to form a joint venture with Pacminex Pty. Ltd. of Western Australia to establish a mine and mill at Barrambie, which would process ore into high-grade concentrate for transportation by slurry pipeline to Geraldton. At Geraldton, electric and chemical plants would convert the concentrate into iron and semi-finished steel, vanadium and titanium slags and vanadium chemicals.

In 1973, the Indian government announced the discovery of a vanadiferous-magnetite deposit in the Mayurbhanj district of Orissa containing an estimated 20 million tons of 0.80 per cent vanadium.

In Finland, Rautaruuki Oy announced plans to bring a new vanadium mine and in situ vanadium processing plant into operation at Mustavaara. Vanadium reserves have been estimated at 44 million tons of ore, mineable by open-pit techniques, with an anticipated annual production of 1.76 million tons of ore yielding 3,000 tons of contained vanadium pentoxide. Meanwhile, Rautaruuki Oy continued its mining and processing operation at its Otanmaki titaniferous magnetite mine producing about 2,200 short tons of V_2O_5 in 1973.

In South Africa, the Vantra Division of Highveld Steel and Vanadium Corporation Limited announced plans in March 1973 to initiate an expansion program to increase its production capacity of vanadiferous slag and steel by 25 per cent. The Highveld production facility near Witbank in Western Transvaal has a current capacity of 480,000 tons a year of pig iron and 23 million pounds of vanadium pentoxide in slag; and the new developments will raise this to 600,000 tons a year of pig iron and 29 million pounds of V_2O_5 by early 1975. The magnetite ore processed in 1973 continued to be derived from the Mapochs mine where proven reserves are about 20 million tons of open-pit ore grading 56 per cent iron, 13 per cent TiO_2 and 1.5-2.0 per cent V_2O_5. The Mapochs mine represents only one sixth of the 120-million-ton reserve available to Highveld.

World consumption and trade

World demand for vanadium reached record levels in 1973 with total world consumption increasing from 33 million pounds of vanadium in 1972 to an estimated 38 million pounds in 1973. The increase was predominantly due to the high level of world steel production in 1973, and increased demand for HSLA steel for pipeline construction in Europe. United States domestic consumption of vanadium increased by 18 per cent in 1973 to 12 million pounds. Consumption outside of the United States increased by about 15 per cent from 21 million pounds of vanadium in 1972 to 24 million pounds in 1973. The United States accounted for about one third of noncommunist world consumption in 1973 with Japan and West Germany accounting for an additional 50 per cent.

Table 2. World production of vanadium in ores and concentrates, 1970-73

	1970	1971	1972	1973[e]
	(short tons)			
Republic of South Africa	7,465	6,530	8,230	9,200
United States	5,319	5,252	4,887	..
U.S.S.R.	3,377	2,917	2,900	..
Finland	1,450	1,222	1,312	..
Norway	1,190	1,160	1,200	..
Chile	610	660	720	..
Southwest Africa	660	730	600	..
France	100	100	100	..
Other Free World*	–	–	–	3,950
Total	20,171	18,571	19,949	..

Source: U.S. Bureau of Mines, *Minerals Yearbook*, Preprint for 1972, U.S. Commodity Data Summaries, January 1974 for 1973.
[e]Estimated; .. Not available; *Excluding United States.

United States exports of ferrovanadium reached an all-time record of 2,500 tons in 1973, with Canada, Belgium, Luxembourg, Mexico and Switzerland being the main importers. United States imports of ferrovanadium also reached an all-time record of 800 tons in 1973, 33 per cent above the 1972 value of about 600 tons. Major suppliers of United States ferrovanadium imports were West Germany, Norway and Austria.

Canadian imports of ferrovanadium increased by 45 per cent in 1973, from 232,000 pounds in 1972 to 336,000 pounds in 1973. The United States supplied the entire ferrovanadium imports to Canada in 1973.

Current technology and uses

The steel industry accounts for over 90 per cent of total vanadium in form of standard ferrovanadium or other vanadium ferroalloys. The addition of vanadium to steel retards the crystallization and grain growth of the austenite phase and promotes the nucleation phase, producing a steel with increased strength, impact and wear resistance, corrosion resistance and maintenance of hardness at elevated temperatures.

The high-strength low-alloy (HSLA) steels are the largest consumers of vanadium, presently consuming 45 per cent of the world's total vanadium production. The HSLA steels commonly contain 0.02-0.08 per cent vanadium and 0.20-0.30 per cent carbon, and their high strength-to-weight ratio realizes large cost savings with respect to lower steel, transportation and welding costs. The steels are now finding extensive applications in oil and natural gas transmission pipelines, structural applications, pressure storage tanks, truck frames and automobile components.

Vanadium is also finding increased application in high-speed tool steels, where vanadium is added in concentrations of 1 to 5 per cent. Vanadium forms the stable carbide which refines the austenitic grain size and imparts excellent wear resistance to steel. Tool steel applications now consume about one quarter of the world's total vanadium production.

Significant quantities of vanadium in conjunction with chromium and molybdenum are also used in the heat-resisting alloy steels and find wide applications in automobile components, nail punches and sets and railway springs. The refining of the austenitic grain size gives more reliable and reproducible mechanical properties and these alloy steels now account for approximately 15-17 per cent of the world's vanadium consumption. Vanadium is also used in plain carbon steels as reinforcing bars and pilings and also in open-die steel forgings for large turbine rotors and shafts.

Titanium-based vanadium alloys have gained acceptance in many engineering materials, especially the aerospace industry, for aircraft frames, engine castings and other aircraft components. The chemical industry also consumes vanadium, particularly for use as catalysts in the processing of such end-use products as phosphatic fertilizers, unsaturated polyesters (Dacron), polyvinyl chloride, nylon, ethylene and propylene rubber. Further uses of vanadium in the chemical industry are as colorants to ceramic tile, pottery and glass and laboratory chemicals.

Table 3. Vanadium consumed in the United States, 1972-73

	1972	1973
	(pounds of vanadium)	
Ferrovanadium	8,818,379	10,566,844
Oxide	282,029	245,566
Ammonium metavanadate	93,943	89,834
Other	988,513	1,112,385
Total	10,182,864	12,014,629

Source: U.S. Bureau of Mines, Mineral Industry Surveys.

Prices

United States quotations for vanadium materials were very stable throughout 1973 with prices maintaining the same level throughout the year. Prices of $4.19 a pound for standard ferrovanadium, $3.66 a pound for Union Carbide Corporation's vanadium carbide product "Carvan" and $3.66 a pound for Foote Mineral Company's special ferrovanadium alloy "Ferovan" remained in effect throughout 1973. Similarly, the price of V_2O_5 remained relatively stable, increasing from $1.60-$1.70 in January to $1.75-$1.80 by December.

In Europe, vanadium prices exhibited an upward trend throughout 1973, with V_2O_5 advancing from $1.50 a pound in January 1973 to $1.75-$1.85 a pound by December, and ferrovanadium advancing from $3.30 a pound in January to $3.90-$4.00 a pound by year-end.

Table 4. Vanadium consumed in the United States by end-use, 1972-73

	1972	1973^p
	(short tons of vanadium)	
Steel		
High-speed tool	620	831
Stainless	30	26
Alloy (excluding stainless and tool)	3,150	3,670
Carbon	630	670
Other steel	–	–
Cast iron	60	42
Welding and hardfacing rods and materials	11	9
Nonferrous alloys	373	523
Chemical and ceramic uses	147	90
Miscellaneous and unspecified	206	146
Total	5,227	6,007

Source: U.S. Bureau of Mines, *Minerals Yearbook, Preprint for 1972* and U.S. Bureau of Mines, Mineral Industry Surveys for 1973.
^{p}Preliminary; – Nil.

Future trends

The 1973 pattern of vanadium demand-supply interaction should continue into 1974. Free world demand should increase by 4 to 5 per cent in 1974, with a concomitant increase in productive capacity of 8 to 10 per cent, creating a minor oversupply in the short-run. The major growth area in the long term will remain the HSLA steels, especially for steel pipeline production in the United States, Canada, Japan, Western Europe and Australia; and possibly increased usage in the automobile industry. However, the use of vanadium in HSLA steels is being very successfully challenged by columbium, which has the advantage of being less expensive and also has certain physical advantages over vanadium, especially in cold climates. Increased substitution of vanadium by columbium is envisaged in both steel pipelines and structural steel, particularly as alternative sources of columbium become available and the reliance of consumers on supplies from Companhia Brasileira de Metalurgia e Mineração (CBMM) and St. Lawrence Columbium and Metals Corporation is relieved somewhat. It is unlikely that the long-term demand for vanadium will exceed 4.5 per cent, unless unforeseen technological changes forge new markets.

Commencing in 1975, vanadium appears to be entering a period of vast oversupply as substantial new projects in Australia, Transvaal and the United States come on stream. By 1978, an increase in productive capacity of about 70 per cent compared to the 1973 base level is predictable, with only a 25 per cent increase in demand foreseeable for the same period of time. The resultant serious oversupply may severely depress the prices of vanadium in the mid-seventies and will adversely affect the cost-revenue pattern of many of the present vanadium producers. The effect will be most serious on producers who mine vanadium as the sole recoverable mineral such as the Union Carbide Corporation mine at Wilson Springs, Arkansas, and some of the Highveld mines in South Africa. In general, vanadium production is highly inelastic being derived as a byproduct of titaniferous magnetite, uranium and phosphate deposits and, in such cases, it could be expected that companies would continue to produce vanadium and stockpile it for future requirements. Demand for vanadium, under its present pricing structure, is also relatively inelastic, but in a period of markedly depressed vanadium prices, demand could become elastic as vanadium begins to compete with other nonferrous metals in the steel, tool and alloy markets. The suitability of the physical characteristics of vanadium in these areas would have to be evaluated before a complete appraisal of the elasticity of vanadium demand and impact on com-

Prices

United States vanadium prices in U.S. currency published in Metals Week of December 22, 1972 and December 21, 1973.

	December 22 1972	December 21 1973
	$	$
Vanadium pentoxide, per lb. of		
V_2O_5, fob mine or mill 98% fused	1.50	1.50
Air dried (technical)	2.21	2.21
Dealers (mainly export)	1.50	1.50
Ferrovanadium, per lb. V, packed fob shipping point, freight equalized to nearest main producer		
Standard grade	4.19	4.19
Carvan	3.66	3.66
Dealers (mainly export)	(*n*)	(*n*)
Ferovan	3.68	3.68

*n*Nominal.

pany revenues could be effectively predicted.

Ultimately, the major source of vanadium could be fly ash derivatives from fossil fuel residues. Even at this stage, technological advances have resulted in the development of economically feasible processes of extraction and increased global attention on deleterious environmental emissions will further stimulate developments in this area. The magnitude of this source of vanadium should not be under-estimated, as it has been estimated that the total fuel oil consumed annually in the United States alone contains over 40 million pounds of recoverable vanadium. This quantity would be sufficient to satisfy almost 80 per cent of anticipated world total demand in 1980.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(%)	(%)
32900-1	Vanadium ores and concentrates	free	free	free
37520-1	Vanadium oxide	free	free	5
35101-1	Vanadium metal, ex-alloy	free	5	25
37506-1	Ferrovanadium	free	5	5

United States

Item No.		Effective On and After January 1 1970	1971	1972
		(%)	(%)	(%)
601.60	Vanadium ores and concentrates	free	free	free
632.58	Vanadium metal, unwrought, waste and scrap (duty on waste and scrap suspended to June 30, 1973)	7	6	5
632.68	Vanadium alloys, unwrought	10	9	7.5
633.00	Vanadium metal, wrought	12.5	10.5	9
607.70	Ferrovanadium	8.5	7	6
422.60	Vanadium pentoxide	22	19	16
422.58	Vanadium carbide	8.5	7	6
427.22	Vanadium salts	22	19	16
422.62	Other vanadium compounds	22	19	16

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1972), TC Publication 452.

Zinc

G.S. BARRY

In 1973, zinc demand experienced a remarkable growth that led to severe shortages in most industrialized countries, particularly in the second half of the year. This upward trend showed no sign of abatement and could have been expected to continue in 1974 and 1975 had not the energy crisis occurred. The effect of the energy crisis however was not extreme, and demand in 1974 is still expected to rise slightly above the 1973 levels. The supply, particularly the mine supply of concentrates to smelters, will continue to be a problem in 1974, so much so that on balance the excellent sellers' market for zinc is forecast to continue.

Canadian recoverable zinc output in 1973 was 1,362,649 short tons, about 9.5 per cent higher than in 1972. The value of production however increased by 37.6 per cent due to a sharp rise in world zinc prices. Canada remained the world's leading mine producer with mine output of 1,488,533 tons (unadjusted for losses and other factors) accounting for 30.1 per cent of the total production of noncommunist countries. Production of refined zinc increased to 587,038 tons in 1973 from 524,885 tons in 1972. Plants operated at their most efficient capacities against a background of buoyant markets. Some production was lost on account of a fire at Cominco Ltd.'s refinery at Trail, British Columbia, in December.

Canadian exports of zinc in concentrates increased by 24.6 per cent from 766,202 tons in 1972 to 955,069 tons in 1973, reflecting, in part, increased mine production and, in part, additional shipments from large concentrate stocks accumulated during prior smelting capacity shortages.

In 1973, exports of refined zinc were 465,776 tons compared to 408,310 tons in 1972; a second consecutive major annual increase. In 1971, exports were only 312,462 tons. Exports to the United States continued at record levels increasing by 27.7 per cent after increasing 72 per cent the previous year. Exports to the U.S.A. were 348,467 tons in 1973 compared to 272,878 tons in 1972. The large increases over the past two years and at the beginning of 1974 are due to a sustained drop in the U.S. domestic metal production resulting from smelter closures and also large increases in consumption. The U.S. market was further supplemented by sales from the U.S. government stockpile of 267,118 tons in 1973 and 200,223 tons in 1972. Britain, as Canada's second best customer for zinc metal, imported 70,811 tons; only slightly less than in 1972. In the past 10 years Canada exported zinc metal to some 57 countries. It exported to 32 countries in 1972 and to 29 countries in 1973. Of these, 17 received in excess of 1,000 tons and nine imported more than in the previous year. In general,

Zinc: Salient Statistics — Canada

	1970	1971	1972	1973^p	1974^e	1975/76^e
			(000's of short tons)			
A) Mine Production	1,381	1,400	1,402	1,495	1,530	1,605
B) Production of primary zinc	461	411	525	587	530	700
C) Export of zinc in conc.	892	891	766	955	928	850
D) Export of primary zinc	351	312	408	466	390	550
E) Domestic consumption (primary zinc only)	106	115	123	135	140	143
Export processing index D/D&C	28	26	35	33	30	42

^{p}Preliminary; ^{e}Estimated.

there is a continuing tendency to ship less to small consumers around the world.

As indicated in the tabulation of salient statistics, in 1973 Canada required for its export commitments and its domestic processing industry 1,604,000 tons of zinc in concentrates (making allowances of 8% for smelter losses) and produced only 1,495,000 tons. Thus, there was a net drain on Canadian producers' stocks during the year.

Domestic industry

Mine production. Table 2 gives information on the operations of 32 mining enterprises that produced zinc-bearing ores or concentrates on a regular basis during 1973 and whose content of zinc was destined for recovery. Of the mines that produced more than 20,000 tons of zinc in concentrates in 1973, eight increased production and five decreased production from the previous year. In addition, two new mines Mattabi and Ruttan entered the major producer category. All the major mine producers experienced normal production conditions except American Smelting and Refining Company (ASARCO) Buchans mine that had a 6-month strike and Cominco's Sullivan mine that stopped on account of a short strike in mid-summer. Many mines and the Trail smelter experienced shipment difficulties on account of the general rail strike in the summer.

The 32 mining enterprises listed in Table 2 had a combined mill capacity of 103,460 tons of ore per day of which the large mills (1,000 tons-per-day and over) accounted for 101,000 tons. Zinc production per ton of installed concentrator capacity in 1973 was 14.4 tons compared to 15.7 tons in 1972. The zinc producing enterprises reported a total employment of 13,488 in 1973, 459 more than in 1972. The 22 large concentrators milled 28,494,000 tons, operating at 77.3 per cent of their theoretical annual capacity of 36,865,000 tons based on a 365-day year.

Newfoundland. Production of zinc at the Buchans mine was only 13,272 tons; about one third of the normal annual output, due to a 25-week strike. The company has sufficient reserves for six years of operation. An intensive exploration program over the past few years failed to find new high-grade deposits, but the company has several million tons of subeconomic reserves that may become economic at the beginning of the next decade. The mine is jointly owned by American Smelting and Refining Company, the operator, and by Terra Nova Properties Limited, a wholly-owned subsidiary of Price (Nfld.) Pulp & Paper Limited.

Teck Corporation Limited and Amax Exploration, Inc., reached a decision to put into production the Daniel's Harbour zinc-lead deposit on the western coast of the island. Production will probably be at 1,500 tons per day and may start in late 1975 or early 1976. The company has outlined several million tons of ore of which approximately 3,750,000 tons are relatively high grade (11.4% zinc).

Nova Scotia. The province's only producer, the Walton mine operated by Dresser Minerals Division of Dresser Industries, Inc., ceased mining lead-zinc ore in 1970, but milled very small amounts from stockpiled material in 1972 and 1973. The province has rock formations favourable for lead-zinc deposits of the Mississippi Valley type in the U.S.A. This induced Imperial Oil Enterprises Ltd. to explore intensively for the past two years, and led to the discovery of a multimillion-ton deposit on the properties of Cuvier Mines Ltd. Total reserves are estimated at about 20 million tons grading about 3.4% zinc and 2.75% lead. Production may start in two or three years. Nova Scotia would then again become an important producer of zinc, in the range of 40,000 to 50,000 tons per year.

New Brunswick. The province's mining future appears to have improved because of better production records at the existing mines, a favourable reserves position, expansion plans for Heath Steele Mines Limited and Brunswick Mining and Smelting Corporation Limited, and an increased possibility of opening new mines in the near future. Nigadoo River Mines Limited is reopening its Robertville mine in early 1974. Remaining reserves at closure in late 1971 were 1,248,000 tons grading 3.22% zinc, 3.23% lead and 4.04 ounces of silver per ton. Brunswick Mining and Smelting Corporation Limited has just completed a reorganization program that involved conversion of the Belledune Imperial Smelting Furnace (ISF) zinc-lead smelter to a lead smelter along with changes in the mining and beneficiation sector. In 1973, the company mined 3,288,081 tons of ore grading 7.00 per cent zinc, 2.81 per cent lead, 0.34 per cent copper and 2.53 ounces of silver per ton to recover 188,946 tons of zinc in concentrates. Some 12,000 tons of zinc reports in the lead concentrates smelted at Belledune. Currently it is not recovered, but zinc-rich slag (12-15% zinc) is being stockpiled for possible future zinc recovery by fuming. Zinc-lead ore reserves at No. 12 mine were increased substantially during the year as a result of an exploration program designed to provide information for long-range planning. The open-pit operation at the No. 6 mine is due to be terminated in late 1975 or early 1976. Therefore, with 84 million tons of zinc-lead ore at the No. 12 mine, it was decided to sink a new shaft to a depth of 4,300 feet and install equipment capable of hoisting 11,000 tons of ore per day. No. 12 mine production will be increased to 7,500 tons per day by 1976 and to 11,000 tons in 1979. The total cost of the new shaft and the increased production facilities is expected to be $28,500,000. For the end of 1973, the company reports proven reserves of 63,688,000 tons grading

(text continued on page 532)

Table 1. Canada, zinc production, trade and consumption, 1972-73

	1972		1973p	
	short tons	$	short tons	$
Production				
All forms[1]				
Ontario	394,891	150,619,352	447,870	214,619,000
New Brunswick	174,536	66,571,498	201,523	96,570,000
Northwest Territories	169,870	64,792,006	187,272	89,741,000
Quebec	163,244	62,264,647	155,855	74,685,000
British Columbia	134,174	51,176,646	151,622	72,657,000
Yukon	118,613	45,241,287	126,327	60,536,000
Manitoba	45,607	17,395,392	68,788	32,963,000
Saskatchewan	16,625	6,340,953	13,330	6,388,000
Newfoundland	26,582	10,138,934	10,062	4,822,000
Total	1,244,142	474,540,715	1,362,649	652,981,000
Mine output[2]	1,401,693		1,488,533	
Refined[3]	524,885		587,038	
Exports				
Zinc, blocks, pigs and slabs				
United States	272,878	85,902,000	348,467	149,772,000
Britain	74,232	21,606,000	70,811	29,906,000
Brazil	5,354	1,367,000	6,059	2,680,000
Singapore	1,530	468,000	4,406	1,849,000
Venezuela	3,573	881,000	4,650	1,818,000
Italy	4,882	1,208,000	4,193	1,446,000
Thailand	2,325	730,000	3,306	1,332,000
Taiwan	4,129	1,274,000	3,291	1,309,000
Hong Kong	2,760	876,000	3,266	1,286,000
India	12,023	3,502,000	1,087	705,000
Belgium-Luxembourg	2,416	722,000	1,869	678,000
Israel	1,900	458,000	1,924	658,000
Pakistan	–	–	1,653	638,000
Germany, West	4,615	1,499,000	1,459	565,000
Colombia	–	–	1,351	553,000
France	1,486	361,000	1,289	527,000
Guatamala	1,183	344,000	1,105	441,000
Other countries	13,024	3,562,000	5,590	2,048,000
Total	408,310	124,760,000	465,776	198,211,000
Zinc contained in ores and concentrates				
Belgium-Luxembourg	190,631	32,064,000	294,616	61,462,000
Japan	150,229	27,811,000	240,904	57,248,000
United States	151,871	19,149,000	135,131	22,250,000
Germany, West	118,897	20,034,000	115,929	21,048,000
Netherlands	34,731	7,211,000	53,208	10,648,000
France	53,785	9,533,000	49,436	10,341,000
Italy	7,864	2,501,000	22,080	5,027,000
Finland	–	–	14,982	3,745,000
India	16,484	2,798,000	14,233	3,350,000
Poland	10,847	1,592,000	11,062	2,653,000
Norway	10,524	1,646,000	3,228	700,000
Brazil	–	–	239	81,000
Other countries	20,339	3,372,000	21	7,000
Total	766,202	127,711,000	955,069	198,560,000

Table 1 (cont'd)

	1972		1973p	
	short tons	$	short tons	$
Zinc and alloy scrap dross and ash (gross weight)				
United States	3,555	759,000	3,455	1,168,000
Britain	973	125,000	1,168	350,000
Belgium-Luxembourg	1,633	113,000	2,034	301,000
Netherlands	2,355	236,000	1,611	169,000
South Africa	281	40,000	539	112,000
Korea, South	319	76,000	214	97,000
Germany, West	–	–	264	73,000
Other countries	777	173,000	721	167,000
Total	9,893	1,522,000	10,006	2,437,000
Zinc fabricated materials nes				
United States	5,990	2,612,000	4,075	2,531,000
Britain	385	81,000	531	274,000
Japan	58	21,000	275	123,000
Italy	60	9,000	181	87,000
Venezuela	132	60,000	42	23,000
Belgium-Luxembourg	161	13,000	150	16,000
Other countries	490	86,000	61	59,000
Total	7,276	2,882,000	5,315	3,113,000
Imports				
In ores and concentrates	339	84,000	4,088	878,000
Dust and granules	1,340	597,000	898	492,000
Slabs, blocks, pigs and anodes	12,497	4,410,000	20,416	8,609,000
Bars, rods, plates, strip and sheet	478	317,000	554	471,000
Slugs, discs, shells	–	–	–	–
Zinc oxide	2,658	787,000	2,434	966,000
Zinc sulphate	1,111	151,000	1,121	194,000
Zinc fabricated material nes	907	1,091,000	947	1,294,000
Total	19,330	7,437,000	30,458	12,904,000

(table concluded on page 533)

9.28 per cent zinc, 3.76 per cent lead, 0.27 per cent copper and 2.74 ounces of silver per ton; plus 9,474,000 tons grading 1.13 per cent zinc, 0.40 per cent lead, 1.11 per cent copper and 0.85 of an ounce of silver per ton in the No. 12 mine. Proven reserves in the No. 6 mine are 3,442,000 tons grading 5.03 per cent zinc, 1.80 per cent lead, 0.42 per cent copper and 1.79 ounces of silver per ton. In addition, the company reports 21 million tons of zinc-lead ore and 4.6 million tons of copper ore in the probable category.

The $12 million expansion program at Heath Steele's Little River mine is more than half completed. A new shaft and equipment are being added to increase production by about one third to 4,000 tons per day. The project was disrupted and delayed by a lengthy stoppage in 1972. The company has further potential for expansion based on current reserves of 34 million tons grading 4.55% zinc, 1.63% lead, 1.16% copper and 1.76 ounces of silver per ton. The province has other promising deposits such as the Caribou property of Anaconda Canada Limited and those of Chester Mines Limited, Key Anacon Mines Limited, Teck Corporation Limited and others. All have a problem, common to the existing mines, of a fine-grained ore, difficult to beneficiate. If concentrating

Table 1 (concl'd)

	1972			1973^p		
	Primary	Secondary	Total	Primary	Secondary	Total
	(short tons)			(short tons)		
Consumption						
Zinc used for or in the manufacture of:						
Copper alloys (bronze, brass, etc.)	15,110			15,988		
Galvanizing						
Electro	2,034	493	75,176	2,347	922	84,031
Hot-dip	57,539			64,774		
Zinc die-cast alloy	25,160	..	25,160	30,000^e	..	30,000^e
Other products (including rolled and ribbon zinc, zinc oxide)	29,496	4,355	33,851	26,302	2,509	28,811
Total	129,339	4,848	134,187	139,411	3,431	142,842
Consumer stocks on hand at end of year	15,251	1,450	16,701	12,897	1,377	14,274

Source: Statistics Canada.
[1]New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2]Zinc content of ores and concentrates produced. [3]Refined zinc produced from domestic and imported ores.
^{p}Preliminary; .. Not available for publication; – Nil; nes Not elsewhere specified.
^{e}Estimated by Mineral Resource Sector

problems are overcome, some properties, probably with Anaconda acting as a pioneer undertaking, will be put in production near the end of the decade. Anaconda commenced mining in 1973 on a small copper-rich orebody on the same property.

Quebec. Mattagami Lake Mines Limited, the province's largest zinc producer, operated at 96.9 per cent capacity in 1973, producing 92,997 tons of zinc. The company reports an improvement in zinc recoveries from 88.6 per cent in 1972 to 91.0 per cent in 1973. Further improvement is expected in 1974 as a regrind mill in the zinc flotation circuit will be installed in early 1974. After mining 1,387,000 tons of ore in 1973, reserves (without dilution) were reported at 13,628,000 tons grading 8.7 per cent zinc, 0.66 per cent copper, 0.014 of an ounce of gold and 1.03 ounces of silver per ton. Employment at the mine was 437. The Lake Dufault Division of Falconbridge Copper Limited completed its second year of full production at its new deep Millenbach mine with good results, producing 18,975 tons of zinc. The ore is concentrated at the Norbec mill and a small part still comes from the Norbec mine. After milling 555,292 tons in 1973 reserves were maintained at the same level as at the end of 1972 or approximately 2,800,000 tons grading 3.9 per cent zinc, 3.1 per cent copper, 0.018 of an ounce of gold and 1.1 ounces of silver per ton.

The Normetal mine of Kerr Addison Mines Limited continued operations on a salvage basis throughout 1973 to produce 12,475 tons of zinc. The mine is expected to close in mid-1974. Orchan Mines Limited milled 270,100 tons of ore from its Orchan mine grading 7.39 per cent zinc and 180,130 tons from the Garon Lake mine grading 3.53 per cent zinc. Metal recoveries in concentrates were 87.53 per cent and 72.79 per cent respectively. Ore reserves at both properties were 1,928,595 tons grading 7.5 per cent zinc, 1.3 per cent copper and 0.8 of an ounce of silver per ton. The company accelerated plans to mine the small Radiore No. 2 deposit and expects production to start in late 1974 or early 1975. Construction is progressing at the Norita mine-site, and full production is expected by early 1976 when the ore at the Garon mine will probably be exhausted. The Norita deposit contains 1,637,000 tons averaging 7.6 per cent zinc, 0.7 per cent copper and 1.0 ounce of silver, per ton.

Joutel Copper Mines Limited began mining a small

(text continued on page 543)

Table 2. Principal zinc mines in Canada 1973 and (1972)

Company and Location	Mill or Mine Capacity	Zinc	Lead	Copper	Silver	Ore Produced	Contained Zinc Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Newfoundland								
American Smelting and Refining Company, Buchans Unit, Buchans	1,250 [1,250]	11.51 [12.89]	6.48 [7.18]	1.00 [1.13]	3.45 [3.73]	124,000 [291,000]	13,272 [34,533]	Company reports about six years ore reserves remaining.
New Brunswick								
Anaconda Canada Limited, Caribou Mine, Bathurst	1,000 [–]	3.0 [–]	– [–]	3.4 [–]	– [–]	45,000 [–]	800 [–]	Mine was activated in September 1973 on secondary copper-zone. In addition mining of a 50 million ton zinc-rich deposit is under consideration.
Brunswick Mining and Smelting Corporation Limited, Bathurst, No. 6 mine and No. 12	9,850 [9,850]	7.00 [7.15]	2.81 [2.77]	0.34 [0.32]	2.53 [2.43]	3,288,081 [3,257,559]	188,946 [190,478]	Mine deepening in progress. Reserves revised upwards.
Heath Steele Mines Limited, Newcastle	3,100 [3,000]	4.90 [3.93]	1.64 [1.46]	0.86 [1.13]	1.83 [1.70]	1,077,816 [835,867]	40,526 [25,132]	Currently sinking of new shaft to depth of 3,000 feet in progress. Expanding concentrator to 4,000 tpd by 1976.
Nigadoo River Mines Limited, Robertville	1,000 [–]	– [–]	– [–]	– [–]	– [–]	– [–]	– [–]	After suspending operations in January 1972, tune-up of mill was started in December 1973. Nominal amount mined in 1973.
Quebec								
Falconbridge Copper Limited, Lake Dufault Division, Noranda	1,500 [1,500]	4.41 [4.39]	– [–]	3.65 [3.16]	1.41 [1.40]	555,292 [561,625]	18,974 [19,109]	Exploration of property both from surface and underground continues.
Joutel Copper Mines Limited, Joutel	700 [700]	10.32 [12.16]	. . [. .]	. . [. .]	. . [. .]	151,427 [70,232]	13,200 [6,761]	
Kerr Addison Mines Limited, Normetal (Normetal Mines Limited)	1,000 [1,000]	4.86 [5.29]	– [–]	1.38 [1.73]	1.37 [1.43]	297,889 [326,475]	12,475 [14,695]	Ore will be depleted in 1974.

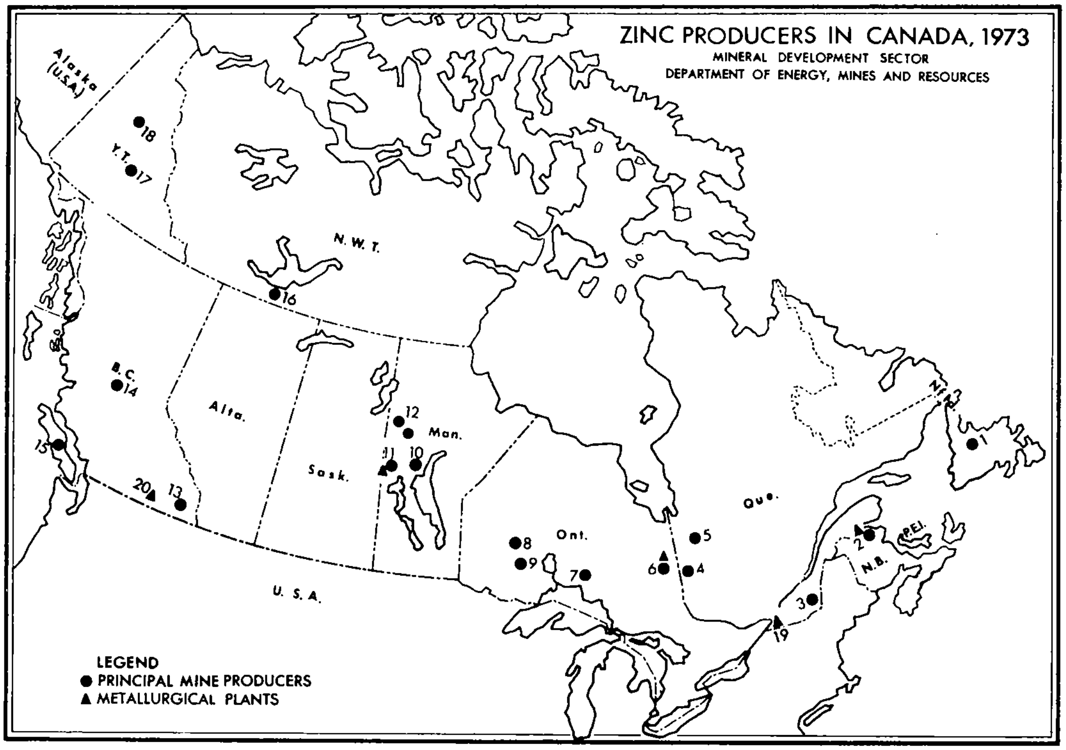
Manitou-Barvue Mines Limited, Val d'Or	1,600 [1,600]	2.07 [1.16]	0.30 [0.33]	. . [. .]	. . [4.68]	197,312 [60,234]	3,467 [500]	Mine was reactivated in July 1972.
Mattagami Lake Mines Limited, Matagami	3,850 [3,850]	7.4 [7.4]	– [–]	0.57 [0.56]	0.84 [0.88]	1,387,251 [1,370,167]	92,997 [90,889]	Extensive exploration continuing.
Orchan Mines Limited, Matagami, Orchan and Garon mines	2,000 [1,900]	5.77 [10.6]	. . [0.20]	1.16 [1.05]	0.69 [1.1]	450,230 [376,840]	21,853 [36,199]	Preparation of Norita Division for production in 1976 and Radiore No. 2 in late 1974.
Sullivan Mining Group Ltd., Stratford Centre, Cupra Division	1,500 [1,500]	4.88 [3.97]	0.66 [0.60]	2.41 [2.24]	1.092 [0.99]	89,814 [117,339]	3,500 [4,380]	Central concentrator for all three mines.
D'Estrie Mining Company Ltd.	– [–]	3.16 [3.28]	0.74 [0.72]	2.74 [2.70]	1.227 [1.21]	130,265 [109,138]	3,289 [3,367]	
Weedon Mines Ltd.	– [–]	0.59 [0.76]	– [–]	2.17 [1.82]	0.332 [0.35]	50,591 [177,248]	129 [1,072]	Ore reserves depleted at year-end; mine closed.
Ontario								
Ecstall Mining Limited, Timmins	10,000 [10,000]	9.78 [10.14]	0.33 [0.39]	1.61 [1.44]	3.72 [4.35]	3,609,657 [3,628,501]	325,888 [330,009]	Expansion of production to 5 million tons per year planned. Capacity of zinc metal plant being increased to 150,000 tpy.
Mattabi Mines Limited, Sturgeon Lake	3,000 [3,000]	11.37 [11.97]	1.06 [1.27]	1.10 [1.27]	5.31 [4.99]	1,111,765 [438,838]	113,732 [44,316]	High-grade zinc ore mined in 1973; grade will be lower in 1974.
Noranda Mines Limited, Geco Division, Manitouwadge	5,000 [5,200]	4.53 [4.30]	0.20 [0.15]	1.70 [2.12]	1.63 [1.93]	1,463,585 [1,815,164]	54,366 [61,555]	Drying plant for copper concentrate installed.
Selco Mining Corporation Ltd., South Bay Division, Uchi Lake	500 [500]	13.04 [12.0]	– [–]	1.86 [2.1]	3.18 [3.2]	191,614 [183,000]	23,062 [22,734]	Plan to sink shaft a further 1,400 feet to 2,100 foot level.
Willroy Mines Limited, Manitouwadge Division, Manitouwadge	1,700 [1,700]	2.74 [3.27]	0.17 [0.14]	0.98 [1.10]	1.42 [1.41]	430,486 [431,067]	8,739 [10,988]	Mine has sufficient reserves for two years of production.

Table 2 (concl'd)

Company and Location	Mill or Mine Capacity	Grade of ore Zinc	Lead	Copper	Silver	Ore Produced	Contained Zinc Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Manitoba and Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited Flin Flon (Flin Flon, Schist Lake, Chisel L., Stall Lake, Osborne Lake, Anderson Lake, Dickstone, White Lake, Ghost Lake mines)	8,500 [6,800]	3.61 [3.28]	– [. .]	2.45 [2.67]	0.75 [0.59]	1,815,027 [1,847,903]	55,598 [29,648]	Ores from all mines shipped to central concentrator at Flin Flon. Centennial mine under development for production in 1975.
Sherritt Gordon Mines, Limited, Fox Mine	3,000 [3,000]	2.07 [1.40]	– [–]	2.01 [2.14]	. . [. .]	963,416 [946,000]	8,352 [5,449]	Recovery of zinc very low. Quality of concentrates improved by circuit modifications in 1973.
Ruttan Mine	10,000 [–]	. . [–]	– [–]	1.14 [–]	. . [–]	1,518,052 [–]	20,759 [–]	Mill tune-up started April 1973.
British Columbia								
Bradina Joint Venture, Owen Lake	500 [600]	4.57 [4.45]	1.02 [0.89]	0.43 [0.42]	4.88 [5.31]	98,471 [111,024]	3,991 [3,981]	Operated by Bralorne Resources Limited. Operations suspended on August 31, 1973.
Cominco Ltd., Sullivan mine, Kimberley	10,000 [10,000]	4.99 [10.8[1]]	4.97	– [–]	1.76 [. .]	2,214,415 [1,925,099]	102,559 [100,680]	For 1972 grade of 10.8 is combined lead and zinc.
H.B. Mine, Nelson	1,250 [–]	4.2 [–]	1.6 [–]	– [–]	. . [–]	351,682 [–]	13,653 [–]	Rehabilitation and start-up preparations were completed and production recommenced in February 1973.

Consolidated Columbia River Mines Ltd., Golden	500 [500]	5.08 [–]	3.69 [–]	0.09 [–]	5.02 [–]	26,957 [–]	552 [–]	Mine reopened and production started in October on a trial basis.
Kam-Kotia Burkam Joint Venture, Silmonac Mine, Sandon	150 [150]	. . [6.62]	. . [5.81]	– [–]	. . [16.44]	13,949 [27,429]	693 [1,693]	Reserves almost depleted.
Reeves MacDonald Mines Limited, Remac Annex mine	1,000 [1,000]	4.49 [8,36]	1.67 [0.89]	– [–]	1.06 [2.51]	191,438 [166,089]	7,864 [13,540]	Reserves at the Annex property are almost depleted. Exploration in progress to determine if future operations warranted and tailings disposal facilities to be built.
Teck Corporation Limited, Beaverdell mine, Beaverdell	110 [115]	0.61 [0.76]	0.62 [0.72]	. . [0.003]	12.36 [18.23]	37,202 [37,091]	227 [284]	Plan to continue mining in 1974.
Western Mines Limited, Lynx and Myra Falls, Buttle Lake, V.I.	1,000 [1,100]	8.29 [6.02]	1.28 [0.68]	1.39 [1.85]	4.60 [. .]	354,420 [374,022]	26,372 [20,786]	Intensive exploration continues. A 2,300-foot adit will be driven on the Price property in 1974.
Yukon Territory								
Anvil Mining Corporation Limited, Faro	8,000 [8,000]	6.37 [6.22]	4.88 [4.63]	– [–]	1.0 [1.0]	2,899,145 [2,905,530]	142,680 [140,523]	Mill expansion to 10,000 tons completed by year-end; will mine lower grade ore to produce same quantity of metals.
United Keno Hill Mines Limited, Elsa, Husky, No Cash mines, Elsa	500 [500]	1.00 [3.19]	4.00 [4.61]	– [–]	34.62 [34.23]	94,819 [80,646]	673 [1,738]	Mill now operating at rate of 330 tpd. Keno mine reopened in late 1973.
Northwest Territories								
Pine Point Mines Limited, Pine Point	11,000 [10,000]	6.01 [6.2]	2.9 [2.7]	– [–]	. . [. .]	3,896,357 [3,809,729]	216,589 [220,045]	Extensive mill modification to depress MgO content of concentrates. Underground mining tests conducted.

– Nil; . . Not available; [r]Revised.
[1]Combined lead-zinc.



Principal Producers

(numbers refer to numbers on map)

1. American Smelting and Refining Company (Buchans Unit)
2. Brunswick Mining and Smelting Corporation Limited
   Heath Steel Mines Limited, Anaconda Canada Limited
3. Sullivan Mining Group Ltd.
4. Falconbridge Copper Limited, Lake Dufault Division
   Manitou-Barvue Mines Limited
   Kerr Addison Mines Limited (Normetal mine)
5. Mattagami Lake Mines Limited
   Orchan Mines Limited
6. Ecstall Mining Limited
   Kam-Kotia Mines Limited
7. Noranda Mines Limited (Geco mine)
   Willroy Mines Limited
8. Selco Mining Corporation Limited
9. Mattabi Mines Limited
10. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake, Osborne Lake, Stall Lake, Dick-stone, Ghost Lake, Anderson Lake, White Lake)
11. Hudson Bay Mining and Smelting Co., Limited (Flin Flon, Schist Lake)
12. Sherritt Gordon Mines, Limited (Fox Lake mine and Ruttan mine)
13. Cominco Ltd. (Sullivan mine and H.B. mine)
    Teck Corporation Limited (Beaverdell mine)
    Reeves MacDonald Mines Limited (Annex mine)
    Kam-Kotia-Burkam Joint Venture (Silmonac mine)
14. Bradina Joint Venture
15. Western Mines Limited
16. Pine Point Mines Limited
17. Anvil Mining Corporation Limited
18. United Keno Hill Mines Limited

Metallurgical Plants

19. Canadian Electrolytic Zinc Limited, Valleyfield
11. Hudson Bay Mining and Smelting Co., Limited, Flin Flon
20. Cominco Ltd., Trail
6. Ecstall Mining Limited

Table 3. Prospective zinc-producing mines

Company and Location	Year Production Expected	Mill or Mine Capacity	Indicated Ore Reserves	Grade of Ore: Zinc	Lead	Copper	Silver	Remarks
		(tons ore /day)	(tons)	(%)	(%)	(%)	(oz/ton)	
New Brunswick								
Nigadoo River Mines Limited, Robertville	1974	1,000	1,248,000	3.22	3.23	0.24	4.04	Company dewatered the shaft in 1973 and reopened the mine in January 1974.
Newfoundland								
Newfoundland Zinc Mines Limited, Daniel's Harbour	1976	1,500	5,400,000	7.70	..	..	..	Optioned to Teck Corporation and Amax. Reserves include 3,700,000 tons grading 8.5% zinc.
Quebec								
Orchan Mines Limited, Norita Mine	1976	..	1,637,000	7.6	–	0.7	1.0	Site preparation completed and mining plant erected. Shaft collared and sinking to depth of 1,600 feet will begin in March 1974.
Radiore No. 2	1974	..	139,400	1.1	–	2.2	..	Mining scheduled for late 1974 – early 1975. Milling in the Orchan concentrator.
Ontario								
Falconbridge Copper Limited and NBU Mines Limited, Sturgeon Lake	1974	1,200	2,110,600	10.64	1.47	2.98	6.14	Being prepared for production by end of 1974 – early 1975 at a cost of $16 million.
Manitoba								
Hudson Bay Mining and Smelting Co., Limited Snow Lake area Centennial mine	1974	..	1,400,000	2.6	–	2.06	..	Reserves are to 1,200 foot level; orebody open at depth. Development is on schedule.

Table 3 (concl'd)

Company and Location	Year Production Expected	Mill or Mine Capacity	Indicated Ore Reserves	Grade of Ore Zinc	Lead	Copper	Silver	Remarks
		(tons ore /day)	(tons)	(%)	(%)	(%)	(oz/ton)	
Northwest Territories								
Mineral Resources International Limited, Strathcona Sound	1978	1,500	7,000,000	16.0 (Zn+Pb)		–	1.50	Feasibility study completed in early 1974. Construction to commence in 1974. Production could be achieved in 1977.

. . Not available; – Nil.

Table 4. Indicated zinc deposits under exploration

Company and Location	Indicated Ore Tonnage	Grade of Ore Zinc	Lead	Copper	Silver	Remarks
	(tons)	(%)	(%)	(%)	(oz/ton)	
New Brunswick						
Anaconda Canada Limited, Bathurst, Caribou property	50,000,000	4.43	1.7	0.47	. .	In temporary production January to November 1971. Feasibility studies continue on bringing this property into production.
Chester Mines Limited, Newcastle	1,600,000	2.12	0.82	0.63	. .	Ore available for open-pit mining.
	3,300,000	. .	–	0.82	–	
	13,000,000	. .	–	0.77	. .	Ore available for underground mining. Feasibility study completed in 1970.
Key Anacon Mines Limited, Bathurst	1,950,000	5.87	2.18	0.24	2.31	Mine partly developed. Revaluation of property in 1970 led to decision to defer placing the property into production at that time.

Teck Corporation Limited, Portage Lakes area, Restigouche property	3,270,000	5.9	4.6	..	2.50	Partly recoverable by open-pit.
Nova Scotia						
Cuvier Mines Ltd. Gays River	24,000,000		7.2 (Pb+Zn)	–	..	Optioned to Imperial Oil Limited. Under exploration since 1972. Full potential not determined yet. Intensive program for 1974.
Quebec						
Selco Mining Corporation Limited, Frotet Lake	1,200,000	3.7	–	1.8	1.0	Optioned from Muscocho Explorations Limited which retains 20% interest. Further work planned for 1974.
Ontario						
Mattagami Lake Mines Limited, Sturgeon Lake	3,096,000		6.20	1.15	3.30	Lyon and Creek zones. Reserves to 1,000 foot depth only.
Giant Yellowknife Mines Limited, Errington and Vermilion Lake mines, Sudbury area	4,418,500 and 9,038,317	3.9 3.82	1.0 0.99	1.33 1.14	1.61 1.58	Extensive underground development in 1961-1967 period. Ore difficult to concentrate. Reserves only for underground explored areas with low pyrite and high pyrite ore respectively.
Manitoba						
Stall Lake Mines Limited, Snow Lake	672,000	2.28	..	5.38	..	Falconbridge Nickel Mines Limited is joint owner of this property. Exploration completed in 1971. Feasibility study on production completed. Decision deferred.
Saskatchewan						
Bison Petroleum & Minerals Limited, Brabant Lake	4,330,000	4.43	..	0.64	..	Further exploration planned.
Yukon Territory						
Hudson Bay Mining and Smelting Co., Limited, Tom deposit MacMillan Pass	8,645,000	8.4	8.1	–	2.75	Underground work through adit including diamond drilling in 1970-1972. Further development planned.
Kerr Addison Mines Limited, Swin Lake deposit, Vangorda Creek	5,000,000		9.5 (Pb+Zn)	..	1.50	
Vangorda Mines Limited, Vangorda Creek	9,400,000	4.96	3.18	0.27	1.76	Feasibility study made. No further exploration.

Table 4 (concl'd)

Company and Location	Indicated Ore Tonnage	Grade of Ore Zinc	Lead	Copper	Silver	Remarks
	(tons)	(%)	(%)	(%)	(oz/ton)	
Northwest Territories						
Arvik Mines Ltd., Little Cornwallis Island	25,000,000 plus		20.0 (Pb+Zn)	–	. .	Cominco Ltd. – 75% and Bankeno Mines Limited – 25%. Underground program (5,300-foot adit) and metallurgical tests completed. Feasibility study in progress.
Buffalo River Exploration Limited, Pine Point	1,350,000	9.6	3.4	–	. .	Feasibility study for joint production with Coronet Mines Ltd. completed in 1971. Decision was made not to put the property into production at present.
Bathurst Norsemines Ltd., Hackett River, Bathurst Inlet area	. .	. .	. .	. .	. .	Optioned to Cominco. Multimillion ton deposit in seven zones with high zinc and silver values. Under active exploration from 1970 to present.

. . Not available; – Nil.

separate zinc orebody in August 1972. Initially, reserves were sufficient for one year of operation, but more drilling in 1973 and a revaluation of lower-grade material as a result of higher prices added substantially to recoverable reserves now stated to be 200,000 tons grading 7.9% zinc. Mining is expected to continue into early 1975. Manitou-Barvue Mines Limited milled 197,930 tons of ore grading about 2.8 per cent zinc in 1973, recovering 3,467.2 tons of zinc in concentrates. At the end of the year, reserves were at 1,220,900 tons grading 2.77 per cent zinc, 0.28 per cent lead, 0.021 ounce gold and 3.94 ounces of silver per ton. The Sullivan Mining Group Ltd. operated three copper-zinc mines and one central concentrator in 1973. The company closed its Weedon mine early 1973 after ore reserves were exhausted.

Selco Mining Corporation Limited and Muscocho Explorations Limited have outlined a copper-zinc orebody on the Lessard property at Frotet Lake. Indicated reserves to a depth of 1,200 feet are placed at 1.2 million tons with an average grade of 3.7 per cent zinc, 1.8 per cent copper and 1.0 ounce of silver per ton. More work is planned in 1974 to determine whether this deposit has economic potential. Another deposit of some potential is at Magus River, 25 miles from Noranda. During 1973, reserves were expanded to 4.1 million tons grading 3.6 per cent zinc, 1.2 per cent copper, and 0.9 of an ounce of silver per ton. It is a joint venture of Copperfields Mining Corporation Limited and Iso Mines Limited. Louvem Mining Company Inc. (subsidiary of Quebec Mining Exploration Company (SOQUEM)) located a small but very high-grade zinc lens on its Louvicourt copper mine. The company plans to begin mining in 1974 and will produce more than 50,000 tons of zinc over a period of two to three years.

Table 5. Canada mine output, zinc, 1972-73

	1972	1973^p
	(short tons)	
Newfoundland	34,206	11,080
Nova Scotia	–	15
New Brunswick	196,621	214,498
Quebec	168,832	158,844
Ontario	461,876	514,374
Manitoba–Saskatchewan	52,901	81,705
British Columbia	132,633	148,058
Yukon Territory	134,589	143,375
Northwest Territories	220,035	216,584
Total	1,401,693	1,488,533

Source: Statistics Canada.
^{p}Preliminary.

Table 6. Canada, zinc production, exports and consumption, 1964-73

	Production		Exports			
	All Forms[1]	Refined[2]	In ores and concentrates	Refined	Total	Consumption[3]
	(st)	(st)	(st)	(st)	(st)	(st)
1964	684,513	337,734	403,102	238,076	641,178	88,494
1965	822,035	358,498	487,445	264,200	751,645	93,796
1966	964,106	382,605	591,332	256,153	847,475	107,052
1967	1,111,453	405,136	735,705	297,652	1,033,357	107,779
1968	1,159,392	426,728	855,818	318,707	1,174,525	115,978
1969	1,207,625	466,357	804,665	307,394	1,112,059	118,681
1970	1,251,911	455,471	892,043	351,454	1,243,497	105,641
1971	1,249,734	410,643	891,092	312,462	1,203,554	115,433
1972	1,244,142	524,885	766,202	408,310	1,174,512	134,187
1973^p	1,362,649	587,038	955,069	465,776	1,420,845	142,842

Source: Statistics Canada.
[1]New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2]Refined zinc produced from domestic and imported ores. [3]Refined primary zinc only, reported by consumers.
^{p}Preliminary.

Ontario. Ecstall Mining Limited, a wholly-owned subsidiary of Texasgulf Inc., which in turn is 30 per cent owned by the Canada Development Corporation (CDC), operates the largest zinc-copper mine in Canada. The mine is near Timmins, Ontario. The Kidd Creek mine completed its second best year in 1973. It produced 325,888 tons of zinc compared to 330,009 tons in 1972. While 80 per cent of the ore still comes from the open pit, underground operations commenced in December 1972 and are reported to account for progressively larger tonnages. By 1976-1977, the entire mill feed of 10,000 tons per day will be supplied from underground operations. It is possible that after 1977 the capacity of the concentrator will be increased. During 1973 the company milled 3,609,657 tons of ore grading 9.78 per cent zinc, 0.33 per cent lead, 1.61 per cent copper and 3.72 ounces of silver per ton. At the end of 1973 the company reported ore reserves at 75 million tons grading 4.62 per cent zinc, 3.02 per cent copper and 1.23 ounces of silver per ton, and 21 million tons grading 9.64 per cent zinc, 0.25 per cent copper and 6.57 ounces of silver per ton. These reserves were calculated above the 2,800-foot level, and substantial additional ore is known to exist below that level.

Noranda Mines Limited's Geco mine at Manitouwadge produced 54,366 tons of zinc from 1,463,585 tons of ore averaging 4.53 per cent zinc, 1.70 per cent copper and 1.63 ounces of silver per ton. The mine, which had a two-month strike that ended on June 10, is processing lower-grade ore than two years ago when a record production of 80,000 tons of zinc was achieved. Further, a gradual drop in the grade is expected as remaining reserves of 29.2 million tons average 3.98 per cent zinc, 1.90 per cent copper and 1.66 ounces of silver per ton. The second Manitouwadge producer, Willroy Mines Limited, continued production at normal levels, milling 430,486 tons in 1973. The grade of zinc however dropped to 2.77 per cent from 3.27 per cent a year ago, and zinc production declined to 8,739 tons. The company reports that it has almost two years of remaining reserves of 713,835 tons averaging 3.98 per cent zinc, 0.20 per cent lead, 0.34 per cent copper and 1.38 ounces of silver per ton.

Mattabi Mines Limited completed its first full year of operation, producing 113,732 tons of zinc from 1,111,765 tons of ore averaging 11.37 per cent zinc, 1.06 per cent lead, 1.10 per cent copper and 5.31 ounces of silver per ton. Recovery is 88.7 per cent zinc. About half of the concentrates are shipped to Europe and the remainder are divided among Canada, U.S.A. and Japan. Since the average grade of ore is substantially below the grades currently mined, the company expects progressively lower outputs of zinc. At the end of 1973, reserves were reported at 12.2 million tons averaging 6.73 per cent zinc, 0.67 per cent lead, 0.76 per cent copper and 2.60 ounces of silver per ton. Total employment in mining and milling operations was 269 in 1973. In the same area a joint venture of Falconbridge Copper Limited and NBU Mines Limited is proceeding to bring the Sturgeon Lake boundary deposit into production in late 1974. Falconbridge is providing 93.4 per cent of the financing which is expected to be about $16 million. Ore reserves are estimated at 2,110,600 tons of open-pit mineable ore averaging 10.64 per cent zinc, 2.98 per cent copper, 1.47 per cent lead and 6.14 ounces of silver per ton. Production is planned at 1,200 tons per day. Mattagami Lake Mines Limited has another property in the area known as the Lyon and Creek zones that will become a producer in the near future. Total reserves of these deposits to the 1,000-foot level are currently estimated at 3,096,000 tons averaging 6.20 per cent zinc, 1.15 per cent copper, 0.60 per cent lead and 3.30 ounces of silver per ton. Selco Mining Corporation Limited, completed a record year, producing 23,062 tons of zinc from 191,614 tons of ore grading 13.04 per cent zinc, 1.86 per cent copper and 3.18 ounces of silver per ton. The company intends to sink the shaft a further 700 feet to the 2,100-foot level. Lynx-Canada Explorations Limited opened a small mine at Long Lake, Rideau Lakes area in March 1973. During the year the company mined 55,042 tons of ore grading 11.3 per cent zinc and upgraded it to about 20 per cent using a sink-float gravity plant. The product was shipped to St. Joe Minerals Corporation in Balmat, N.Y. The company has sufficient reserves to continue operations through 1974, at least.

Manitoba. Hudson Bay Mining and Smelting Co., Limited operated nine mines during 1973, producing a total of 1,815,027 tons of ore averaging 3.61 per cent zinc and 2.45 per cent copper. About 28 per cent of the ore comes from the Saskatchewan part of the Flin Flon mine. The company's mines that have ore rich in zinc are the Ghost Lake mine, the Chisel Lake mine, the White Lake mine, and the Schist Lake mine. The Flin Flon, Dickstone and Osborne Lake mines have moderate grades and the Stall Lake and Anderson Lake mines have very low grades. Development of the Centennial mine, a copper-zinc orebody started in 1973 with the objective of bringing the mine into production in late 1974. The company will start developing the Westarm property (Schist Lake) during 1974.

Sherritt Gordon Mines, Limited completed construction of its Ruttan Mine in early 1973 and officially commenced production on July 1, 1973. The first zinc concentrates however were produced in early June. The total capital costs for this 10,000 ton-per-day operation were approximately $61 million or 9 per cent above original estimates. Production for 1973 was 20,759 tons of zinc derived from 1,518,052 tons of ore; the recovery of zinc was 65 per cent. At the end of 1973, reserves were restated at 49,100,000 tons averaging 1.60 per cent zinc and 1.46 per cent copper of which approximately 20 million tons are for open-pit mining. The company started an underground development program with a decline that reached the 1,000-foot level by December and will be continued to the 1,500-foot level. After six years of open-pit mining it is planned to phase in the underground operation, so that by the eighth year of operation, full production from underground will be at a rate of 2,500,000 tons per year. The mine's zinc concentrates are shipped to Japan under a 10-year contract. The Fox mine produced 8,352 tons of zinc, a considerable improvement over 1972. However, the annual report indicates that the overall recovery of zinc from ore was only about 42 per cent. The zinc circuit in the mill was modified, so that at least the grade of the zinc concentrate was raised to a satisfactory level. At the end of 1973, ore reserves were recorded at 11,800,000 tons averaging 2.15 per cent zinc and 2.23 per cent copper. Work commenced during 1973 at deepening the mine from the 2,000-foot to the 2,200-foot level by means of an access decline. Exploration in 1973 by the Freeport Canadian Exploration Company resulted in the discovery on the south shore of Reed Lake of a one million-ton-deposit, grading about 4 per cent zinc and 2 per cent copper.

British Columbia. Ore production at Cominco's Sullivan mine was substantially higher in 1973 compared to 1972 in spite of considerable difficulty encountered with spontaneous oxidation of sulphides from certain parts of the mine which resulted in "hot" ore. The company developed suitable mining procedures to deal with this situation. The Sullivan mine produced 102,559 tons of zinc, and the H.B. mine, reopened in January 1973, produced 13,653 tons. The company has some latitude in mining the grade of ore it chooses at Sullivan, and during 1973 the combined grade mined was 10 per cent distributed evenly between lead and zinc. In 1974 the company plans to mine a slightly higher proportion in zinc. The H.B. operated at a combined grade of 5.3 per cent, of which approximately 1.0 per cent is lead and the remainder zinc. At year end, combined reserves at the Sullivan mine and H.B. mine were reported at 62,000,000 tons with a combined lead-zinc grade of 10.8 per cent.

Reeves MacDonald Mines Limited continued production at its Annex mine on the Pend-d'Oreille River. Ore reserves on the property are nearing depletion, but exploration is currently at progress on the adjoining Hecla Mining Company property. If successful, it would permit the company to operate beyond July 1974.

Western Mines Limited produced 354,240 tons of ore in 1973 compared to 379,405 tons in 1972, but the total amount of zinc recovered was 27 per cent higher at 26,372 tons. The Lynx pit produced 20 per cent of the mill feed, the Lynx underground mine 59 per cent and the Myra underground mine 21 per cent. The lower tonnage milled was caused, in part, by difficulties in obtaining adequate labour and partly by limits set by the pollution-control permit. A new chlorine plant to destroy cyanide and precipitate heavy metal was installed at a cost of approximately $100,000. Ore reserves at the end of 1973 are reported at 1,671,100 tons grading 7.9 per cent zinc, 1.3 per cent lead, 1.3 per cent copper, 2.2 ounces of silver and 0.06 ounce of gold per ton. The company plans to drive a long exploration adit on the adjoining Price property in 1974.

The Bradina mine of Bralorne Resources Limited, which opened in 1972, closed on August 31, 1973. The Silmonac mine recorded a much lower output in 1973 and is expected to close shortly unless new ore is discovered.

In the Robb Lake area of northern British Columbia, Barrier Reef Resources Ltd. and other companies are exploring lenticular occurrences of stratiform lead-zinc mineralization occurring in conditions similar to the Pine Point deposits. The mineralization is widespread and values of 5 to 10 per cent combined lead-zinc over "mineable width" are not uncommon, but lenses outlined to date are not large enough for mining. Exploration will continue in 1974.

Yukon Territory. Anvil Mining Corporation Limited has shown consistent improvement in its operations in 1973, producing 142,680 tons of zinc from 2,899,145 tons of ore grading 6.37 per cent zinc, 4.88 per cent lead and about one ounce of silver per ton. The company completed an expansion of the concentrator from 8,000 to 10,000 tons per day, so that lower grade ore can be treated while the concentrate output is maintained at current high levels. The company intends to mine just over 3.5 million tons of ore in 1974. Anvil has reserves of 52,600,000 tons grading 5.5 per cent zinc, 3.1 per cent lead and one ounce of silver per ton, sufficient for 15 years of operation. The company continues active exploration in a number of promising areas of the Yukon Territory. United Keno Hill Mines Limited, produced 672 tons of zinc from its high-grade silver mines, Elsa, Husky and No Cash, near Mayo. This is less than half of last year's total because the mining was redirected into ores rich in lead. The grade of the 94,819 tons mined in 1973 was 1.0 per cent zinc, 4.0 per cent lead and 34.62 ounces of silver per ton. Ore reserves of the mine are limited.

Barrier Reef Resources Ltd. made what appears to be a most important discovery, 125 miles northeast of Mayo, known as the Goz Creek property. The main mineralized beds continue for a distance of 4,400 feet and vary in thickness from 25 to 40 feet. The dip is gentle to the south. The mineralization continues over several thousand feet into adjoining properties, mainly of Cypress Resources Limited. Substantial zinc values and low-lead values are reported in many surface samples taken across the strike of the beds. Exploration in 1974 should prove the economic viability of these deposits. Conwest Exploration Company Limited and Brinco Limited will carry out a major drilling program in 1974 on the above deposit. Exploration in the Summit Lake area, mainly by Placer Development Limited continued in 1973. The mineralization there is very extensive and intermittent; and much more remains to be done before the full potential of this area can be assessed.

Hudson Bay Mining and Smelting Co., Limited maintained interest in their Tom deposit near the MacMillan Pass at the boundary of the Yukon and Northwest Territories. This deposit represents a significant reserve for the future and contains 8,645,000 tons grading 8.4 per cent zinc, 8.1 per cent lead and 2.75 ounces of silver per ton. The silver values in this deposit appear to be substantially higher in part of the deposit.

Northwest Territories. Pine Point Mines Limited recorded a slightly lower production of zinc in concentrates at 216,589 tons against 220,045 tons in 1972 mainly because ore grade was slightly richer in lead and poorer in zinc. The company completed mill modifications by adding two stages to the zinc cleaning circuit and an acid leach circuit which effectively lowers MgO content in zinc concentrates to meet customer limits of this contaminant. Ore reserves at the end of 1973 were 38,255,800 tons averaging 5.7 per cent zinc and 2.3 per cent lead. In addition the company reports that some 22 million tons of mineralization that is subeconomic under current conditions have been outlined during the period 1969 to 1972. About 70 per cent of Pine Point concentrates are processed in Canada, chiefly by Cominco, 25 per cent in Europe and the rest is exported to India. Near Bathurst Inlet, Cominco completed its fifth season of exploration on the Hackett River property of Bathurst Norsemines Ltd. Exceptionally high-grade intersections in silver and zinc were encountered during the latest drilling. There is little doubt that this is an important, multimillion ton deposit, but overall grades must be exceptionally high since capital and operating costs for such a property, would probably be more than double those in more Southern latitudes.

One of the richest deposits in Canada, the Polaris property on Little Cornwallis Island, is held by Arvik Mines Ltd. (Cominco Ltd. 75%; Bankeno Mines Limited 25%). An underground program consisting of a 5,305 foot incline adit and some 600 feet of drifting, together with extensive underground diamond drilling, was completed at the Polaris property. This work provided more detailed information on the grade, tonnage and mining conditions which prevail at this 25 million ton orebody. A shipment of 3,600 tons of ore for large-scale metallurgical testing was made in 1973. Preliminary results indicate no significant difficulties. A feasibility study for production was still underway at year-end. Cominco is directing its attention to resolving the problems attendant upon transporting the year's production to markets from this remote location in the very short shipping season available. Mineral Resources International Limited (MRI) and Texasgulf Inc. have a 6.9-million-ton deposit grading 14.1 per cent zinc, 1.4 per cent lead and 1.8 ounces of silver per ton in the north part of Baffin Island on Strathcona Sound. The company completed a feasibility study to put the property into production by 1977/78, and negotiations are underway with the federal government for infrastructure support. The shipping season at Strathcona Sound is a little longer than at Little Cornwallis Island, where it is estimated at a maximum of 35 days, but the logistics of production are no less difficult to resolve. In any case, mining at these two arctic localities will take place before or at the end of this decade.

Metal production. Production of refined zinc at the four Canadian plants in 1973 was 587,038 tons or 12 per cent higher than in 1972 after a 28 per cent rise the previous year. Approximately 75 per cent of the Canadian zinc production is High Grade (HG – 99.9%) and Special High Grade (SHG – 99.996%) form, the rest in other grades. The production was distributed as follows:

	Production Refined Zinc	Rated Annual Capacity
Canadian Electrolytic Zinc Limited, Valleyfield, Quebec	148,748	145,000*
Cominco Ltd., Trail, B.C.	248,331	295,000
Hudson Bay Mining and Smelting Co., Limited, Flin Flon, Manitoba	82,882	79,000
Ecstall Mining Limited, Hoyle, Ontario	107,079	120,000**

* Expansion to 225,000 tons by 1975 is underway.
** Expansion to 150,000 tons by mid-1974 is underway.

Production of refined zinc in 1973 was 92 per cent of rated capacity compared to 88 per cent in 1972 and only 77 per cent in 1971. Canadian Electrolytic Zinc Limited (CEZ) treated concentrates from Quebec (Mattagami mine and Orchan mines) and from Ontario (Geco mine and Mattabi mine). In early 1973, construction started on a 50 per cent expansion of the plant at an originally estimated cost of $32 million. Shortages of a wide range of construction materials have caused some delays, but the target for mid-1975 completion should be met. Construction costs are escalating rapidly, and the outlay for this project is now expected to exceed $50 million. Noranda is providing 50 per cent of the capital required for expansion and is increasing its ownership of the plant to 22.67 per cent from 9 per cent currently. The balance of the plant will be owned by Mattagami Lake (51.67 per cent), Orchan (15.83 per cent) and Kerr Addison Mines Limited (9.83 per cent). The zinc plant at Hoyle of Ecstall Mining Limited (Texasgulf Inc.) which came on stream in mid-1972, operated satisfactorily and reached near-capacity level of production in the second half of 1973. The company began an expansion program to 150,000 tons per year which will be completed by mid-1974. A new tin recovery circuit was added to the concentrator in December 1973.

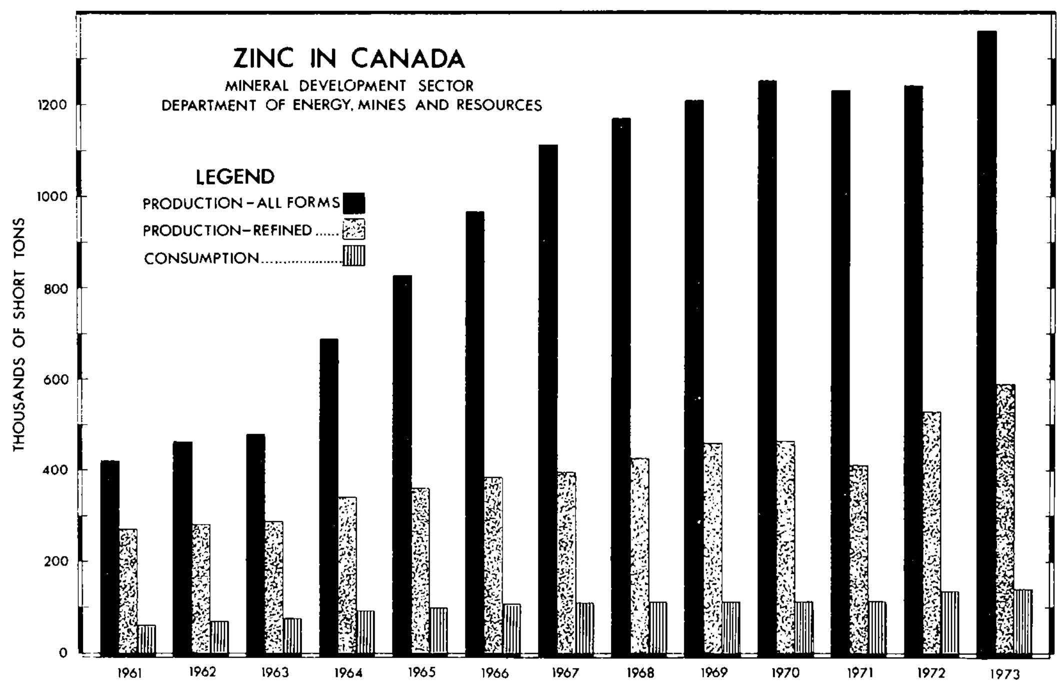
Hudson Bay Mining and Smelting Co., Limited produced a record 82,882 tons of zinc in 1973 or 7.9 per cent more than in 1972. Some 10,953 tons of zinc oxide from smelter-stack dust and 32,869 tons from the fuming furnaces were delivered to the zinc refinery allowing it to operate above its theoretical-rated capacity. About 72 per cent of the concentrates are from company mines and 28 per cent is purchased. The company completed construction of an 825-foot stack at its Flin Flon smelter, as part of a $6-million program to improve air quality. The system will be fully operational by November 1974. Construction of an anode-casting plant was started in early 1973 and it is expected to be operating early in 1974.

Cominco produced 248,748 tons of zinc in 1973 compared to 243,000 in 1972. The increase for the year would have been larger but production was adversely affected by the national rail strike during last summer and an electrical fire at the zinc plant in December which caused an approximate loss of 12,000 tons of refined zinc. Modernization of part of the zinc electrowinning plant, at a cost of $2.5 million began and, when completed in early 1974, will result in significantly improved working conditions in this labour intensive section. A 10,000 ton-per-year increase in refined zinc capacity will also result.

Table 7. Canada producers' domestic shipments of refined zinc, 1971-73

	1971	1972	1973
	(short tons)		
1st Quarter	27,561	38,336	33,169
2nd Quarter	32,258	41,925	37,125
3rd Quarter	29,927	26,212	36,322
4th Quarter	32,418	31,226	41,920
Total	122,164	137,699	148,536

Source: Statistics Canada.



Metal consumption. Producers' domestic shipments, which are a measure of apparent consumption were 148,536 tons in 1973 compared to 137,699 tons in 1972. Buoyant domestic consumption which began in early 1972 continued throughout 1973 and is likely to continue for most of 1974. As shown in Table 1, Statistics Canada measures consumption at the reported consumer level and consistently reports primary consumption below levels of shipments. Some of the difference is due to incomplete coverage and some to direct re-exports of metal originally acquired for domestic consumption by companies which took advantage of higher prices overseas. Increases in galvanizing and die-casting uses accounted for the moderate increase. Consumption of secondary zinc is just less than 5 per cent of the total, which is considerably below U.S. levels and is expected to increase over the next few years.

World industry

Mine production. World mine production of zinc in 1973 increased only by 65,300 tons to 4,928,400 tons which is less than expected. Peru was the only country with a substantial increase, followed by modest increases in Canada, Finland, Spain, Sweden and Yugoslavia. Offsetting these were decreases in production in Japan, Australia and Italy. Mexico and U.S.A. and West Germany, the only other substantial producers, remained almost static. New mining projects now under construction or completion have a potential of adding some 320,000 tpy in 1974 and 1975, offset by a decline of some 80,000 tpy in mine closures. In 1974, the largest expected increases will be from full production at Cominco's (Greenex) Black Angel mine in Greenland (90,000 tons per year), followed by The New Jersey Zinc Company, Elmwood mine in U.S.A. (20,000 tpy). In addition, a number of small new mines or increases in production will occur in U.S.A., Canada, Japan, Peru, India, Brazil, Bolivia, Nicaragua, Spain, Yugoslavia and Guatemala. For 1975, we expect full production from the Sturgeon Lake mine in Canada (34,000 tpy); and possibly full production from the Thai Zinc Co. Ltd. mine at Mae Sot in Thailand (30,000 tpy); an increase of production by 20,000 tons per year at the Prieska mine in South Africa; the reopening of the Park City mine in the U.S.A. (20,000 tpy); an expansion of the Matilda mine in Bolivia (20,000 tpy); and the reopening of the Sonarem mine in Algeria, which eventually will produce 50,000 tpy of zinc. Beyond 1975 the largest mine development is the Navan mine of Tara Exploration and Development Company Limited in Ireland that plans to construct a 10,000 ton-per-day concentrator and has a producing potential of approximately 200,000 tpy of zinc. During 1973, Noranda has agreed to provide $6 million in interim financing. Both Noranda and Cominco have acquired a substantial interest in Tara. New mines will be opened by Société Minière et Métallurgique de Penarroya, S.A. in France (Saint Salvy–25,000 tpy by 1976) Andaluza de Piritas Espanola, controlled by Metallgesellschaft A.G. in Spain (Aznacollar–65,000 tpy by 1977), Exploracion Minera Internaciónal (España) S.A. (Exminesa) controlled by Cominco also in Spain (Rubiales–60,000 tpy by the end of 1977), and St. Joe Minerals Corporation in Australia (Woodland–55,000 tpy by 1977). Further expansion in mine capacities are expected in India, Sweden, Mexico, Canada, Peru, Turkey, Yugoslavia and the Dominican Republic. All these developments may not be fully adequate to meet demand for mine concentrates in the period to 1980.

At about the end of the present decade or the early 1980's some major production may become available from the Strathcona Sound deposit (Mineral Resources International Limited) as well as Arvik's deposit (Cominco) in the Canadian Arctic and the Mount Isa deposit in Australia. It is also possible that mining could start earlier than currently expected at the large Gamsberg deposit in South Africa (O'okiep Copper Company Ltd.–Newmont Mining Corporation).

Table 8. World[1] mine production of zinc, 1971-73

	1971	1972	1973^p
	(short tons)		
Canada	1,400,217	1,401,693^r	1,488,533
United States	552,257	525,581	522,274
Australia	459,663	518,306	478,954
Peru	343,259	352,739	450,845
Japan	324,520	309,749	290,900
Mexico	287,923	296,962	295,419
West Germany	162,811	153,001	157,189
Sweden	105,381	121,034	126,435
Italy	116,845	113,097	88,846
Republic of Zaire	120,152	110,231	..
Ireland	96,452	104,719	91,492
Spain	101,413	98,106	102,956
Yugoslavia	84,657	81,902	97,003
Zambia	75,949	77,713	80,689
Finland	56,108	55,005	64,595
Other countries	437,335	478,848	589,212
Total	4,724,942	4,798,686	4,925,342

Sources: International Lead and Zinc Study Group. For Canada, Statistics Canada.
[1]Total figures in respect to "other" countries exclude data relating to Bulgaria, China, Czechoslovakia, East Germany, Poland, Romania, North Korea and the U.S.S.R.
^{p}Preliminary; .. Not available; ^{r}Revised.

Metal production. World* metal production in 1973 totalled 4,603,200 tons compared to 4,532,200 in 1972. This modest rise followed an 8.7 per cent rise between 1971 and 1972. Producers' stocks at the beginning of the year amounted to 268,000 tons and declined to 173,000 tons at the end of 1973. They reached a peak of 445,000 tons at the end of January 1971. Zinc smelters and refineries operated at or near their capacities which is about 90 per cent of the total world rated capacity. Labour problems, concentrate supply and delivery problems and some plant breakdowns contributed to losses that the market could ill afford during this very tight zinc supply situation.

The only important industrial country that showed a continuing decrease in zinc production was the United States which registered a 16.5 per cent (revised) drop between 1971 and 1972 and a further decline of 18.6 per cent in 1973. Of the 23 countries reporting production to the International Lead and Zinc Study Group, 12 recorded increases of metal production, the largest being in Belgium, West Germany, Italy, Canada and Japan.

In the 1970 to 1973 period, several obsolete or uneconomic smelters were closed in U.S.A., Japan, Britain, Canada, Belgium, West Germany and Holland. In each case except in the U.S.A. and Canada, these were directly replaced by modern or completely rehabilitated facilities of higher total capacity.

In Central America, Mexico is increasing its metal output which remained static for four years with the commissioning in December of 1973 of its new Torreon zinc plant (120,000 tpy) constructed at a cost of $72 million. Asarco Mexicana and Japanese companies are considering the possibility of constructing by 1977, a 70,000 to 100,000 tpy zinc plant at San Luis Potosi which would replace some obsolete facilities. Towards the end of 1973, a strike in Mexico shut down Asarco's facilities and the government imposed a ban on the export of Mexican zinc. Peru, which now produces 66,000 tons of zinc per year at the Cerro de Pasco Corporation La Oroya plant, plans to complete construction of a new 100,000 tpy electrolytic refinery near Lima by 1976. Brazil plans to expand its 13,000 tpy plant at Minas Gerais to 63,000 tpy by 1976/77.

Following the closure of six smelters in the United States between 1969 and 1971 and the closure of the large Anaconda company's plant in 1972, the full impact of the cutback in metal production was felt in 1973 with total production down to 575,000 tons from a high of 1,111,000 tons in 1969. Adding to the decline in 1973 was the closure of the Blackwell plant (Oklahoma) coupled with start-up problems at the rehabilitated Sauget plant (Illinois) which was expected to replace Blackwell's output. American Smelting and Refining Company (Asarco) will close its Amarillo, Texas smelter in May 1975. Thereafter the U.S.A. outlook appears to be for the better with St. Joe Minerals adding 40,000 tpy to the capacity of their Monaka plant, Pennsylvania; Bunker Hill Company either entirely replacing or modernizing and expanding its Silver King plant in Idaho; Asarco adding 20,000 tpy to their Corpus Christi plant in Texas; National Zinc Co. replacing its Bartlesville, Oklahoma smelter and The New Jersey Zinc Company planning the replacement of its Palmerton, Pennsylvania facility. Furthermore, Asarco has delayed its expected announcement on the new 180,000 tpy plant at Stevensport, Kentucky, which could be in full production by 1977. Construction, at a cost of $150 million, would take about two years.

In Europe, Hoboken-Overpelt of Belgium will commission a new 88,000 tpy electrolytic refinery at Overpelt and close its retort plant in 1974. Cie Royale Asturienne des Mines S.A. will also replace its Auby plant in France with expanded electrolytic facilities by 1976. In Italy, AMMI's new ISF Portovesme plant will continue to be expanded to a total of 77,000 tpy by the end of 1974 and Pertusola's Crotone plant will be

* Excluding Communist Countries.

Table 9. World[1] production of refined zinc, 1971-73

	1971	1972	1973p
	(short tons)		
Japan	789,695	887,139	928,917
Canada	410,643	524,885	587,038
United States	847,346	706,911	575,406
West Germany	289,467	395,399	434,420
Australia	292,884	333,559	324,189
Belgium	229,170	280,207	304,568
France	241,075	288,254	284,506
Italy	153,882	171,850	190,810
Spain	107,034	119,049	122,136
Britain	128,419	81,350	92,374
Norway	68,780	80,799	88,845
Finland	70,210	89,397	88,073
Mexico	91,933	92,374	83,776
Peru	64,595	66,139	74,516
Republic of Zaire	69,446	73,855	70,548
Netherlands	48,500	53,241	49,493
Other countries	265,559	287,814	303,589
Total	4,168,638	4,532,222	4,603,204

Sources: International Lead and Zinc Study Group. For Canada, Statistics Canada.
[1]Total figures in respect to "other" countries exclude data relating to Bulgaria, China, Czechoslovakia, East Germany, Poland, Romania, North Korea and U.S.S.R.
pPreliminary.

expanded by 22,000 tpy in 1976. Netherland's new 165,000 tpy Budelco plant that started production in late 1973, should be operating to full capacity by the beginning of 1975; it replaces the old 55,000 tpy plant that closed in 1973. In Spain, Asturiana del Zinc at Oviedo and Espanola del Zinc at Cartagena, plan to expand their operations by 50,000 tpy and 16,000 tpy respectively by 1975. Finland's Outokumpu Oy is expected to expand its plant by 66,000 tpy by 1975 and Cominco will probably have a new 110,000 tpy electrolytic plant operating in Britain by or before 1977. Algeria began construction of a 44,000 tpy plant at Ghazouoet which should be completed by 1975-76, and in South Africa, Zincor will further expand its Vogelstruisbult plant by 25,000 tpy by 1977. A new plant near Kayseri, Turkey is being built for Cinko-Kursun Metal Sanayii AS by the Canadian firm of Surveyer, Nenniger and Chenevert Inc. of Montreal. It will consist of Waeltz kilns plus an electrolytic plant to process oxide ore and will have a capacity of 44,000 tpy. The target date for completion is 1975 and for full production in 1977. Thailand has a very rich oxide deposit at Moe Sod and has announced plans for an integrated development by or before 1977 which includes a 44,000 tpy electrolytic plant. India has planned to add capacity for some years at its Udaipur and Binani (Cominco) plants and may do so by 1978/79. Hindustan Zinc Co. also plans to commission a new 33,000 tpy plant at Vizag by 1978/80. Total Indian capacity by the end of this decade should be about 143,000 tpy, still not enough to satisfy growing domestic demand.

In Japan, Mitsui Mining & Smelting Co. Ltd. is increasing the capacity of its new Hikoshima plant by some 26,000 tpy from the current 66,000 tpy by the end of 1974. Plans were announced to double the capacity of this plant to 185,000 tpy by 1976 but might have to be postponed because the company has difficulty in securing a power commitment. Akita Co., which recently commissioned the

		Type and Location of New and Expanded Smelter Capacity	Increase in Capacity (short tons per year)
1974	Canada	Electrolytic (expansion), Timmins	30,000
	Australia	Electrolytic (expansion), Risdon	22,000
	Algeria	Electrolytic (new), Ghazaouet	44,000
	Belgium	Electrolytic (new), Overpelt (replacing 70,000)	88,000
	Mexico	Electrolytic (new, further expansion), Torreon	90,000
	U.S.A.	Electrothermic (expansion), Monaka, Pa.	40,000
1975	Japan	Electrolytic (further expansion), Iijima	86,000
	Japan	Electrolytic (further expansion), Hikoshima	26,000
	Spain	Electrolytic (expansion), Oviedo	50,000
	Spain	Electrolytic (expansion), Cartagena	16,000
	Canada	Electrolytic (expansion), Valleyfield, Que.	80,000
	Canada	Electrolytic (expansion), Trail, B.C.	10,000
	U.S.A.	Electrolytic (expansion), Corpus Christi, Tex.	20,000
1976	U.S.A.	Electrolytic (new), Stevensport, Ky.	180,000
	Peru	Electrolytic (new, first phase), Lima	44,000
	France	Electrolytic (replacing 88,000), Auby	110,000
	Brazil	Electrolytic (expansion), Très Marias	45,000
	Finland	Electrolytic (expansion), Kokkola	66,000
	Italy	Electrolytic (expansion), Crotona	22,000
1977	India	Electrolytic (expansion), Udaipur	20,000
	India	Electrolytic (new), Vizag	33,000
	Mexico	Electrolytic (new), San Luis Potosi	110,000
	India	Electrolytic (expansion), Kerala	22,000
	Peru	Electrolytic (further expansion), Lima	33,000
	Thailand	Electrolytic (new), Amphoe	44,000
	Turkey	Electrolytic (new), Kayseri	44,000
	South Africa	Electrolytic (expansion), Vogelstruisbult	25,000
	U.S.A.	Electrolytic (replacing 45,000), Bartlesville	60,000

86,000 tpy Iijima plant has also announced plans to expand to 172,000 tpy by the end of 1975. The Annaka refinery (Toho Zinc Co. Ltd.) has been operating below capacity for over two years because of local cadmium pollution problems; it is expected that the company might return to full production in 1974. Large increases in smelting capacity in Australia are not expected before 1977, but Electrolytic Zinc Company of Australia Ltd. is expected to boost its operating capacity at the Risdon plant to about 231,000 tpy by mid-1974 and the Cockle Creek, ISF plant will operate closer to its design capacity.

The accompanying table shows new and expanded zinc plant capacity planned up to 1977. Comparison with the 1972 review indicates that construction or completion dates for several projects have been deferred by one year. Not given in the table are possible developments and increases beyond 1977; these could include plants in U.S.A., Britain, Bolivia, Canada and Ireland.

World consumption and trade

A preliminary estimate of world consumption of zinc in 1973 is 5,206,600 tons or 6.8 per cent higher than in 1972 after a rise of 10.9 per cent between 1972 and 1971. European consumption increased by 3.6 per cent, that of Japan 15.3 per cent and that of the U.S.A. 5.1 per cent. These preliminary estimates are frequently subject to substantial revisions: witness the International Lead and Zinc Study Group estimate of a rise in world consumption of only 7.7 per cent between 1971 and 1972 reported in our 1972 review and currently revised to 10.9 per cent.

Of the 29 countries that reported consumption to the International Lead and Zinc Study Group, 22 showed increases in consumption for the year, a high record similar to last year. Generally, consumption was strong throughout the year, with small signs of easing in November and December, particularly in the U.S.A., but early results for 1974 indicate a continuation of buoyant demand.

The major consuming areas in the world, excluding communist countries are western Europe, the United States, and Japan, which among themselves used 4.29 million tons of zinc in 1973 or 82.4 per cent of the total world consumption, compared to 83.7 per cent in 1972. By contrast, these areas produced only 1.65 million tons or 33.4 per cent of the world's mine output of zinc. The remaining requirements, approximately 2.64 million tons, were imported as either zinc in concentrates or as refined metal. Japan and western Europe imported mainly concentrates whereas the United States imported 74.7 per cent of its requirements as metal and 25.3 per cent as concentrates. In 1973 the major consuming areas produced 3.24 million tons of refined metal, or 70.4 per cent of world production. This illustrates the fact that most of the world's smelting and refining capacity is concentrated in industrialized areas which must depend largely on imported concentrates. This relationship is slowly changing; for example, the net zinc metal production of these countries in 1973 was equivalent to 75 per cent of their demand compared to 89 per cent in 1968. Canada, Peru, Australia and Mexico, in that order, are the largest exporters of zinc, jointly accounting for approximately 78 per cent of trade in concentrates and 43 per cent of trade in metal.

Table 10. United States zinc consumption by end-use, 1972-73

	1972	1973^p
	(short tons)	
Galvanizing	518,204	529,107
Brass products	192,147	196,195
Zinc-base alloy	579,761	597,561
Rolled zinc	45,216	39,135
Zinc oxide	51,992	59,640
Other uses	31,029	27,299
Estimated undistributed consumption	–	40,000
Total	1,418,349	1,488,937

Source: U.S. Bureau of Mines, Mineral Industry Surveys, Zinc Industry in December 1973.
^{p}Preliminary. – Nil.

Outlook

To compose an outlook for zinc under the cloud of the energy crisis is difficult because the long-term impact of energy costs on Western economies has not been adequately assessed. Prior to the crisis, experts were able to forecast a fairly long period of tight supply for zinc. World metal consumption exceeded production by some 330,000 tons in 1972, but the deficit was readily made up by substantial reductions of inventories and releases from non-commercial stockpiles. By 1973, the unexpectedly strong rise in demand could no longer be fully satisfied. The major problem became a lack of sufficient smelting capacity, compounded by the closure of obsolete plants during the year, and the late start-up of some new electrolytic facilities. Producers and consumers ran their stocks to the lowest possible levels, and the additional release of some 268,000 tons from the U.S. stockpile was not enough to satisfy the demand. This situation of tight metal supply was expected to continue throughout 1974, with much apprehension that this source will be exhausted early in 1975. At the same time (1973, 1974) world mine production was forecast to barely equal metal production capacity. Although the world shortage of metal producing capacity is going to ease by 1975-77, substantial increases in mine production after 1974 could not be foreseen. There is a strong probability therefore that the tightness in the zinc market will continue up to 1977 at least, the shortage of metal productive capacity being replaced by a scarcity of concentrates. Those countries, e.g., the U.S.A., that intended to increase their metal producing capacities would have to do it hand-in-hand with planned increases in mine output, or risk major supply difficulties in the concentrate markets.

Once the depth of the energy crisis becomes clearer and subject to analysis various discounting parameters might have to be imposed on the original evaluation. Indeed, even at the time of writing (May, 1974) it is certain that an irreversible effect of the crisis will be an acceleration of a trend towards more small-car production. Since, on an average, a small car uses less than 40 pounds of zinc die-cast alloy as compared to over 50 pounds in a standard model, a substantial saving of zinc is forecast from this sector. Furthermore, more substitution by aluminum to save weight is also expected. Balancing this is a trend to conservation and durability which implies excellent demand for the galvanizing sector for many years.

Finally, a longer-term assessment of world mine producing capacities suggest that, even near the end of the current decade, mine supplies might fall considerably short of smelter and refineries requirements to supply strong markets.

Zinc uses

Zinc is used to galvanize steel and to make castings, alloys, sheet, zinc oxide and other compounds.

In galvanizing, zinc is applied as an impervious, corrosion-resistant coating to iron and steel products to prevent rust. Galvanized sheet is used in industrial, agricultural and residential construction; for guard rails, culverts and signs in road construction; and for rocker panels and other vulnerable parts of automobiles. Galvanized reinforcing rods are used in the construction industry, and galvanized structural members in bridge construction to save on painting and maintenance costs. Wire, pipe and numerous other articles are galvanized where protection is required. In the automotive industry the usage of galvanized sheet has been relatively steady over the last several years, averaging 160 to 170 pounds (using 11 to 12 pounds of zinc) per vehicle, but has declined to approximately 100 to 120 pounds in the 1971/73 models. The 1974 and 1975 consumption is expected to stabilize at this lower level or possibly at a slightly increased level because of the expanding availability of one-side galvanized sheet and, consequently, higher welding productivity. Zinc die-cast components might decrease considerably in the 1975 and future models.

Die-castings made of zinc-base alloys are used in the automotive industry for such parts as grilles, headlight and taillight assemblies, fender extensions, door and window hardware, carburettors and fuel pumps. On average, new models contain about 50 lbs. of zinc in these parts. Zinc-base die-castings are used as components in household appliances such as washing machines and refrigerators, and in plumbing and hardware supplies. The alloys most commonly used for die-castings are made of special high-grade zinc (99.99 per cent or higher) to which is added 4 per cent aluminum, 0.04 per cent magnesium and up to 1 per cent copper. A new application which holds great promise is superplastic zinc alloy. It is a material containing 78 per cent zinc and 22 per cent aluminum, which behaves like a metal at normal temperatures and like a plastic when heated to just over 500° F for forming. It has excellent pressure-vacuum forming characteristics with excellent deep-drawing and elongation characteristics. It has very good electrical conductivity and is highly corrosion-resistant. It will take electroplating or painting. Principally because of its ductility it is called a superplastic alloy, and will be used to manufacture pressed parts for the automobile and appliance industry.

Brass, a copper-zinc alloy containing as much as 40 per cent zinc, has many applications in the form of sheets and strips, tubes, wire, rods, castings and extruded shapes. Rolled zinc is used in Canada mainly for making dry-cell batteries in which zinc serves both as the negative pole of the cell and as the container. In Europe, rolled zinc is a popular roofing and roof-flashing material. Other uses of rolled zinc are terrazzo strip and anticorrosion plates for boilers, dock pilings and ships' hulls. Zinc, in the form of 0.2 to 0.3 micron-size particles of zinc oxide, is finding increasing use as the major constituent of the paper coating for coated-paper electrostatic copiers. Demand for this application is expected to grow at a faster rate than for any other in zinc over the next few years. Zinc oxide is also used in compounding rubber and in making rayon yarn, ceramic materials, inks, matches, and many other commodities.

Weather-resistant paints based on zinc oxide and zinc dust provide one of the most effective and durable protective coatings on outside surfaces, especially metallic. A new application is a two-coat paint system known as Zincrometal that can be hot-rolled on coiled steel. It is applied on a chromium base coating. This system is reported to have corrosion resistance similar to galvanized steel, and could replace it in some applications. It has, however, important limitations, since tests show that it gives little if any sacrificial protection on scratched surfaces or cut edges.

Zinc dust, which is a finely divided form of zinc metal, is used in the process of printing and dyeing textiles, in zinc-rich paints, in purifying fats and precipitating gold and silver from cyanide solutions. The more important industrial compounds of zinc are zinc sulphide, which in combination with barium sulphate forms the pigment lithopone; zinc sulphate, used in rayon fibre manufacture; and zinc chloride, a wood preservative.

The International Lead Zinc Research Organization, Inc. (ILZRO) is the main body assisting industry to find new uses for lead and zinc. Promotion and advertising of new zinc products and processes is carried on by the Zinc Institute, Inc., which opened a branch office in Toronto in 1968. The development of thin-walled die-castings and of improved zinc-based die-casting alloys has done much to expand the use of zinc as a die-casting metal in competition with alternative materials such as aluminum and plastics.

Prices

Prices of zinc metal moved upward throughout 1973. The Canadian price (basis North America) moved up 64% from 19.5 to 31.0 cents per pound and the European producers' price moved by 73% from £173 per metric ton to £300. Due to the devaluation of the pound sterling the European price rise was about equivalent to that in North America. These are the only truly relevant prices that reflected the unusually tight supply situation, the devaluation of currencies and rapidly rising costs of production throughout the year.

The U.S.A. average prices remained at low levels on account of price restrictions imposed by the Cost of Living Council, beginning the year at 18.6 cents a pound and rising modestly to 20.6 cents a pound by November. The domestic pricing situation changed completely on December 6, 1973 when zinc was removed from price controls.

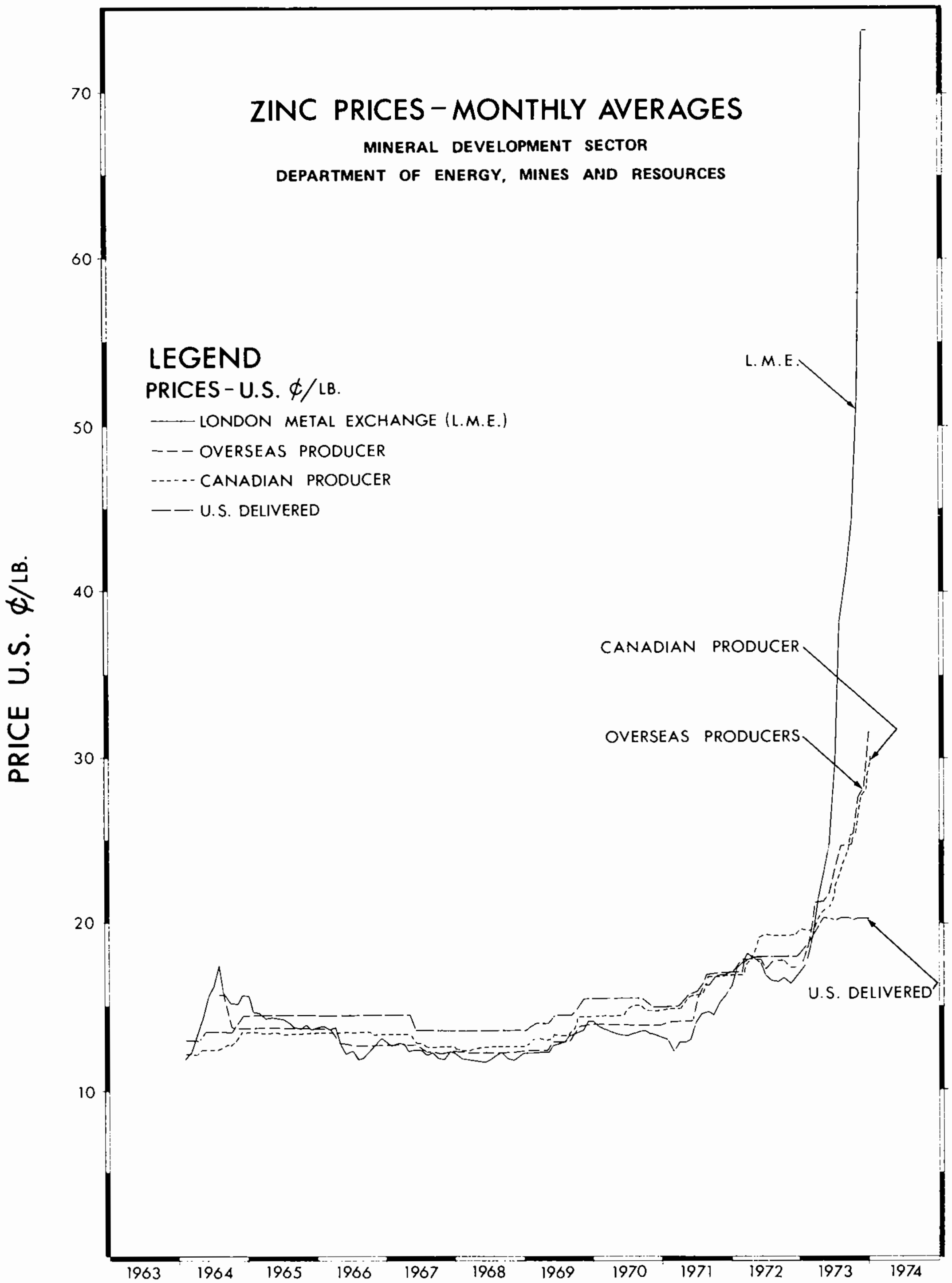
The London Metal Exchange (LME) price, behaved erratically, increasing from a daily low of £160¼ a metric ton on January 2 to a high of £875 on December 5. This price, until October, reflected the increasing difficulty that merchants had in acquiring small quantities of metal on the open market for consumers not covered by long-term sale agreements or for consumers that required incremental supplies above the volume contracted under prevailing producer prices. Near the end of the year, when the LME stocks fell to below 5,000 tons, an unprecedented tight situation developed in nearby contract positions, forcing short covering and prices to levels above £800 per ton. Such technical moves no longer simply reflect an overall tight zinc supply situation as they are heavily weighted by speculative activities.

Throughout 1973, European supply-demand conditions were the prime factors for zinc price increases; these were followed, sometimes with considerable lag, by increases in North America. Thus, when producers raised the "European producers' price" for the first time on February 28 by £17 to £190 per ton, the North American price was raised by 1.5 cents a pound to 21.0 cents on March 5. The two subsequent increases of £15 each for the European price (June 12 and July 11) resulted in an increase of 4 cents to 25.0 cents a pound for North American zinc. The early price increases in Europe, were partly attributed to weakness of the pound sterling. By mid-year, metal began to be in short supply and a further raise of £30 to £250 a ton of September 24 was followed the next day by an upward move of 3 cents to 28 cents a

Table 11. Monthly zinc prices in 1973

	Canada	United States	Producer basis (outside North America)	London Metal Exchange
	cents/lb	cents/lb	£/metric ton	£/metric ton
Jan.	19.5	18.6	173.0	164.1
Feb.	19.5	19.3	173.0	173.7
Mar.	20.9	19.7	190.0	191.9
Apr.	21.0	20.5	190.0	206.6
May	21.0	20.6	190.0	216.9
June	22.1	20.6	200.0	254.6
July	22.9	20.6	213.9	331.4
Aug.	24.9	20.6	220.0	369.2
Sept.	25.1	20.6	220.0	403.2
Oct.	27.7	20.6	250.0	478.6
Nov.	27.7	20.6	255.7	680.1
Dec.	29.9	27.5	294.1	700.2
Year	23.5	20.8	214.1	347.5

Source: International Lead and Zinc Study Group Bulletin.


ZINC PRICES – MONTHLY AVERAGES
MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES
LEGEND
PRICES - U.S. ¢/LB.
LONDON METAL EXCHANGE (L.M.E.)
OVERSEAS PRODUCER
CANADIAN PRODUCER
U.S. DELIVERED
L.M.E.
CANADIAN PRODUCER
OVERSEAS PRODUCERS
U.S. DELIVERED
PRICE U.S. ¢/LB.
70
60
50
40
30
20
10
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974

pound on the North American market. The last price increase in Europe to £300 a ton on November 22 was not followed by a Canadian increase in North America to 31.0–32.0 cents a pound until December, and only occurred as a response to general increases that followed the lifting of U.S. domestic price controls. The Cost of Living Council announced complete removal of controls on zinc and the United States producers immediately followed by announcing increases to levels that vary from 28.0 to 32.0 cents per pound for Prime Western zinc. At the end of the year it is apparent that these last increases of producer prices were only reluctantly introduced by Canadian corporations which are cognizant that the long term market stability is best served by adequate supply and reasonable prices. It is noteworthy that by November, when Canadian zinc in U.S.A. was still priced at 28 cents a pound (28.5 cents for Special High Grade (SHG) zinc), Indussa Corporation, Minero Peru and Australian producers sold SHG zinc in North America for 37 to 42 cents a pound.

Until early December, Canadian prices in U.S.A. were quoted delivered and U.S. duty included (0.7 cent a pound) by all producers except Texasgulf, that, starting in August required U.S. customers to absorb the duty. Although after December 6, U.S. producers split, some quoting prices f.o.b. plants and some delivered, Canadian producers maintained their quotations on a delivered basis but no longer included the U.S. duty. Quotas on zinc and lead metal and increased duties were proposed in the U.S.A., but these bills were not passed by the Congress. Nevertheless, similar proposals will be reinstituted during 1974.

Canadian price of Prime Western zinc, fob Toronto and Montreal, during 1973.

	(¢/lb)
Jan. 1 to Jan. 16	19.20
Jan. 17 to March 6	19.50
March 7 to June 10	21.00
June 11 to July 24	23.00
July 25 to Sept. 25	25.00
Sept. 26 to Dec. 11	28.00
Dec. 12 to Dec. 31	31.00

United States price, Prime Western zinc, delivered U.S.A.

	(¢/lb)
Jan. 1 to Jan. 23	18.00 – 18.52
Jan. 24 to March 8	19.00 – 19.50
March 9 to March 14	19.00 – 20.25
March 15 to March 20	19.00 – 20.50
March 21 to April 18	19.25 – 20.25
April 19 to Dec. 9	20.25 – 21.00
Dec. 10 to Dec. 31	28.00 – 32.00

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
32900-1	Zinc in ores and concentrates	free	free	free
34505-1	Zinc smelter, zinc and zinc alloys containing not more than 10% by weight of other metal or metals, in the form of pigs, slabs, dust or granules/lb	free	free	2¢
34500-1	Zinc dross and zinc scrap for remelting, or for processing into zinc dust	free	free	10%
35800-1	Zinc anodes	free	free	10%

United States

Item No.		
		(¢/lb)
602.20	Zinc ores and concentrates, on zinc content	0.67
	Unwrought zinc	
626.02	Other than alloys of zinc	0.7
626.10	Zinc waste and scrap	0.75
603.30	Zinc dross and skimmings	0.75
		(%)
626.04	Alloys of zinc	19
653.25	Zinc anodes	
	On and after Jan. 1, 1970	13
	1971	11
	1972	9.5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1972) TC Publication 452.

Statistical Summary and Tables

General. The statistical summary presents comprehensive statistical data on Canada's mining and mineral industries. The summary is as thorough as possible given the availability of data.

The summary begins with selected economic indicators for Canada from 1952 to 1973. The summary is then divided into ten sections, each containing a number of statistical tables relating to a topic. For more information on the sections and contents, refer to the detailed index on pages 558 and 559.

The principal source of Canadian mineral industry statistics is Statistics Canada. Other federal agencies and departments, provincial governments and company reports are also used. Several sources are used for international data: U.S. Bureau of Mines; American Bureau of Metal Statistics; World Bureau of Metal Statistics; *Metals Week; Engineering and Mining Journal;* United Nations; and the Organization for Economic Cooperation and Development.

Concepts and Definitions. The Statistics for Canada's mineral production were compiled as early as 1886 by the Geological Survey of Canada, then carried on by the Department of Mines until 1921 when Statistics Canada began publishing the series.

The mineral production series is composed of more than 60 commodities. Production of some metals and all nonmetallic mineral products is defined as shipments from the mine or mill and fob values are reported by the producers. Metal recovered from Canadian ores and concentrates treated at smelting and refining operations in Canada represent quantities and are valued using average metal prices. Recoverable metal content calculated after allowing for smelter deductions and refinery losses represent quantities for Canadian ores and concentrates exported and are valued at average metal prices. The mineral production series is not based on the Standard Industrial Classification (S.I.C.) as it is commodity oriented.

The indexes of industrial production for the mining and mineral manufacturing industries are based on the Standard Industrial classification. These indexes depict the changes in output without the distorting influences of price fluctuation. The census value added for the mining and mineral manufacturing industries is an indicator which can be used to compare the contribution of each industry to the total, since value added eliminates inter-industry duplication. The census value added is obtained by deducting the cost of fuel, electricity, process supplies, containers, freight and treatment charges from the value of production.

The mineral trade data reported in Section 2, are composed of selected export and import trade classifications. These selected items are either mine products or closely related to the latter. The value of goods imported is based on the selling price fob point of shipment reported by importers. Export documents define the value to be reported as fob place of lading.

Section 3 deals with consumption of minerals commodities in Canada. Where data are not available directly from the consumers, an apparent consumption is derived by adding imports of a commodity to production and subtracting exports without adjustments for stocks.

Section 4 deals with annual average mineral and metal prices. All prices except gold are obtained from *Metals Week* and are reported in United States currency. The Royal Canadian Mint buying price for gold is reported in Canadian currency. The Wholesale price indexes (1935-39=100) of minerals and mineral include prices of producers, transactions of "middle men" who trade in commodities of a type or in quantities characteristic of primary marketing functions. The Industry Selling price index (1961=100) measures the movements of prices of gross shipments of industries, including inter-industry shipments.

Section 5 outlines the principal statistics of the mining and mineral manufacturing industries. The principal statistics are on the S.I.C. basis and report such items as labour data, cost of fuel and electricity, cost of materials and supplies, gross value of production and value added.

Section 6 is concerned with labour statistics in the mineral industries. An attempt has been made to report all labour-related activities in the mineral industries.

Sections 7 to 10 present a number of statistical tables that serve to portray the role of mineral industries in the Canadian economy. The tables include such items as exploration and development expenditures, ore mined and rock quarried, transportation data, taxation data, investment in mineral activities and ownership information.

The Statistical Summary was prepared by J.T. Brennan and Staff, Statistics Section, Mineral Development Sector.

STATISTICAL TABLES

Table No.

		1952	1953	1954	1955	1956	1957	1958	1959	1960
Gross National Product—current prices	$ millions	24,588	25,833	25,918	28,528	32,058	33,513	34,777	36,846	38,359
Gross National Product—1961 = 100	"	27,968	29,408	29,047	31,788	34,474	35,283	36,098	37,470	38,553
Value of manufacturing industry shipments	"	. .	. .	. .	19,513	21,637	22,178	22,171	23,353	23,444
Value of mineral production	"	1,285	1,336	1,488	1,795	2,085	2,190	2,101	2,409	2,493
Merchandise exports	"	4,282	4,097	3,860	4,258	4,760	4,789	4,791	5,022	5,256
Merchandise imports	"	3,916	4,248	3,967	4,568	5,547	5,473	5,050	5,509	5,482
Balance of trade, current account	"	+151	+443	+432	+698	+1,366	+1,455	+1,131	+1,504	−1,243
Corporation profits before taxes	"	2,640	2,611	2,290	2,965	3,345	3,056	3,075	3,504	3,359
Capital investment, current prices	"	5,424	5,968	5,802	6,531	8,196	8,813	8,488	8,500	8,328
Capital investment, 1961 = 100	"	6,073	6,682	6,458	7,068	8,439	8,944	8,634	8,568	8,281
Population	000's	14,459	14,845	15,287	15,698	16,081	16,610	17,080	17,483	17,870
Labour	"	5,324	5,397	5,493	5,610	5,782	6,008	6,137	6,242	6,411
Employed	"	5,169	5,235	5,243	5,364	5,585	5,731	5,706	5,870	5,965
Unemployed	"	155	162	250	245	197	278	432	372	446
Unemployment rate	%	2.9	3.0	4.6	4.4	3.4	4.6	7.0	6.0	7.0
Employment index	1961 = 100	94.7	96.2	93.2	95.4	101.9	100.0	100.4	100.2	100.7
Labour income	$ millions	11,208	12,110	12,432	13,215	14,719	15,825	16,180	18,309	19,303
Index industrial production	1961 = 100	65.3	70.1	70.0	77.7	85.8	87.2	86.7	94.2	96.2
Index manufacturing production	"	71.5	76.6	74.9	82.2	89.9	89.7	88.0	94.5	96.1
Index mining production	"	46.5	50.6	56.1	66.4	77.1	84.6	86.0	97.3	97.4
Index real domestic product	"	72.5	75.5	74.3	82.1	89.1	89.5	91.0	95.7	98.0
General wholesale price index	1935-39=100	226.0	220.7	217.0	218.9	225.6	227.4	227.8	230.6	230.0
Consumer price index	1961 = 100	90.2	89.4	89.9	90.1	91.4	94.3	96.8	97.9	99.1

. . Not available; p Preliminary; r Revised.

indicators, 1952-73

1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973[p]
39,646	42,927	45,978	50,280	55,364	61,828	66,409	72,586	79,815	85,610	93,307[r]	103,493	118,902
39,646	42,349	44,531	47,519	50,685	54,207	56,016	59,292	62,448	64,046	67,585[r]	71,515	76,345
24,428	26,713	28,741	31,560	33,889	37,303	38,955	41,997	45,110	45,991	49,130	55,335	65,253
2,603	2,881	3,027	3,365	3,715	3,981	4,381	4,722	4,736	5,722	5,962[r]	6,403	8,238
5,755	6,179	6,799	8,094	8,525	10,071	11,112	13,270	14,498	16,401[r]	17,397[r]	19,661	24,644
5,769	6,258	6,558	7,487	8,633	9,866	11,075	12,366	14,130	13,952[r]	15,618[r]	18,669	23,317
−982	−830	−521	−424	−1,130	−1,162	−499	−107	−952	+1,036	+397	−655	−425
3,427	3,819	4,188	4,819	5,199	5,145	5,020	6,142	6,527	6,048	6,929	8,378	11,802
8,292	8,769	9,398	10,980	12,935	15,088	15,348	15,455	16,927	17,798	20,184	21,877	26,131
8,292	8,646[r]	9,008[r]	10,168[r]	11,387[r]	12,638[r]	12,598[r]	12,605[r]	13,239[r]	13,341[r]	14,422[r]	14,915	16,744
18,238	18,583	18,931	19,290	19,644	20,015	20,405	20,701[r]	21,061	21,377	21,569[r]	21,830	22,095
6,521	6,615	6,748	6,933	7,141	7,420	7,694	7,919	8,612	8,374	8,631	8,891	9,279
6,055	6,225	6,375	6,609	6,862	7,152	7,379	7,537	7,780	7,879	8,079	8,329	8,759
466	390	374	324	280	267	315	382	382	495	552	562	520
7.1	5.9	5.5	4.7	3.9	3.6	4.1	4.8	4.7	5.9	6.4	6.3	5.6
100.0	102.2	104.4	108.2	114.3	120.7	122.6	122.7	126.9	127.1	127.8	129.9	136.0
20,399[r]	21,816[r]	23,262[r]	25,367[r]	28,201[r]	31,878[r]	35,303[r]	38,444[r]	43,065[r]	46,706[r]	51,342[r]	56,976	64,108
100.0	108.3	115.2	126.6	137.0	146.0	150.8	161.9	172.6	175.3	184.2	198.3	214.8
100.0	109.0	116.2	127.4	138.8	148.7	152.3	163.6	175.4	173.0	181.7	195.8	211.9
100.0	106.2	112.1	126.0	131.9	134.2	142.1	152.4	153.5	175.3	182.9	192.2	210.5
100.0	106.9	112.7	120.4	129.0	138.0	142.4	152.5	161.6	165.6	175.0	184.6	197.2
233.3	240.0	244.6	245.4	250.3	259.5	264.1	269.9	282.4	286.4	289.9	310.3	376.9
100.0	101.2	103.0	104.8	107.4	111.4	115.4	120.1	125.5	129.7	133.4	139.8	150.4

Table 1. Mineral production[1] of Canada, 1972 and 1973 and average 1969-73

	Unit of Measure	1972		1973^{p}		Average 1969-1973	
		Quantity	$000	Quantity	$000	Quantity	$000
Metals							
Antimony	000 lb	. .	1,243	. .	3,219	. .	1,264
Bismuth	" "	275	850	90	444	361	1,719
Cadmium	" "	4,268	10,798	4,285	15,592	4,428	13,592
Calcium	" "	469	338	617	446	566	480
Cobalt	" "	3,351	8,321	3,946	11,667	3,887	9,295
Columbium (Cb_2O_5)	" "	3,874	3,868	2,867	3,720	3,436	3,576
Copper	" st	793	806,427	899	1,147,629	732	816,319
Gold	" troy oz	2,079	119,742	1,930	186,111	2,245	113,948
Iron ore	" lt	38,123	489,023	49,203	613,112	42,415	539,996
Iron remelt	" st	. .	41,544	. .	41,423	. .	34,405
Lead	" st	369	113,990	386	124,556	374	113,569
Magnesium	" lb	11,848	4,537	11,660	4,319	15,991	5,685
Molybdenum	" "	28,493	44,068	27,450	39,188	28,406	46,430
Nickel	" st	259	717,485	269	785,213	268	722,797
Platinum group	" troy oz	406	34,656	288	34,274	392	36,638
Selenium	" lb	582	5,186	598	5,430	632	5,256
Silver	" troy oz	44,792	74,803	48,843	122,107	45,488	86,917
Tantalum	" lb	41	247	115	785	211	1,424
Tellurium	" "	46	271	45	266	47	290
Thorium	" "	. .	. .	. .	. .	. .	. .
Tin	" "	351	474	280	638	300	485
Tungsten (WO_3)	" "	4,447	. .	5,793	. .	3,718	. .
Uranium (U_3O_8)	" "	9,763	. .	9,328	. .	8,644	. .
Zinc	" st	1,244	474,541	1,363	652,981	1,263	462,477
Total metals			2,952,412		3,793,120		3,016,562
Nonmetals							
Arsenious oxide	000 lb	–	–	–	–	–	–
Asbestos	" st	1,687	206,089	1,974	241,001	1,714	210,889
Barite	" "	77	804	98	1,020	117	1,130
Feldspar	" "	12	232	–	–	. .	. .
Fluorspar	" "	. .	5,432	. .	5,505	. .	4,278
Gemstones	" lb	704	305	. .	325	. .	203
Gypsum	" st	8,099	19,336	8,316	21,998	7,162	17,122
Magnesite dolomite and brucite	" "	. .	2,929	. .	3,100	. .	3,049
Nepheline	" "	559	5,902	576	7,372	528	6,243
Peat moss	" "	376	13,612	390	14,855	351	12,000
Potash K_2O	" "	3,852	135,513	4,432	151,123	3,839	119,934
Pyrite pyrophyllite	" "	126	456	22	147	241	1,136
Quartz	" "	2,664	9,536	2,800	10,250	2,711	8,058
Salt	" "	5,417	40,144	5,327	45,185	5,261	38,389
Soapstone talc pyrophyllite	" "	81	1,463	110	2,162	81	1,385
Sodium sulphate	" "	507	6,201	525	6,930	504	7,170
Sulphur in smelter gas	" "	679	5,118	742	9,641	684	6,956
Sulphur elemental	" "	3,636	19,588	4,545	22,630	3,570	30,520
Titanium dioxide	" "	. .	40,828	. .	46,318	. .	38,239
Total nonmetals			513,488		589,562		506,701

Table 1. (concl'd)

	Unit of Measure	1972		1973P		Average 1969-1973	
		Quantity	$000	Quantity	$000	Quantity	$000
Fuels							
Coal	000 st	20,709	150,600	21,960	176,979	17,675	117,190
Natural gas	" mcf	2,913,537	397,186	3,152,410	482,155	2,564,002	359,865
Natural gas by-products	" bbl	108,587	250,940	118,732	341,127	91,501	216,657
Petroleum crude	" bbl	561,977	1,568,828	649,868	2,246,149	515,351	1,468,589
Total fuels			2,367,554		3,246,410		2,162,301
Structural material							
Clay products	000 $	..	52,348	..	57,995	..	52,043
Cement	" st	9,976	209,221	10,884	228,094	9,225	189,278
Lime	" "	1,730	26,733	1,826	28,421	1,693	23,852
Sand and gravel	" "	225,194	178,100	228,000	187,500	214,144	154,789
Stone	" "	80,203	103, 326	85,500	107,000	74,404	96,605
Total structural materials			569,728		609,010		516,567
Total all minerals			6,403,182		8,238,102		6,202,131

.. Not available or not applicable; – Nil; P Preliminary.

Notes: 1. Production statistics for the following are not available for publication: indium, mercury, helium, nitrogen, diatomite, yttrium.

2. Nil production for the following between 1969 and 1974: grindstone, iron oxide, lithia, mica.
3. Dollar values only available for publication for the following: iron remelt, fluorspar, magnesite, dolomite and brucite, titanium dioxide, and clay products.
4. Quantities only available for publication for the following: tungsten and uranium.

lb - pound; st - short ton; lt - long ton; oz - ounce; mcf - thousand cubic feet.

Table 2. Canada, values of mineral production, per capita values of mineral production and population, 1933-1973

	Metallics $ million	Industrial Minerals $ million	Fuels $ million	Total $ million	Per Capita Value of Mineral Production $	Population of Canada 000
1933	147	27	48	222	20.85	10,633
1934	194	30	54	278	25.91	10,741
1935	222	36	55	313	28.84	10,845
1936	260	43	60	363	33.11	10,950
1937	335	57	66	458	41.48	11,045
1938	324	54	65	443	39.71	11,152
1939	343	61	71	475	42.12	11,267
1940	382	69	79	530	46.55	11,381
1941	395	80	85	560	48.69	11,507
1942	392	83	92	567	48.63	11,654
1943	357	80	93	530	44.94	11,795
1944	308	81	97	486	40.67	11,946
1945	317	88	94	499	41.31	12,072
1946	290	110	103	503	40.91	12,292
1947	395	140	110	645	51.38	12,551
1948	488	172	160	820	63.97	12,823
1949	539	178	184	901	67.01	13,447
1950	617	227	201	1,045	76.24	13,712
1951	746	266	233	1,245	88.90	14,009
1952	728	293	264	1,285	88.90	14,459
1953	710	312	314	1,336	90.02	14,845
1954	802	333	353	1,488	97.36	15,287
1955	1,008	373	414	1,795	114.37	15,698
1956	1,146	420	519	2,085	129.65	16,081
1957	1,159	466	565	2,190	131.87	16,610
1958	1,130	460	511	2,101	122.99	17,080
1959	1,371	503	535	2,409	137.79	17,483
1960	1,407	520	566	2,493	139.48	17,870
1961	1,387	542	674	2,603	142.72	18,238
1962	1,496	574	811	2,881	155.05	18,583
1963	1,510	632	885	3,027	159.91	18,931
1964	1,702	690	973	3,365	174.45	19,290
1965	1,908	761	1,046	3,715	189.11	19,644
1966	1,985	844	1,152	3,981	198.88	20,015
1967	2,285	861	1,235	4,381	214.69	20,405
1968	2,493	886	1,343	4,722	228.10[r]	20,701[r]
1969	2.378	893	1.465	4,736	224.87	21,061
1970	3,073	931	1,718	5,722	267.67	21,377
1971	2,940	1,008[r]	2,014	5,962[r]	276.40[r]	21,569[r]
1972	2,952	1,083	2,368	6,403	293.30	21,830
1973[p]	3,793	1,199	3,246	8,238	372.80	22,095

[p]Preliminary; [r]Revised.

Table 3. Canada value of mineral production by provinces and mineral classes, 1973p

	Metals		Industrial Minerals		Fuels		Total	
	$000	% of Total	$000	% of Total	$000	% of Total	$000	% of Total
Alberta	–	–	77,895	6.5	2,669,613	82.2	2,747,508	33.3
Ontario	1,478,883	39.0	293,533	24.5	6,855	0.2	1,779,271	21.6
British Columbia	659,094	17.4	105,453	8.8	226,332	7.0	990,879	12.0
Quebec	506,376	13.4	396,636	33.1	28	–	903,040	11.0
Saskatchewan	23,842	0.6	174,576	14.6	300,673	9.3	499,091	6.0
Manitoba	351,889	9.3	35,781	3.0	17,244	0.5	404,914	4.9
Newfoundland	343;488	9.1	33,663	2.8	–	–	377,151	4.6
Northwest Territories	164,777	4.3	–	–	5,531	0.2	170,308	2.1
New Brunswick	133,839	3.5	19,163	1.6	3,642	0.1	156,644	1.9
Yukon	130,745	3.4	14,849	1.2	–	–	145,594	1.8
Nova Scotia	187	–	45,823	3.8	16,492	0.5	62,502	0.8
Prince Edward Island	–	–	1,200	0.1	–	–	1,200	. . .
Total	3,793,120	100.0	1,198,572	100.0	3,246,410	100.0	8,238,102	100.0

pPreliminary; – Nil; . . . Too small to be expressed.

Table 4. Canada, production of leading minerals by

	Unit of Measure	Nfld.	P.E.I.	N.S.	N.B.	Quebec	Ontario
Petroleum	000 bbl	–	–	–	10	–	825
	$000	–	–	–	14	–	2,791
Copper	st	6,616	–	15	9,823	155,345	277,262
	$000	8,441	–	18	12,533	198,205	353,750
Nickel	st	–	–	–	–	400	195,958
	$000	–	–	–	–	1,224	565,065
Zinc	st	10,062	–	–	201,523	155,855	447,869
	$000	4,822	–	–	96,570	74,685	214,619
Iron ore	000 st	26,370	–	–	–	14,813	12,336
	$000	325,837	–	–	–	128,338	145,025
Natural gas	000 Mcf	–	–	–	84	198	9,450
	$000	–	–	–	42	28	4,064
Asbestos	000 st	80	–	–	–	1,648	34
	$000	13,950	–	–	–	185,170	3,850
Cement	000 st	. .	–	. .	. .	3,449	4,111
	$000	3,167	–	5,290	4,878	63,798	82,216
Sand and gravel	000 st	5,500	1,600	10,000	7,600	45,000	78,000
	$000	6,900	1,200	10,000	5,000	23,000	65,000
Coal	000 st	–	–	1,217	394	–	–
	$000	–	–	16,492	3,586	–	–
Gold	000 oz	12	–	–	5	482	902
	$000	1,166	–	–	501	46,468	86,930
Potash (K_2O)	000 st	–	–	–	–	–	–
	$000	–	–	–	–	–	–
Lead	st	6,499	–	322	39,727	1,094	12,442
	$000	2,098	–	104	12,824	353	4,016
Silver	000 oz	362	–	26	3,688	2,970	19,938
	$000	906	–	65	9,220	7,421	49,845
Stone	000 st	300	–	1,100	1,900	44,700	32,700
	$000	700	–	2,700	3,200	49,300	41,800
Clay products	$000	210	–	1,991	774	9,133	33,624
Salt	000 st	–	–	744	–	–	3,980
	$000	–	–	8,993	–	–	28,916
Titanium dioxide	st	–	–	–	–	. .	–
	$000	–	–	–	–	46,318	–
Iron remelt	st	–	–	–	–	. .	–
	$000	–	–	–	–	41,423	–
Molybdenum	000 lb	–	–	–	–	–	–
	$000	–	–	–	–	–	–
Platinum metals	000 oz	–	–	–	–	–	288
	$000	–	–	–	–	–	34,274
Lime	000 st	–	–	–	. .	316	1,228
	$000	–	–	–	630	4,264	19,036
Sulphur elemental	000 st	–	–	–	–	–	1
	$000	–	–	–	–	–	3
Gypsum	000 st	787	–	6,119	93	–	746
	$000	2,409	–	15,674	255	–	1,950
Total leading minerals	$000	370,606	1,200	61,327	150,027	879,128	1,736,774
Total all minerals	$000	377,151	1,200	62,502	156,644	903,040	1,779,271
Leading minerals as % of all minerals		98.3	100.0	98.1	95.8	97.4	97.6

P Preliminary; – Nil; . . Not available.

provinces and territories, 1973ᵖ

Manitoba	Sask.	Alberta	B.C.	Y.T.	N.W.T.	Total Canada
5,112	85,000	536,315	21,569	–	1,037	649,868
17,244	280,500	1,873,175	71,180	–	1,245	2,246,149
74,121	10,395	–	354,271	10,793	834	899,475
94,570	13,262	–	452,015	13,771	1,064	1,147,629
70,279	–	–	1,000	1,271	–	268,908
211,976	–	–	3,060	3,888	–	785,213
68,788	13,330	–	151,622	126,327	187,272	1,362,648
32,963	6,388	–	72,657	60,536	89,741	652,981
–	–	–	1,588	–	–	55,107
–	–	–	13,912	–	–	613,112
–	68,900	2,550,474	486,033	–	37,271	3,152,410
–	9,000	405,813	58,922	–	4,286	482,155
–	–	–	113	99	–	1,974
–	–	–	23,182	14,849	–	241,001
594	205	1,006	947	–	–	10,884
15,438	6,353	25,161	21,793	–	–	228,094
13,700	8,000	20,600	38,000	–	–	228,000
13,800	4,400	18,200	40,000	–	–	187,500
–	3,950	9,028	7,371	–	–	21,960
–	8,273	59,162	89,466	–	–	176,979
48	26	–	200	4	252	1,931
4,601	2,517	–	19,280	386	24,262	186,111
–	4,432	–	–	–	–	4,432
–	151,123	–	–	–	–	151,123
62	–	–	100,901	113,749	111,068	385,864
20	–	–	32,570	36,718	35,853	124,556
1,061	451	–	8,671	6,156	5,520	48,843
2,653	1,128	–	21,677	15,391	13,801	122,107
700	–	200	3,900	–	–	85,500
1,400	–	900	7,000	–	–	107,000
973	1,901	4,572	4,817	–	–	57,995
35	258	310	–	–	–	5,327
150	4,300	2,826	–	–	–	45,185
–	–	–	–	–	–	. .
–	–	–	–	–	–	46,318
–	–	–	–	–	–	. .
–	–	–	–	–	–	41,423
–	–	–	27,450	–	–	27,450
–	–	–	39,188	–	–	39,188
–	–	–	–	–	–	288
–	–	–	–	–	–	34,274
. .	–	132	47	–	–	1,826
1,228	–	2,385	878	–	–	28,421
2	17	4,465	60	–	–	4,545
22	174	22,111	320	–	–	22,630
206	–	–	365	–	–	8,316
650	–	–	1,060	–	–	21,998
397,688	489,319	2,414,305	972,977	145,539	170,252	7,789,142
404,914	499,091	2,747,508	990,879	145,594	170,308	8,238,102
98.2	98.0	87.9	98.2	99.9	99.9	94.6

Table 5. Canada, percentage contribution of leading minerals to total value of mineral production, 1964-73

	1964-73									
	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973p
Petroleum	20.0	19.4	19.8	19.8	19.9	21.4	20.2	22.7	24.5	27.2
Copper	9.6	10.3	11.4	13.3	12.8	12.4	13.6	12.7	12.6	13.9
Nickel	11.2	11.6	9.5	10.6	11.1	10.2	14.5	13.4	11.2	9.5
Zinc	5.7	6.7	7.3	7.3	6.9	7.8	7.0	7.0	7.4	7.9
Iron ore	12.0	11.1	10.8	10.7	11.2	9.6	10.3	9.3	7.6	7.4
Natural gas	4.3	4.3	4.4	4.5	4.8	5.5	5.5	5.7	6.2	5.9
Asbestos	4.3	3.9	4.1	3.7	4.0	4.1	3.6	3.4	3.2	2.9
Cement	3.8	3.8	3.9	3.3	3.1	3.4	2.7	3.2	3.3	2.8
Sand and gravel	3.7	3.6	3.8	3.3	2.7	2.6	2.3	2.6	2.8	2.3
Coal	2.2	2.1	2.1	1.3	1.1	1.1	1.5	2.0	2.4	2.2
Gold	4.3	3.6	3.1	2.5	2.1	2.0	1.5	1.3	1.9	2.2
Potash (K_2O)	0.9	1.5	1.6	1.5	1.8	1.5	1.9	2.3	2.1	1.8
Lead	1.6	2.4	2.3	2.0	1.9	2.0	2.2	1.8	1.8	1.5
Stone	2.5	2.6	2.7	2.3	2.0	1.9	1.5	1.6	1.6	1.3
Silver	1.2	1.2	1.2	1.4	2.2	1.8	1.4	1.2	1.2	1.5
Clay products	1.2	1.2	1.1	1.0	1.0	1.1	0.7	0.8	0.8	0.7
Salt	0.7	0.6	0.6	0.6	0.7	0.6	0.6	0.7	0.6	0.6
Titanium dioxide	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.7	0.6	0.6
Iron remelt	0.6	0.5	0.4	0.4	0.5	0.6	0.6	0.5	0.7	0.5
Molybdenum	0.06	0.5	0.9	0.9	0.8	1.1	1.0	0.6	0.7	0.5
Platinum metals	0.8	0.9	0.8	0.8	0.9	0.7	0.8	0.7	0.5	0.4
Lime	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.3
Sulphur, elemental	0.6	0.7	1.0	1.6	1.7	1.3	0.5	0.4	0.3	0.3
Gypsum	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.3
Other minerals	7.3	6.1	5.8	6.0	5.5	6.0	4.9	4.7	5.3	5.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

pPreliminary.

Table 6. Canada, value of mineral production by provinces, 1964-73

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973p
						($ millions)				
Alberta	709	762	849	974	1,092	1,205	1,396	1,641	1,978	2,747
Ontario	904	994	958	1,195	1,356	1,223	1,593	1,555r	1,535	1,779
British Columbia	269	280	331	380	389	434	490	541r	678	991
Quebec	685	716	771	741	725	717	803	766r	783	903
Saskatchewan	293	329	349	362	357	345	379	410r	410	499
Manitoba	174	182	179	185	210	246	332	330	323	405
Newfoundland	182	208	244	266	310	257	353	343	291	377
Northwest Territories	18	77	111	118	116	119	105	116	120	170
New Brunswick	49	83	90	90	88	95	134	107	120	157
Yukon	15	13	12	15	21	35	77	93	107	146
Nova Scotia	66	71	86	53	57	59	59	60	57	63
Prince Edward Island	1	–	1	2	1	1	1	1	1	1
Total	3,365	3,715	3,981	4,381	4,722	4,736	5,722	5,963	6,403	8,238

pPreliminary; rRevised; – Nil.

Table 7. Canada, percentage contribution of provinces to total value of mineral production, 1964-73

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973p
Alberta	21.1	20.5	21.3	22.2	23.1	25.4	24.4	27.5	30.9	33.4
Ontario	26.9	26.8	24.1	27.3	28.7	25.8	27.8	26.0	23.9	21.6
British Columbia	8.0	7.5	8.3	8.7	8.2	9.2	8.6	9.1	10.6	12.0
Quebec	20.3	19.2	19.4	16.9	15.4	15.2	14.0	12.9	12.2	10.9
Saskatchewan	8.7	8.9	8.7	8.3	7.6	7.3	6.6	6.9	6.4	6.1
Manitoba	5.2	4.9	4.5	4.2	4.4	5.2	5.8	5.5	5.0	4.9
Newfoundland	5.4	5.6	6.1	6.1	6.6	5.4	6.2	5.8	4.6	4.6
Northwest Territories	0.5	2.1	2.8	2.7	2.4	2.5	2.4	1.9	1.9	2.0
New Brunswick	1.4	2.2	2.3	2.1	1.9	2.0	1.8	1.8	1.9	1.9
Yukon	0.5	0.3	0.3	0.3	0.5	0.7	1.4	1.6	1.7	1.8
Nova Scotia	2.0	1.9	2.2	1.2	1.2	1.3	1.0	1.0	0.9	0.8
Prince Edward Island	0.02	0.02	0.02	0.04	0.02	0.02	0.02	0.02	0.02	0.01
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

pPreliminary.

Table 8. Canada's world role as a producer of certain

	Year	World Production
Nickel (mine production)	1972[r] st	609,387
	% of world total	
Zinc (mine production)	1972[r] st	5,855,351
	% of world total	
Asbestos	1972[p] st	4,141,391
	% of world total	
Silver	1971[r] 000 troy oz	297,101
	% of world total	
Titanium concentrate (Ilmenite)	1972[p] st	3,586,377
	% of world total	
Potash K_2O (equivalent)	1972[p] 000 st	22,187
	% of world total	
Molybdenum (excludes communist countries)	1972[p] st	87,628
	% of world total	
Elemental sulphur	1972 000 st	20,123
	% of world total	
Gypsum	1972[p] 000 st	59,949
	% of world total	
Platinum group metals (mine production)	1972 troy oz	4,502,431
	% of world total	
Gold (mine production)	1971[r] troy oz	46,193,439
	% of world total	
Uranium (U_3O_8 concentrates)	1972[p] st	27,277
	% of world total	
Copper (mine production)	1972 st	7,480,550
	% of world total	
Aluminum (primary metal)	1972[r] st	12,553,881
	% of world total	
Lead (mine production)	1972[r] st	3,785,997
	% of world total	
Cadmium (smelter production)	1972[p] 000 lb	38,927
	% of world total	
Iron ore	1972[r] 000 lt	747,504
	% of world total	

[p]Preliminary; [r]Revised; [e]Estimated.

important minerals, 1972

Rank of Six Leading Countries with % of World Total

1	2	3	4	5	6
Canada 258,987 42.5	U.S.S.R. 135,000[e] 22.2	New Caledonia 101,444 16.6	Cuba 40,000 6.6	Australia 38,400 6.3	U.S.A. 17,000 2.8
Canada 1,244,142 21.2	U.S.S.R. 690,000[e] 11.8	Australia 519,000 8.9	U.S.A. 481,965 8.2	Peru 385,595 6.6	Japan 309,729 5.3
Canada 1,687,051 40.7	U.S.S.R. 1,345,000[e] 32.5	Rep.S.Africa 356,206 8.6	China 220,000[e] 5.3	Italy 145,675 3.5	U.S.A. 131,663 3.2
Canada 46,024 15.5	U.S.A. 41,564 14.0	Peru 39,952 13.4	U.S.S.R. 39,000[e] 13.1	Mexico 36,657 12.3	Australia 21,615 7.3
Canada 920,400 25.7	Australia 781,324 21.8	U.S.A. 681,644 19.0	Norway 670,723 18.7	Malaysia 167,743 4.7	Finland 150,000[e] 4.2
U.S.S.R. 6,060[e] 27.3	**Canada** 3,852 17.4	West Germany 3,136 14.1	East Germany 2,680[e] 12.1	U.S.A. 2,659 12.0	France 1,930[e] 8.7
U.S.A. 56,069 64.0	**Canada** 12,422 14.2	U.S.S.R. 9,050[e] 10.3	Chile 6,523 7.4	Peru 856 1.0	Norway 440 0.5
U.S.A. 8,230 40.9	**Canada** 3,246 16.1	Poland 2,579 12.8	France 1,521 7.6	U.S.S.R. 1.500 7.5	Mexico 829 4.1
U.S.A. 12,328 20.6	**Canada** 8,099 13.5	France 6,451 10.8	U.S.S.R. 5,200[e] 8.7	United Kingdom 4,590 7.7	Spain 4,520 7.5
U.S.S.R. 2,350,000 52.2	Rep.S.Africa 1,803,000 40.0	**Canada** 288,000 6.4	Colombia 26,000[e] 0.6	U.S.A. 17,112 0.4	Japan 9,899 0.2
Rep.S.Africa 31,388,671 68.0	U.S.S.R. 6,700,000[e] 14.5	**Canada** 2,260,730 4.9	U.S.A. 1,495,108 3.2	Ghana 697,517 1.5	Australia 670,136 1.5
U.S.A. 12,900 47.3	Rep.S.Africa 5,589 20.5	**Canada** 4,898 18.0	France 1,921 7.0	Niger 956 3.5	Gabon 577 2.1
U.S.A. 1,642,800 22.0	U.S.S.R. 1,050,000 14.0	**Canada** 793,303 10.6	Zambia 791,147 10.6	Chile 790,137 10.6	Rep.Zaire 472,008 6.3
U.S.A. 4,122,451 32.9	U.S.S.R. 1,980,000[e] 15.8	Japan 1,118,700 8.9	**Canada** 1,012,674 8.1	Norway 597,678 4.8	Germany 489,916 3.9
U.S.A. 618,361 16.3	U.S.S.R. 600,000[e] 15.8	Australia 445,000 11.8	**Canada** 369,425 9.8	Peru 199,527 5.3	Mexico 177,865 4.7
U.S.A. 8,290 21.3	Japan 6,678 17.2	U.S.S.R. 5,400[e] 13.9	**Canada** 4,268 11.0	Belgium 2,500[e] 6.4	W.Germany 2,180[e] 5.6
U.S.S.R. 204,716 27.4	U.S.A. 75,284 10.1	Australia 62,497 8.4	France 54,250 7.3	China 44,289 5.9	**Canada** 38,123 5.1

Table 9. Canada, census value added, commodity-producing industries, 1965-71

	1965	1966	1967	1968	1969	1970	1971[p]
				($ millions)			
Primary Industries							
Agriculture	2,635	3,298	2,693	2,870	3,032	2,775[r]	3,049
Forestry	528	596	615	644	734	683	686
Fishing	160	176	164	186	184	204[r]	205
Trapping	12	14	10	12	16	13	11
Mining*	2,476	2,613	2,918	3,176	3,342	3,805[r]	3,809
Electric power	1,037	1,132	1,234	1,360	1,511	1,707[r]	1,859
Total	6,848	7,829	7,634	8,248	8,819	9,187[r]	9,619
Secondary Industries							
Manufacturing	14,928	16,352	17,006	18,332	20,134	20,048	21,738
Construction	3,987	4,844	5,148	5,269	5,794	6,167[r]	7,391
Total	18,915	21,196	22,154	23,601	25,928	26,215[r]	29,129
Grand Total	25,763	29,025	29,788	31,849	34,747	35,402[r]	38,748

*Excludes Cement, Lime and Clay and Clay Products (from domestic clays) manufacture. These industries in the above tables are included under Manufacturing.

[p]Preliminary; [r]Revised.

Table 10. Canada, census value added, mining and mineral manufacturing industries, 1967-71

	1967	1968	1969	1970	1971p
Mining			($000)		
Metallic					
Placer gold	257	264	155	120	92
Gold quartz	85,352	78,032	74,993	63,902	59,516
Copper-gold-silver	357,488	377,800	465,309	432,678	378,384
Silver-cobalt	6,870	7,645	6,088	4,184	2,874
Silver-lead-zinc	138,912	150,565	171,239	171,603	156,050
Nickel-copper	377,487	437,372	386,383	634,644	448,779
Iron	289,595	339,402	315,378	367,599r	345,900
Misc. metal mines	78,437	72,306	104,433	101,824	90,705
Total	1,334,398	1,463,386	1,523,978	1,776,554r	1,482,300
Industrial minerals					
Asbestos	136,918	143,591	157,855	168,612r	165,018
Feldspar, quartz and nepheline	6,784	7,368	9,065	8,939	9,473
Gypsum	7,968	9,277	11,496	10,756	11,608
Peat	7,898	8,857	8,066	9,432	11,227
Salt	21,087	23,484	22,238	28,124	29,842
Sand and gravel	37,182	40,286	44,329	42,059	51,454
Stone	43,428	44,339	45,153	47,165	50,827
Talc and soapstone	640	824	785	784	897
Misc. nonmetals	64,268	60,450	62,005	97,850r	117,497
Total	326,173	338,476	360,992	413,721	447,843
Fuels					
Coal	73,280	66,088	64,321	74,035	103,918
Petroleum and natural gas	1,183,818	1,307,995	1,392,994	1,540,581	1,775,798
Total	1,257,098	1,374,083	1,457,315	1,614,616	1,879,716
Total mining industry	2,917,669	3,175,945	3,342,285	3,804,891r	3,809,859
Mineral manufacturing					
Primary metal industries					
Iron and steel mills	617,092	684,684	708,727	835,956	866,948
Steel pipe and tube mills	56,820	73,844	75,525	76,558	86,564
Iron foundries	108,944	106,610	123,331	119,721	120,039
Smelting and refining	448,124	477,763	513,806	552,540	545,192
Aluminum rolling, casting and extruding	58,410	66,496	82,837	80,163	87,491
Copper and alloy rolling, casting and extruding	51,968	59,105	61,054	52,319	55,780
Metal rolling, casting and extruding, nes	42,251	46,365	55,867	51,831	50,144
Total	1,383,609	1,514,867	1,621,147	1,769,088	1,812,158
Nonmetallic mineral products industries					
Cement manufacturers	100,496	107,088	117,521	115,175	131,404
Lime manufacturers	7,769	8,573	10,368	11,248	11,937
Gypsum products manufacturers	27,460	32,079	36,877	31,874	40,395
Concrete products manufacturers	116,742	122,789	126,965	125,170	160,480
Ready-mix concrete manufacturers	92,273	106,314	109,951	108,467	133,290
Clay products (domestic clay)	30,906	33,996	37,270	32,553	37,514

(Continued on page 574)

Table 10. (concl'd)

	1967	1968	1969	1970	1971^p
			($000)		
Clay products (imported clay)	23,195	24,652	22,399	21,947	22,791
Refractories manufacturers	16,132	16,924	19,759	23,212	20,741
Stone products manufacturers	6,435	6,278	6,630	5,960	10,622
Mineral wool manufacturers	20,540	21,808	24,748	24,692	29,535
Asbestos products manufacturers	23,811	29,359	31,135	31,600	37,269
Glass manufacturers	71,631	93,692	100,230	104,955	123,390
Glass products manufacturers	40,175	43,396	50,784	44,434	55,878
Abrasives manufacturers	28,830	29,198	33,228	31,037	27,944
Other nonmetallic mineral products industries	8,914	9,895	11,074	11,415	12,497
Total	615,309	686,041	738,939	723,739	855,687
Petroleum and coal products industries					
Petroleum refining	270,086	307,298	293,416	331,965	401,032
Manufacturers of lubricating oils and greases	14,338	13,635	15,486	15,908	17,495
Other petroleum and coal products industries	8,367	8,484	8,266	8,355	10,629
Total	292,791	329,417	317,168	356,228	429,156
Total mineral manufacturing	2,291,709	2,530,325	2,677,254	2,849,055	3,097,001
Total mining and mineral manufacturing	5,209,378	5,706,270	6,019,539	6,653,946	6,906,860

^{p}Preliminary; nes Not elsewhere specified, ^{r}Revised.

Table 11. Canada, indexes of physical volume of total industrial production, mining and mineral manufacturing, 1958-73 (1961 = 100)

	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973p
Total industrial production	86.7	94.2	96.2	100.0	108.3	115.2	126.6	137.0	146.0	150.8	161.9	172.6	175.3	184.2	198.3	214.8
Total mining	86.0	97.3	97.4	100.0	106.2	112.1	126.0	131.9	134.2	142.1	152.4	153.5	175.3	182.9	192.2	210.5
Metals																
All metals	95.5	110.0	107.3	100.0	102.2	104.1	120.2	122.8	121.1	129.3	135.7	127.4	152.1	153.3	143.3	158.4
Placer gold and gold-quartz mines	104.1	102.2	104.4	100.0	95.1	91.4	90.1	87.4	82.2	73.6	66.8	64.9	57.7	55.5	50.6	44.9
Iron mines	70.7	105.2	103.6	100.0	139.3	170.4	208.6	224.8	241.5	260.7	313.8	274.8	347.0	338.7	279.2	362.5
Miscellaneous metal mines, nes	..	..	..	100.0	97.5	95.7	111.4	112.7	108.6	117.9	119.2	114.7	137.2	140.5	137.6	145.3
Fuels																
All fuels	76.5	84.1	87.1	100.0	114.3	123.0	133.0	142.0	152.4	166.1	181.1	199.0	229.6	249.0	304.0	331.8
Coal	113.8	103.8	107.0	100.0	97.9	104.5	109.8	111.9	103.7	103.1	100.2	99.6	128.2	149.0	205.5	219.5
Crude petroleum and natural gas	..	..	..	100.0	117.3	126.3	137.2	147.4	161.2	177.5	195.7	217.0	247.9	267.1	321.8	352.2
Nonmetals																
All nonmetals	80.3	92.0	91.5	100.0	108.7	121.4	139.2	151.5	164.2	173.6	191.9	202.3	211.0	219.6	213.8	233.7
Asbestos	79.8	86.4	90.3	100.0	103.2	109.0	121.9	118.2	127.7	125.6	135.9	133.0	146.5	146.3	147.4	157.3
Mineral manufacturing																
Primary metals	..	..	..	100.0	105.5	114.3	128.4	140.4	146.1	141.1	158.2	164.8	171.0	172.6	177.1	175.8
Nonmetallic mineral products	91.8	99.0	95.8	100.0	115.0	116.7	128.0	139.3	144.9	135.4	147.2	154.3	145.9	157.4	177.5	196.3
Petroleum and coal products	82.3	90.2	94.1	100.0	108.7	117.2	118.5	124.4	129.1	130.5	144.3	150.2	153.2	165.2	188.1	206.4

pPreliminary; .. Not available; nes Not elsewhere specified.

Table 12. Indexes of real domestic product by industries, 1964-73
(1961 = 100)

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973[p]
Real domestic product, all industries	120.4	129.0	138.0	142.4	152.5	161.6	165.6	175.0	184.6	197.2
Agriculture	123.9	127.6	145.9	118.6	126.0	133.3	131.4	152.7	140.8	142.3
Forestry	119.2	122.5	132.7	130.3	131.2	139.5	136.8	135.0	129.0	158.0
Fishing and trapping	108.9	106.6	118.2	112.1	127.1	112.8	115.5	107.9	102.4	102.6
Mining (including milling) quarries and oil wells	126.0	131.9	134.2	142.1	152.4	153.5	175.3	182.9	192.2	210.5
Electric power, gas and water utilities	120.8	129.9	141.4	151.2	162.8	177.7	194.3	207.6	229.4	247.2
Manufacturing	127.4	138.8	148.7	152.3	163.6	175.4	173.0	181.7	195.8	211.9
Construction	117.4	131.6	141.7	141.2	147.4	152.1	150.6	165.6	166.5	177.9
Transportation, storage and communication	120.3	127.6	138.0	145.3	154.7	165.5	174.0	182.7	198.8	216.7
Trade	119.5	129.4	137.6	144.7	150.6	158.3	160.0	170.6	182.6	192.5
Community, business and personal service	119.0	128.8	140.4	150.4	160.5	172.0	179.4	187.0	194.8	202.7
Finance, insurance and real estate	115.0	120.8	125.6	131.4	152.8	162.1	170.0	179.3	186.0	197.4
Public administration and defence	106.3	108.3	112.2	118.2	120.1	122.7	127.0	132.4	138.9	148.9

[p]Preliminary.

Table 13. Canada, exports of crude minerals and fabricated mineral products, by main groups, 1969-73

	1969	1970	1971	1972	1973p
	($ millions)				
Ferrous					
Crude material	363.5	508.9	431.8	371.8	497.7
Fabricated material	352.9	487.3	463.6	485.9	597.0
Total	716.4	996.2	895.4	857.7	1,094.7
Nonferrous					
Crude material	775.2	993.8	954.8	1,014.1	1,488.9
Fabricated material*	1,286.2	1,689.7	1,389.7	1,388.9	1,682.4
Total	2,061.4	2,683.5	2,344.5	2,403.0	3,171.3
Nonmetals					
Crude material	427.3	453.2	456.9	475.5	592.1
Fabricated material	87.9	99.8	100.6	133.2	166.6
Total	515.2	553.0	557.5	608.7	758.7
Mineral fuels					
Crude material	711.7	884.6	1,124.6	1,420.9	1,999.4
Fabricated material	58.9	85.1	117.0	209.5	311.4
Total	770.6	969.7	1,241.6	1,630.4	2,310.8
Total minerals and products					
Crude material	2,277.7	2,840.5	2,968.1	3,282.3	4,578.1
Fabricated material	1,785.9	2,361.9	2,070.9	2,217.5	2,757.4
Total	4,063.6	5,202.4	5,039.0	5,499.8	7,335.5

*Includes gold, refined and unrefined.
pPreliminary.

Table 14. Canada, value of imports of crude minerals and fabricated mineral products, by main groups, 1969-73

	1969	1970	1971	1972	1973^p
			($ millions)		
Ferrous					
Crude material	47.5	54.4	50.9	53.1	75.3
Fabricated material	723.6	718.4	805.0	850.4	1,010.4
Total	771.1	772.8	855.9	903.5	1,085.7
Nonferrous*					
Crude material	145.7	188.9	192.0	185.8	250.2
Fabricated material	328.2	277.5	301.4	343.7	446.5
Total	473.9	466.4	493.4	529.5	696.7
Nonmetals					
Crude materials	63.8	63.7	73.1	71.6	88.4
Fabricated materials	165.6	165.9	180.3	198.7	235.9
Total	229.4	229.6	253.4	270.3	324.3
Mineral fuels					
Crude material	493.6	571.4	700.0	867.6	1,116.4
Fabricated material	223.5	205.7	213.4	209.2	213.1
Total	717.1	777.1	913.4	1,076.8	1,329.5
Total minerals and products					
Crude material	750.6	878.4	1,016.0	1,178.1	1,530.3
Fabricated material	1,440.9	1,367.5^r	1,500.1	1,602.0	1,905.9
Total	2,191.5	2,245.9^r	2,516.1	2,780.1	3,436.2

*Includes gold, refined and unrefined.
^{p}Preliminary.

Table 15. Canada, value of exports of crude minerals and fabricated mineral products in relation to total export trade, 1969-73

	1969		1970		1971		1972		1973[p]	
	$ millions	% of Total	$ millions	% of Total	$ millions	% of Total	$ millions	% of Total	$ millions	% of Total
Crude material	2,277.7	15.7	2,840.5	17.3[r]	2,968.1	17.1[r]	3,282.3	16.7	4,578.1	18.6
Fabricated material	1,785.9	12.3	2,361.9	14.4[r]	2,070.9	11.9	2,217.5	11.3	2,757.4	11.2
Total	4,063.6	28.0	5,202.4	31.7[r]	5,039.0	29.0	5,499.8	28.0	7,335.5	29.8
Total exports* all products	14,498.2	100.0	16,401.1[r]	100.0	17,396.6[r]	100.0	19,660.7[r]	100.0	24,643.6	100.0

*Includes gold, refined and unrefined.
[r]Revised; [p]Preliminary.

Table 16. Canada, value of imports of crude minerals and fabricated mineral products in relation to total import trade, 1969-73

	1969		1970		1971		1972		1973[p]	
	$ millions	% of Total	$ millions	% of Total	$ millions	% of Total	$ millions	% of Total	$ millions	% of Total
Crude material	750.6	5.3	878.4	6.3	1,016.0	6.5	1,178.1	6.3	1,530.3	6.5
Fabricated material	1,440.9	10.2	1,367.5	9.8	1,500.1	9.6	1,602.0	8.6[r]	1,905.9	8.2
Total	2,191.5	15.5	2,245.9	16.1	2,516.1	16.1	2,780.1	14.9[r]	3,436.2	14.7
Total imports* all products	14,130.3	100.0	13,951.9[r]	100.0	15,618.1[r]	100.0	18,669.4[r]	100.0	23,316.8	100.0

*Includes gold, refined and unrefined.
[p]Preliminary; [r]Revised.

Table 17. Canada, value of exports of crude minerals and fabricated mineral products by main groups and destination, 1973

	Britain	United States	Other Countries	Total
		($ millions)		
Ferrous materials and products	75.9	782.5	236.3	1,094.7
Nonferrous* materials and products	485.3	1,199.3	1,486.7	3,171.3
Nonmetallic mineral materials and products	32.0	421.3	305.4	758.7
Mineral fuels, materials and products	.9	2,130.3	179.6	2,310.8
Total	594.1	4,533.4	2,208.0	7,335.5
Percentage	8.1	61.8	30.1	100.0

*Includes gold, refined and unrefined.

Table 18. Canada, value of imports of crude minerals and fabricated mineral products, by main groups and country of origin, 1973[p]

	Britain	United States	Other Countries	Total
		($ millions)		
Ferrous materials and products	74.0	700.9	310.8	1,085.7
Nonferrous* materials and products	33.1	400.5	263.1	696.7
Nonmetallic mineral materials and products	17.9	226.7	79.7	324.3
Mineral fuels, material and products	3.0	261.4	1,065.1	1,329.5
Total	128.0	1,589.5	1,718.7	3,436.2
Percentage	3.7	46.3	50.0	100.0

*Includes gold, refined and unrefined.
[p]Preliminary.

Table 19. Canada, value of exports of crude minerals and fabricated mineral products, by commodity and destination, 1973[p]

	U.S.A.	Britain	E.F.T.A.[1]	E.E.C.[2]	Japan	Other Countries	Total
			($000)				
Aluminum	219,487	34,698	1,619	41,354	43,408	55,008	395,574
Asbestos	97,873	22,164	7,548	63,962	19,395	73,095	284,037
Copper	259,043	158,504	50,743	111,866	448,728	41,628	1,070,512
Fuels	2,130,288	903	699	1,653	169,351	7,888	2,310,782
Iron ore	304,330	51,459	1,805	67,022	30,062	7,318	461,996
Lead	22,334	19,152	220	15,569	31,028	4,954	93,257
Molybdenum	591	7,645	663	19,853	15,031	3,427	47,210
Nickel	324,394	168,502	131,441	35,454	62,003	111,866	833,660
Primary ferrous metals	63,738	6,685	177	14,957	4,444	23,575	113,576
Uranium	46,794	17,356	–	–	–	–	64,150
Zinc	177,624	29,894	4,820	111,973	49,644	21,026	394,981
All other minerals[3]	886,937	77,102	7,431	85,764	50,355	158,218	1,265,807
Grand Total	4,533,433	594,064	207,166	569,427	923,449	508,003	7,335,542

1. Other European Free Trade Association countries: Norway, Sweden, Austria, Switzerland, Portugal, Finland and Iceland.

2. European Economic Community (Common Market) Countries: Belgium and Luxembourg, Netherlands, West Germany, France, Italy, Ireland and Denmark. Excluding Britain.

3. Includes gold refined and unrefined.

– Nil; [p]Preliminary.

Table 20. Canada, reported consumption of minerals

	Unit of Measure	1970 Consumption	1970 Production	1970 Consumption as % of Production	1971 Consumption	1971 Production	1971 Consumption as % of Production
Metals							
Aluminum	st	275,743	1,061,020	26.0	322,082[r]	1,104,644	29.2
Antimony	lb	1,142,009	726,474	157.2	1,461,763	323,525	451.8
Bismuth	lb	24,548	590,340	4.2	35,876	271,196	13.2
Cadmium	lb	124,959	4,307,953	2.9	117,395	4,063,805	2.9
Chromium (chromite)	st	61,963	–	. .	61,313	–	. .
Cobalt	lb	327,030	4,561,213	7.2	220,994	4,323,318	5.1
Copper	st	237,916[1]	672,717	35.4	221,053[1]	721,430	30.6
Lead	st	93,437[2]	389,185	24.0	94,617[2]	405,510	23.3
Magnesium	st	4,937	10,353	47.7	6,276	7,234	86.8
Manganese ore	st	169,586	–	. .	174,761	–	. .
Mercury	lb	340,558	. .	. .	193,968	. .	. .
Molybdenum (Mo Content)	lb	2,286,061	33,771,716	6.8	1,814,586	22,662,732	8.0
Nickel	st	11,794	305,881	3.9	8,583	294,341	2.9
Selenium	lb	15,730	663,336	2.4	15,686	718,440	2.2
Silver	oz	6,034,028	44,250,804	13.6	7,050,956	46,023,570	15.3
Tellurium	lb	880	58,333	1.5	1,178	24,488	4.8
Tin	lt	4,482	118	3,798.3	3,911	142	2,754.2
Tungsten (W Content)	lb	984,777	3,726,800	26.4	639,765	4,624,208	13.8
Zinc	st	108,364[2]	1,251,911	8.7	114,334[2]	1,249,734	9.1
Nonmetals							
Barite	st	55,200	147,251	37.5	85,200	120,765	48.2
Feldspar	st	7,540	10,656	70.8	8,854[r]	10,774	82.2
Fluorspar	st	212,949	136,800[e]	155.7	197,449	85,000[e]	232.3
Mica	lb	5,746,000	–	. .	8,354,000	–	. .
Nepheline syenite	st	83,360	486,667	17.1	83,091[r]	517,190	16.1
Phosphate rock	st	1,896,684	–	. .	2,031,289	–	. .
Potash (K_2O)[3]	st	192,479	3,930,662	4.9	203,193	3,422,430	5.9
Sodium sulphate	st	406,812	490,547	82.9	401,908[r]	481,919	83.4
Sulphur elemental	st	841,728	3,548,310	23.7[r]	804,656[r]	3,149,280[r]	25.6
Talc, etc.	st	36,145[r]	72,055	50.2	38,650[r]	65,562	59.0
Fuels							
Coal	st	29,512,533[r]	16,604,164	177.7	28,249,835[r]	18,432,199	153.3[r]
Natural gas	mcf	917,440,879[4]	2,277,108,791[r]	40.3	1,001,328,624[4]	2,499,023,600	40.1
Petroleum, crude	bbl	467,306,197[5]	461,180,059	101.3	507,463,990[5]	492,739,049	103.0

Note: Unless otherwise stated, consumption refers to reported consumption of refined metals or nonmetallic minerals by consumers. Production of metals, in most cases, refers to production in all forms, and includes the recoverable metal content of ores, concentrates, matte, etc., and the metal content of primary products recoverable at domestic smelters and refineries. Production of nonmetals refers to producers' shipments. For fuels, production is equivalent to actual output less waste.

1. Producers' domestic shipments of refined metal; 2. Includes primary and secondary refined metal; 3. Production and consumption for year ended June 30; 4. Domestic sales; 5. Refinery receipts.

[p]Preliminary; [r]Revised; [e]Estimated.

– Nil; . . Not available or not applicable.

and relation to production, 1970-73

		1972			1973		
	Unit of Measure	Consumption	Production	Consumption as % of Production	Consumption	Production	Consumption as % of Production
Metals							
Aluminum	st	333,550	1,012,132	33.0	. .	1,037,859	. .
Antimony	lb	2,026,300	. .	. .	979,566	. .	. .
Bismuth	lb	37,892[r]	275,029	13.8	56,852	90,000	57.4
Cadmium	lb	123,395	4,267,987	2.9	120,958	4,285,000	2.8
Chromium (chromite)	st	62,712	–	. .	38,030	–	. .
Cobalt	lb	381,260	3,351,108	11.4	431,420	3,946,000	10.9
Copper	st	228,907[1]	793,303	28.9	254,613[1]	899,475	28.3
Lead	st	86,596[2]	369,425	23.4	119,082[2]	385,864	30.9
Magnesium	st	5,923	5,924	100.0	7,293	5,830	125.1
Manganese ore	st	183,175[r]	–	. .	188,072	–	. .
Mercury	lb	114,636	1,112,412	10.3	142,163	943,000	15.1
Molybdenum (Mo Content)	lb	2,708,059	28,493,007	9.5	4,434,714	27,450,000	16.2
Nickel	st	10,093	258,987	3.9	. .	268,908	. .
Selenium	lb	20,677	582,060	3.6	22,435	598,000	3.8
Silver	oz	8,424,314	44,792,209	18.8	16,870,929	48,843,000	34.5
Tellurium	lb	1,419	45,649	3.1	1,222	45,000	2.7
Tin	lt	4,685	157	2,984.1	5,152	250	2,060.8
Tungsten (W Content)	lt	1,176,546	4,447,316	26.5	1,019,706	5,793,000	17.6
Zinc	st	134,187[2]	1,244,142	10.8	133,085[2]	1,362,649	9.8
Nonmetals							
Barite	st	78,900	77,261	102.1	. .	98,000	. .
Feldspar	st	9,651	11,684	82.6	. .	. .	. .
Fluorspar	st	232,128	180,000[e]	129.0	. .	180,000[e]	. .
Mica	lb	–	. .	. .	. .	–	. .
Nepheline syenite	st	96,112	559,483	17.2	. .	576,000	. .
Phosphate rock	st	2,362,010	–	. .	. .	–	. .
Potash (K_2O)[3]	st	274,397	4,151,105	6.6	210,220	3,994,685	5.3
Sodium sulphate	st	303,656[r]	507,275	59.9	. .	525,000	. .
Sulphur elemental	st	948,590	3,635,631	26.1	861,000	4,545,000	18.9
Talc, etc.	st	37,482	80,946	46.3	28,563	110,000	26.0
Fuels							
Coal	st	28,393,096	20,709,316	137.1	. .	21,960,000	. .
Natural gas	mcf	1,145,797,145[4]	2,913,537,215	39.3	1,229,409,641[4]	3,152,410,000	39.0
Petroleum, crude	bbl	561,992,407[5]	561,976,934	100.0	611,416,074[5]	649,868,000	94.1

Table 21. Canada, apparent consumption[1] of some minerals

		1970			1971		
	Unit of Measure	Apparent Consumption	Production	Consumption as a % of Production	Apparent Consumption	Production	Consumption as a % of Production
Asbestos	st	105,045	1,661,644	6.3	68,755	1,634,579	4.2
Cement	st	7,476,585	7,945,915	94.1	8,234,823	9,066,795	90.8
Gypsum	st	1,504,099	6,318,523	23.8	1,772,909	6,702,100	26.5
Iron ore	lt	10,107,938	46,708,946	21.6	10,016,147	42,278,733	23.7
Lime	st	1,481,125	1,647,954	89.9	1,340,961	1,598,254	83.9
Quartz (silica)	st	4,469,629	3,238,037	138.0	3,873,498	2,553,884	151.7
Salt	st	4,739,000[e]	5,358,896	88.4	5,312,000[e]	5,541,904	95.8

[1]Apparent consumption – production plus imports less exports.
[2]Production – producers' shipments.
[e]Estimated; [p]Preliminary.

and relation to production[2], 1970-73

	Unit of Measure	1972 Apparent Consumption	1972 Production	1972 Consumption as a % of Production	1973[p] Apparent Consumption	1973[p] Production	1973[p] Consumption as a % of Production
Asbestos	st	94,956	1,687,051	5.6	124,172	1,974,000	6.3
Cement	st	8,765,056	9,975,762	87.9	9,603,068	10,884,000	88.3
Gypsum	st	2,198,890	8,099,480	27.2	2,065,483	8,316,000	24.8
Iron ore	lt	11,036,181	38,123,627	29.0	14,777,215	49,203,000	30.0
Lime	st	1,462,854	1,730,311	84.5	1,469,166	1,826,000	80.5
Quartz (silica)	st	3,895,112	2,663,836	146.2	3,773,304	2,800,000	134.8
Salt	st	3,931,080[e]	5,416,925	72.6	4,051,300[e]	5,327,000	76.1

Table 22. Canada, domestic consumption of principal refined metals in relation to refinery production,[1] 1964-73

	Unit of Measure or Percentage	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973p
Copper											
Domestic consumption[2]	st	202,225	224,684	262,557	219.680	250,104	226,281	237,916	221,053	228,907	254,613
Production	st	407,942	434,133	433,004	499,846	524,474	449,232	543,727	526,403	546,685	548,488
Consumption of production	%	49.6	51.8	60.6	43.9	47.7	50.4	43.8	42.0	41.9	46.4
Zinc											
Domestic consumption[3]	st	91,052	97,345	110,481	110,487	118,581	121,420	108,364	114,334	134,187	133,085
Production	st	337,734	358,498	382,605	405,136	426,728	466,357	455,471	410,643	524,885	587,038
Consumption of production	%	27.0	27.2	28.9	27.3	27.8	26.0	23.8	27.8	25.6	22.7
Lead											
Domestic consumption[3]	st	82,736	90,168	96,683	93,953	94,660	105,915	93,437	94,617	86,596	119,082
Production	st	151,372	186,484	184,871	193,235	202,100	187,143	204,630	185,554	205,978	206,012
Consumption of production	%	54.7	48.4	52.3	48.6	46.8	56.6	45.7	51.0	42.0	57.8
Aluminum											
Domestic consumption[3]	st	172,443	213,094	243,301	217,484	242,390	269,027	275,743	322,082	333,550	. .
Production	st	842,640	830,505	889,915	963,343	979,171	1,078,717	1,061,020	1,104,644	1,012,132	1,037,859
Consumption of production	%	20.5	25.7	27.3	22.6	24.8	24.9	26.0	29.2	33.0	. .

[1] Production of refined metal from all sources, including metal derived from secondary materials at primary refineries.
[2] Producers' domestic shipments of refined metal.
[3] Consumption primary and secondary refined metal, reported by consumers.
[p] Preliminary; . . Not available.

Table 23. Annual averages of prices of main metals[1], 1969-73

	Unit of Measure	1969	1970	1971	1972	1973
Aluminum ingots, 99.5%	¢/lb	27.176	28.716	29.000	26.409	25.00
Antimony, RMM, fob Laredo, Texas	¢/lb	55.700	141.640	69.300	57.000	66.498
Bismuth, ton lots, delivered	$/lb	4.625	6.000	5.260	3.625	4.915
Cadmium	¢/lb	331.917	362.452	197.262	255.600	364.00
Calcium, ton lots, crowns	$/lb	0.95	0.95	0.95	0.95	0.95
Chromium metal, 98.5%, 0.5%C	$/lb	0.97	1.15	1.15	1.30	1.36
Cobalt metal, 500 lb lots	$/lb	1.910	2.20	2.20	2.450	3.007
Columbium	$/lb	11-22	11-22	11-22	11-22	11-22
Copper, U.S. domestic, fob refinery	¢/lb	47.534	57.700	51.433	50.617	58.865
Gold, Royal Canadian						
Mint buying price	$Cdn/t.oz	37.70	36.56	35.35	36.58	..
London free market[2]	$Cdn/t.oz	..	37.51	41.20	57.54	97.35
Iridium	$/t.oz	177-182	154-159	150-155	150-178	224.58-232.92
Iron ore, 51.5% Fe, lower lake ports						
Bessemer						
Mesabi	$/lt	10.69	10.55-10.95	11.25	11.32	12.01
Old Range	$/lt	10.95	10.95-11.20	11.51	11.57	12.26
Non-Bessemer						
Mesabi	$/lt	10.55	10.55-10.80	11.11	11.17	11.86
Old Range	$/lt	10.80	10.80-11.05	11.36	11.42	12.44
Lead, common, New York	¢/lb	14.895	15.619	13.800	15.029	16.285
Manganese	¢/lb	25.69	27.25	29.10	33.25	33.25
Magnesium, ingot	¢/lb	35.250	35.250	36.250	37.250	38.250
Mercury	$flask(76 lb)	505.043	407.769	292.413	218.279	286.227
Molybdenum metal	$/lb	3.82	4.00	4.00	4.00	4.00
Molybdenite, 95% MoS_2 contained Mo	$/lb	1.68	1.73	1.72	1.72	1.72
Nickel, fob Port Colborne (duty free)	¢/lb	105.431	129.080	133.000	139.700	153.000
Osmium	$/t.oz	254-331	200-225	200-225	200-225	200-225
Palladium	$/t.oz	40.845	36.416	37.000	41.644	77.679
Platinum	$/t.oz	121.667	130.00	120.524	120.779	150.036
Rhenium	$/lb	..	..	1,400	975-1,400	887.5-1,050
Rhodium	$/t.oz	235-240	211-217	198-208	195-200	225.83-230.83
Ruthenium	$/t.oz	50-55	50-55	50-55	50-55	59.17-64.17
Selenium	$/lb	5.31	8.25	9.00	9.00	9.17-10.33
Silver, New York	¢/t.oz	179.067	177.082	154.564	168.455	255.756
Tantalum	$/lb	40-52	36-50	35.38-49.04	36-50	30-40
Tellurium, 100 lb powder	$/lb	6.00	6.00	6.00	6.00	6.00
Tin, Straits, New York	¢/lb	164.347	174.205	167.348	177.474	227.558
Titanium metal, 500 lb lots, 99.3%	$/lb	1.32	1.32	1.32	1.32	1.42-1.43
Titanium ore (ilmenite) 54% TiO_2	$/lt	20-50	20-21	20-21	22-24	25.33-26.67
Tungsten metal	$/st	2.75	4.50	4.50	4.50	4.50
Vanadium 90%, 100 lb lots	$/lb	3.45	..	..	..	..
Zinc, prime, western East St. Louis	¢/lb	14.600	15.319	16.128	17.753	20.658

[1]These prices (U.S. currency) except for gold are from *Metals Week.*
[2]Average of A.M. and P.M. fixings of the London Gold Market, converted to Canadian dollars.

.. Not available or applicable.

Table 24. Canada, wholesale price indexes of minerals and mineral products, 1970-73 (1935-39 = 100)

	1970	1971	1972	1973p
Iron and products	305.1	316.4	325.0	354.2
Pig iron	304.2	313.5	317.2	341.2
Rolling mill products	291.7	306.7	315.9	338.8
Pipe and tubing	309.2	321.4	331.8	358.9
Wire	347.3	368.3	382.8	416.3
Scrap iron and steel	328.9	284.2	268.1	388.8
Tin plate and galvanized sheet	267.2	282.5	295.0	311.3
Nonferrous metal and products				
Total (including gold)	281.0	260.1	262.9	326.4
Total (excluding gold)	422.9	387.6	388.4	543.5
Copper and products	511.5	440.3	428.0	579.4
Lead and products	330.5	282.9	322.7	466.5
Silver	478.1	405.6	430.6	663.3
Tin	349.6	324.2	338.8	435.6
Zinc and products	349.2	365.9	419.1	536.8
Nonmetallic minerals and products	215.7	225.8	233.6	284.6
Clay and clay products	274.6	280.3	289.8	308.2
Pottery	304.9	313.9	351.2	439.2
Coke	347.4	413.4	. .	. .
Petroleum products	170.8	182.6	187.3	224.4
Asphalt	197.7	225.2	229.2	243.9
Asphalt shingles	135.0	144.0	138.1	152.8
Plaster	183.1	185.0	198.0	213.3
Lime	282.1	299.4	347.1	394.5
Cement	207.9	216.4	229.7	233.5
Sand and gravel	186.9	187.8	216.6	234.7
Crushed stone	177.4	180.2	186.5	203.7
Building stone	266.9	282.6	298.3	314.0
Asbestos	375.9	383.2	397.4	413.0
General wholesale price index (all products)	286.4	289.9	310.3	376.9

pPreliminary; . . Not available.

Table 25. Canada, general wholesale price index and wholesale price indexes of mineral and nonmineral products, 1949-73 (1935–39 = 100)

	Mineral Products			Nonmineral Products					
	Iron Products	Nonferrous Metal Products	Nonmetallic Mineral Products	Vegetable Products	Animal Products	Textile Products	Wood Products	Chemical Products	General Wholesale Price Index
1949	175.5	145.2	158.3	190.5	237.5	222.5	241.6	155.2	198.3
1950	183.6	159.5	164.8	202.0	251.3	246.7	258.3	157.8	211.2
1951	208.7	180.6	169.8	218.6	297.7	295.9	295.9	187.3	240.2
1952	219.0	172.9	173.9	210.3	248.2	251.5	291.0	180.1	226.0
1953	221.4	168.6	176.9	199.0	241.7	239.0	288.6	175.7	220.7
1954	213.4	167.5	177.0	196.8	236.0	231.1	286.8	176.4	217.0
1955	221.4	187.6	175.2	195.1	226.0	226.2	295.7	177.0	218.9
1956	239.8	199.2	180.8	197.3	227.7	230.2	303.7	180.1	225.6
1957	252.7	176.0	189.3	197.0	238.4	236.0	299.4	182.3	227.4
1958	252.6	167.3	188.5	198.1	250.7	229.0	298.5	183.0	227.8
1959	255.7	174.6	186.5	199.5	254.3	228.0	304.0	187.0	230.6
1960	256.2	177.8	185.6	203.0	247.6	229.8	303.8	188.2	230.9
1961	258.1	181.6	185.2	203.1	254.7	234.5	305.1	188.7	233.3
1962	256.2	192.1	189.1	211.6	262.5	241.2	315.9	190.5	240.0
1963	253.6	197.5	189.5	227.8	255.6	248.0	323.4	189.3	244.6
1964	256.4	205.9	190.9	223.3	250.8	248.4	330.9	191.2	245.4
1965	264.5	217.6	191.6	218.4	270.7	246.4	334.0	200.2	250.3
1966	268.0	229.9	193.7	225.9	296.2	251.5	337.8	207.1	259.5
1967	274.4	240.2	199.2	230.9	293.1	252.7	346.3	212.6	264.1
1968	276.8	250.8	206.0	230.8	294.6	256.5	367.9	213.7	269.9
1969	285.8	264.0	210.0	237.9	322.4	256.7	389.4	219.7	282.4
1970	305.1	281.0	215.7	238.4	326.0	257.0	377.5	225.7	286.4
1971	316.4	260.1	225.8	237.1	326.0	261.9	394.4	237.8	289.9
1972	325.0	262.9	233.6	249.2	371.8	278.3	436.0	245.5	310.3
1973[p]	354.2	326.4	284.6	354.8	455.3	337.8	503.7	261.4	376.9

[p]Preliminary.

Table 26. Canada, mineral products industries, selling price indexes (1961 = 100), 1970-73

	1970	1971	1972	1973p
Iron and steel products industries				
Agriculture implements industry	122.1	125.5	130.2	136.8
Hardware, tool and cutlery manufacturers	126.5	130.9	137.0r	142.9
Heating equipment manufacturers	111.1	113.5	116.8	119.6
Primary metal industries	136.9	132.3	134.7	154.7
Iron and steel mills	112.6	118.0	121.9	130.6
Steel pipe and tube mills	98.9	103.0	106.9r	116.9
Iron foundries	127.7	131.4	136.3	143.0
Wire and wire products manufacturers	119.5	124.5	129.6	142.2
Nonferrous metal products industries				
Aluminum rolling, casting and extruding	109.7	109.8	109.4	109.7
Copper and alloy, rolling, casting and extruding	181.0	169.4	167.1	208.9
Jewellery and silverware manufacturers	148.5	145.5	155.6r	198.8
Metal rolling, casting and extruding, nes	176.0	151.0	156.6	187.1
Nonmetallic metal products industries				
Abrasive manufacturers	112.2	110.9	111.3	116.2
Cement manufacturers	125.8	130.3	138.7	140.4
Clay products manufacturers from imported clay	116.9	121.2	124.5r	129.6
Glass manufacturers	125.4	130.6	139.7r	145.5
Lime manufacturers	129.1	138.3	149.4	161.9
Gypsum products manufacturers	119.4	119.5	127.1	134.6
Concrete products manufacturers	125.4	127.5	130.8	140.3
Clay products from domestic clay	121.1	124.6	129.9r	140.2
Petroleum and coal products industries	103.1	113.9	115.7	132.4
Petroleum refining	102.8	113.7	116.7r	133.0
Lubricating oils and grease	122.2	128.4	133.4	143.1
Manufacturers of mixed fertilizers	108.9	112.8	117.6r	133.8

Note: Industry selling price indexes reflect wholesale price trends of products or groups of products sold by the industries listed.

nes: Not elsewhere specified; pPreliminary; rRevised.

Table 27. Canada, principal statistics of the mining industry, 1971

	Mining Activity								Total Activity		
		Production and Related Workers									
	Esta-blish-ments	Em-ployees	Man-hours Paid	Wages	Cost of Fuel and Elec-tricity	Cost of Materials and Supplies	Value of Production	Value Added	Em-ployees	Salaries and Wages	Value Added
	(Number)	(Number)	(000)	($000)	($000)	($000)	($000)	($000)	(Number)	($000)	($000)
Metals											
Placer gold	19	3	4	14	10	38	140	92	3	14	92
Gold quartz	26	5,135	10,739	32,557	5,084	24,366	88,966	59,516	6,145	40,976	59,606
Copper-gold-silver	51	11,868	24,452	100,358	18,919	252,205	649,508	378,384	15,754	139,217	386,765
Silver cobalt	5	228	468	1,637	380	789	4,043	2,874	282	2,051	2,945
Silver-lead-zinc	18	4,640	9,658	39,224	9,288	140,656	305,995	156,050	6,224	56,338	157,301
Nickel-copper	8	17,664	34,245	159,779	13,901	426,937	889,617	448,779	21,959	215,087	451,059
Iron	17	7,493	15,742	72,172	43,042	138,977	527,919	345,900	11,524	121,004	345,093
Misc. metal mines	16	3,090	6,761	28,481	6,120	34,905	131,728	90,705	4,121	38,175	91,590
Total	160	50,121	102,069	434,222	96,744	1,018,873	2,597,916	1,482,300	66,012	612,862	1,494,451
Nonmetals											
Asbestos	12	6,443	14,616	54,374	14,292	46,041	225,350	165,018	8,101	70,895	164,749
Feldspar, quartz and nepheline syenite	14	345	726	2,141	756	2,564	12,793	9,473	435	2,826	9,420
Gypsum	10	500	1,111	3,324	814	2,718	15,140	11,608	603	4,210	11,541
Peat	58	1,138	2,386	4,874	564	3,356	15,148	11,227	1,269	5,818	11,147
Salt	9	893	1,822	6,655	1,753	7,226	38,821	29,842	1,357	10,841	29,873
Sand and gravel	176	1,906	4,507	13,675	3,924	10,094	65,472	51,454	2,496	19,168	52,650
Stone	128	2,376	5,623	16,733	4,749	17,798	73,373	50,827	2,832	20,554	50,626
Talc and soapstone	4	60	145	316	90	295	1,283	897	84	493	920
Misc. nonmetallics	21	2,494	5,287	20,262	10,482	17,743	145,723	117,497	3,256	27,772	117,955
Total	432	16,155	36,223	122,354	37,424	107,835	593,103	447,843	20,433	162,577	448,881
Fuels											
Coal	35	6,343	11,625	50,760	7,097	44,062	155,077	103,918	8,069	64,790	103,563
Petroleum and natural gas	1,035	4,082	8,918	39,564	23,067	53,212	1,852,077	1,775,798	15,896	175,432	1,779,369
Total	1,070	10,425	20,543	90,324	30,164	97,274	2,007,154	1,879,716	23,965	240,222	1,882,932
Total Mining Industry	1,662	76,701	158,835	646,900	164,332	1,223,982	5,198,173	3,809,859	110,410	1,015,661	3,826,264

Note: Total activity in this table and also in Tables 28, 29 and 30 includes sales and head offices.

Table 28. Canada, principal statistics of the mineral manufacturing industries, 1971

	Mineral Manufacturing Activity								Total Activity		
	Establishments	Employees	Man-hours Paid	Wages	Cost of Fuel and Electricity	Cost of Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(Number)	(Number)	(000)	($000)	($000)	($000)	($000)	($000)	(Number)	($000)	($000)
Primary metal industries											
Iron and steel mills	50	38,308	79,270	333,581	67,432	842,036	1,764,037	866,948	49,601	461,627	874,322
Steel pipe and tube mills	26	4,292	9,424	36,656	4,795	181,156	273,581	86,564	5,306	47,673	85,648
Iron foundries	116	8,400	17,914	62,764	6,688	86,889	215,246	120,039	9,897	77,781	123,127
Smelting and refining	25	25,517	51,906	210,166	95,280	405,149	1,045,621	545,192	36,445	327,458	563,956
Aluminum rolling, casting and extruding	63	4,142	8,793	31,619	4,007	162,648	248,449	87,491	5,612	47,076	87,122
Copper and alloy rolling, casting and extruding	51	2,839	6,079	21,862	2,827	203,497	263,338	55,780	3,608	29,756	55,465
Metal rolling, casting and extruding	74	2,954	6,158	17,952	2,386	86,388	138,186	50,144	3,845	26,342	52,139
Total primary metal industries	405	86,452	179,544	714,600	183,415	1,967,763	3,948,458	1,812,158	114,314	1,017,713	1,841,779
Nonmetallic mineral products industries											
Cement manufacturers	26	2,550	5,616	23,910	27,909	30,656	192,729	131,404	3,954	38,215	131,276
Lime manufacturers	13	525	1,103	3,616	5,536	5,213	22,585	11,937	670	4,941	11,913
Gypsum products manufacturers	18	1,164	2,554	8,983	2,895	26,230	68,889	40,395	1,874	15,656	43,067
Concrete products manufacturers	488	8,461	18,680	60,125	6,502	98,068	265,354	160,480	10,719	81,233	166,190
Ready mix concrete manufacturers	340	6,177	13,627	48,515	8,570	177,005	318,686	133,290	7,997	64,986	140,297
Clay products manufacture (domestic)	73	2,235	4,742	14,306	5,339	9,576	53,245	37,514	2,786	19,072	37,933
Clay products manufacture (imported)	38	1,495	3,145	9,005	1,290	10,712	35,107	22,791	1,896	12,146	23,244
Refractories manufacturers	19	764	1,708	5,596	1,361	18,361	39,806	20,741	1,180	9,917	24,241
Stone products manufacturers	98	769	1,632	4,179	492	6,330	17,789	10,622	986	5,825	10,670

Table 28. (concl'd)

	Mineral Manufacturing Activity								Total Activity		
	Esta-blish-ments	Em-ployees	Man-hours Paid	Wages	Cost of Fuel and Elec-tricity	Cost of Materials and Supplies	Value of Production	Value Added	Em-ployees	Salaries and Wages	Value Added
	(Number)	(Number)	(000)	($000)	($000)	($000)	($000)	($000)	(Number)	($000)	($000)
Glass manufacturers	18	6,759	14,260	49,138	10,307	38,664	169,400	123,390	8,532	66,180	127,631
Glass products manufacturers	86	2,347	4,857	16,655	1,808	57,316	115,008	55,878	3,140	24,629	56,423
Mineral wool manufacturers	10	865	2,035	7,571	1,956	15,001	46,800	29,535	1,311	11,993	29,968
Asbestos products manufacturers	16	1,793	3,921	13,765	1,329	19,730	58,332	37,269	2,828	23,145	42,667
Abrasive manufacturers	23	1,677	3,584	12,500	7,106	25,656	60,884	27,944	2,310	18,685	28,454
Other nonmetallic mineral products industries	41	454	1,011	3,181	781	11,252	24,560	12,497	1,108	8,508	15,309
Total nonmetallic minerals	1,307	38,035	82,475	281,045	83,181	549,770	1,489,174	855,687	51,291	405,131	889,283
Petroleum and coal products industries											
Petroleum refining industry	41	5,874	13,112	63,153	20,222	1,635,520	2,045,825	401,032	14,506	164,424	403,895
Manufacture of lubricating oils and greases	18	255	544	1,992	219	25,457	43,076	17,495	450	3,883	18,877
Other petroleum and coal products industries	42	428	954	3,071	979	14,034	25,423	10,629	561	4,286	12,513
Total petroleum and coal products industries	101	6,557	14,610	68,216	21,420	1,675,011	2,114,324	429,156	15,517	172,593	435,285
Total mineral manufacturing industries	1,813	131,044	276,629	1,063,861	288,016	4,192,544	7,551,951	3,097,001	181,122	1,595,437	3,166,347

Table 29. Canada, principal statistics of the mining industry[1], 1966-1971

	Mining Activity								Total Activity		
	Establishments	Employees	Man-hours Paid	Wages	Cost of Fuel and Electricity	Cost of Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(Number)	(Number)	(000)	($000)	($000)	($000)	($000)	($000)	(Number)	($000)	($000)
1966	1,422	74,195	158,156	419,496	98,867	706,109	3,417,868	2,612,891	102,063	629,232	2,636,524
1967	1,478	74,230	159,182	465,489	107,563	806,577	3,831,808	2,917,669	102,678	700,678	2,943,224
1968	1,548	75,066	160,346	510,003	119,640	900,344	4,195,930	3,175,945	104,916	772,453	3,189,271
1969	1,686	71,368	151,072	513,708	126,999	931,354	4,400,637	3,342,285	102,088	804,839	3,355,312
1970	1,636	77,208	164,835	614,084	146,049	1,167,456	5,118,396[r]	3,804,891[r]	110,094[r]	994,014[r]	3,830,364[r]
1971	1,662	76,701	158,835	646,900	164,332	1,223,982	5,198,173	3,809,859	110,410	1,015,661	3,826,264

[1]Excludes cement manufacturing, lime manufacturers, clay and clay products (domestic clays). These industries are included in the Mineral Manufacturing Industries. Industry coverage is the same as in Tables 27, 31 and 32.

[r]Revised.

Table 30. Canada, principal statistics of the mineral manufacturing industries[1], 1966-71

	Mineral Manufacturing Activity								Total Activity		
	Establishments	Workers	Man-hours	Wages	Cost of Fuel and Electricity	Cost of Materials and Supplies	Value of Production	Value Added	Employees	Salaries Wages	Value Added
	(Number)	(Number)	(000)	($000)	($000)	($000)	($000)	($000)	(Number)	($000)	($000)
1966	1,844	134,141	289,377	773,247	209,020	3,242,891	5,701,881	2,299,294	171,452	1,043,324	2,359,168
1967	1,797	131,090	282,982	801,636	210,519	3,241,716	5,692,956	2,291,709	169,441	1,095,187	2,342,764
1968	1,760	130,909	279,997	850,059	227,679	3,537,700	6,264,415	2,530,325	173,932	1,188,721	2,588,302
1969	1,802	128,263	275,947	890,911	232,861	3,689,337	6,581,618	2,677,254	167,487	1,237,095	2,741,440
1970	1,781	131,570	278,547	989,725	263,827	3,954,629	7,002,306	2,849,055	181,620	1,480,524	2,920,381
1971	1,813	131,044	276,629	1,063,861	288,016	4,192,544	7,551,951	3,097,001	181,122	1,595,437	3,166,347

[1]Industry coverage in this table is the same as in Tables 28, 33 and 34.

Table 31. Canada, consumption of fuel and electricity in the mining industry[1], 1971

	Unit	Metals	Nonmetals	Fuels	Total
Coal and coke	000 st	50	23	...	73
	$000	892	327	4	1,223
Gasoline	000 gal	5,337	8,898	2,319	16,554
	$000	2,223	3,493	573	6,289
Fuel oil, kerosene, coal oil	000 gal	209,250	69,981	7,226	286,457
	$000	30,215	13,633	1,352	45,200
Liquified petroleum gas	000 gal	5,642	1,005	317	6,964
	$000	952	282	36	1,270
Natural gas	000 Mcf	11,687	18,446	1,829	31,962
	$000	5,437	5,215	670	11,322
Other fuels[2]	$000	168	1	–	169
Total fuels	$000	39,887	22,951	2,635	65,473
Electricity purchased	Million kwh	8,692	1,584	1,763	12,039
	$000	56,847	14,474	27,528	98,849
Total value of fuels and electricity purchased	$000	96,734	37,425	30,163	164,322
Value of fuels and electricity of small establishments[3]	$000	10	–	–	10
Total value of fuels and electricity purchased, all reporting companies	$000	96,744	37,425	30,163	164,332
Electricity generated by industry for own use	Million kwh	240	178	–	448
Electricity generated by industry for sale	Million kwh	89	–	–	89

[1] Excludes cement and lime manufacturing and manufacture of clay products (from domestic clays). These industries are included under mineral manufacturing, Tables 33 and 34. Industry coverage is same as in Tables 27, 29 and 32.
[2] Includes wood, manufactured gas, steam purchased and other miscellaneous fuels.
[3] Value of fuels and electricity used by small establishments which have reported in total only without commodity detail.
... Less than 1,000 short tons. – Nil.

Table 32. Canada, cost of fuel and electricity in the mining industry[1], 1964-71

	Units	1964	1965	1966	1967	1968	1969	1970	1971
Metals									
Fuel	$000	16,246	19,854	22,038	26,116	29,340	27,070	33,370	39,887
Electricity purchased	million Kwh	4,371	5,533	5,511	6,300	7,020	7,073	7,995	8,692
	$000	27,810	34,517	35,248	38,342	42,340	46,002	52,257	56,847
Value of fuel and electricity used by small establishments[2]	$000	59	57	51	24	21	22	21	10
Total cost of fuel and electricity	$000	44,115	54,428	57,337	64,482	71,701	73,094	85,648	96,744
Electricity generated for own use and for sale	million Kwh	447	483	473	510	466	476	459	359
Nonmetals[3]									
Fuel	$000	12,279	14,623	15,410	16,180	18,448	19,793	20,029	22,951
Electricity purchased	million Kwh	820	939	1,022	1,127	1,291	1,473	1,468	1,584
	$000	7,901	8,711	8,867	9,537	10,809	12,728	13,980	14,474
Value of fuel and electricity used by small establishments[2]	$000	703	740	735	548	342	401	–	–
Total cost of fuel and electricity	$000	20,883	24,074	25,012	26,265	29,599	32,922	34,009	37,425
Electricity generated for own use and for sale	million Kwh	34	41	123	151	156	173	161	178
Fuels									
Fuels	$000	765	827	720	690	678	739	2,072	2,635
Electricity purchased	million Kwh	859	888	955	989	1,101	1,265	1,540	1,763
	$000	16,514	17,064	15,798	16,126	17,662	20,244	24,320	27,528
Value of fuel and electricity used by small establishments[2]	$000	–	–	–	–	–	–	–	–
Total cost of fuel and electricity	$000	17,279	17,891	16,518	16,816	18,340	20,983	26,392	30,163
Electricity generated for own use and for sale	million Kwh	30	34	37	–	–	–	–	–
Total mining industry									
Fuel	$000	29,290	35,304	38,168	42,986	48,466	47,602	55,470	65,473
Electricity purchased	million Kwh	6,050	7,360	7,488	8,416	9,412	9,811	11,003	12,039
	$000	52,225	60,292	59,913	64,005	70,811	78,974	90,558	98,849
Value of fuel and electricity used by small establishments[2]	$000	762	797	786	572	363	423	21	10
Total cost of fuel and electricity	$000	82,277	96,393	98,867	107,563	119,640	126,999	146,049	164,332
Electricity generated for own use and for sale	million Kwh	511	558	633	661	622	649	620	537

1. See footnote Table 31. Industry coverage is the same as in Tables 27, 29 and 31.
2. Value of fuel and electricity used by small establishments which have reported in total only, without detail.
3. Nonmetals includes structural material.
– Nil.

Table 33. Canada, consumption of fuel and electricity in the mineral manufacturing industries[1], 1971

	Unit	Primary Metals Industries	Nonmetallic Mineral Products Industries	Petroleum and Coal Products Industries	Total
Coal and coke	000 st	1,203	260	4	1,467
	$000	26,131	4,221	9	30,361
Gasoline	000 gal	3,987	16,891	465	21,343
	$000	1,396	6,581	187	8,164
Fuel oil, kerosene, coal oil	000 gal	327,327	193,211	3,764	524,302
	$000	32,863	21,018	527	54,408
Liquefied petroleum gas	000 gal	11,795	2,669	7	14,471
	$000	1,484	564	2	2,050
Natural gas	000 Mcf	62,386	52,492	14,643	129,521
	$000	29,781	24,107	4,273	58,161
Other fuels	$000	1,248	758	348	2,354
Total fuels	$000	92,903	57,249	5,346	155,498
Electricity purchased	Million kwh	15,028	3,279	2,326	20,633
	$000	90,512	25,932	16,074	132,518
Total value, fuels and electricity purchased	$000	183,415	83,181	21,420	288,016
Value of purchased fuels and electricity of small establishments[2]	$000	–	–	–	–
Total value of fuels and electricity purchased, all reporting companies	$000	183,415	83,181	21,420	288,016

[1] Industry coverage is the same as in Tables 28, 30 and 34.
[2] Value of fuels and electricity used by small establishments which have reported in total only, without detail.
– Nil.

Table 34. Canada, cost of fuel and electricity used in the mineral manufacturing industries[1], 1964-71

		1964	1965	1966	1967	1968	1969	1970	1971
Primary metals									
Fuel	$000	58,010	67,121	71,129	71,133	73,938	69,185	83,034	92,903
Electricity purchased	million kwh	11,150	11,326	12,531	13,118	14,363	15,370	14,539	15,028
	$000	47,920	52,388	56,774	60,624	68,834	73,114	87,656	90,512
Cost of fuel and electricity for small establishments[2]	$000	373	384	326	199	171	202	–	–
Total cost of fuel and electricity	$000	106,303	119,893	128,229	131,956	142,943	142,501	170,690	183,415
Nonmetallic mineral products									
Fuel	$000	38,453	42,925	45,479	44,055	45,237	47,310	49,451	57,249
Electricity purchased	million kwh	2,584	2,885	3,265	2,987	3,118	3,182	3,270	3,279
	$000	16,340	18,397	20,791	19,962	21,566	23,297	24,507	25,932
Cost of fuel and electricity for small establishments[2]	$000	893	1,104	1,122	852	1,165	1,231	–	–
Total cost of fuel and electricity	$000	55,686	62,426	67,392	64,869	67,968	71,838	73,958	83,181
Petroleum and coal products									
Fuel	$000	2,828	2,738	3,213	2,980	5,294	5,450	4,749	5,346
Electricity purchased	million kwh	1,527	1,518	1,586	1,659	1,818	1,980	2,171	2,326
	$000	9,751	9,820	10,177	10,699	11,467	13,059	14,430	16,074
Cost of fuel and electricity for small establishments[2]	$000	–	18	9	15	7	13	–	–
Total cost of fuel and electricity	$000	12,579	12,576	13,399	13,694	16,768	18,522	19,179	21,420
Total mineral manufacturing industries									
Fuel	$000	99,291	112,784	119,821	118,168	124,469	121,945	137,234	155,498
Electricity purchased	million kwh	15,261	15,729	17,832	17,764	19,299	20,532	19,980	20,633
	$000	74,011	80,605	87,742	91,285	101,867	109,470	126,593	132,518
Cost of fuel and electricity for small establishments[2]	$000	1,266	1,506	1,457	1,066	1,343	1,446	–	–
Total cost of fuel and electricity	$000	174,568	194,895	209,020	210,519	227,679	232,861	263,827	288,016

[1] Industry coverage is the same as in Tables 28, 30 and 33.
[2] Total cost of fuel and electricity purchased by small establishments; No detail reported.
– Nil.

Table 35. Canada, employment, salaries and wages in the mining industry[1], 1964-71

		1964	1965	1966	1967	1968	1969	1970	1971
Metals									
Production and related workers	Number	46,727	49,050	48,276	48,262	49,238	46,023	51,102	50,121
Salaries and wages	$000	244,549	269,457	284,477	317,978	350,321	341,495	421,893	434,222
Annual average salary and wage	$	5,234	5,494	5,893	6,589	7,115	7,420	8,256	8,663
Administrative and office workers	Number	10,921	11,892	13,394	13,466	14,131	14,527	15,488	15,891
Salaries and wages	$000	77,056	87,398	100,666	111,405	124,451	137,756	158,653	178,640
Annual average salary and wage	$	7,056	7,349	7,516	8,273	8,807	9,482	10,244	11,242
Total, metals									
Employees	Number	57,648	60,942	61,670	61,728	63,369	60,550	66,590	66,012
Salaries and wages	$000	321,605	356,855	385,143	429,383	474,772	479,251	580,546	612,862
Annual average salary and wage	$	5,579	5,856	6,245	6,956	7,492	7,915	8,718	9,284
Nonmetals									
Production and related workers	Number	14,211	14,688	14,916	15,049	15,458	15,933	16,245	16,155
Salaries and wages	$000	67,134	72,352	77,984	84,755	94,850	107,622	114,345	122,355
Annual average salary and wage	$	4,724	4,926	5,228	5,632	6,135	6,754	7,039	7,574
Administrative and office workers	Number	3,560	3,676	3,818	3,807	4,051	4,081	4,415	4,278
Salaries and wages	$000	21,914	24,239	26,049	28,397	32,836	34,980	39,533	40,222
Annual average salary and wage	$	6,156	6,594	6,823	7,459	8,106	8,573	8,954	9,402
Total, nonmetals									
Employees	Number	17,771	18,364	18,734	18,856	19,509	20,014	20,660	20,433
Salaries and wages	$000	89,048	96,591	104,033	113,152	127,686	142,602	153,878	162,577
Annual average salary and wage	$	5,011	5,260	5,553	6,000	6,545	7,125	7,448	7,957
Fuels									
Production and related workers	Number	11,399	11,308	11,003	10,919	10,370	9,412	9,861	10,425
Salaries and wages	$000	53,083	54,922	57,035	62,756	64,832	64,591	77,846	90,324
Annual average salary and wage	$	4,657	4,857	5,184	5,747	6,252	6,862	7,894	8,664
Administrative and office workers	Number	9,639	10,206	10,656	11,175	11,668	12,112	12,983	13,540
Salaries and wages	$000	66,991	73,733	83,021	95,387	105,163	118,395	131,744	149,898
Annual average salary and wage	$	6,950	7,224	7,791	8,536	9,013	9,775	10,147	11,070
Total fuels									
Employees	Number	21,038	21,514	21,659	22,094	22,038	21,524	22,844	23,965
Salaries and wages	$000	120,074	128,655	140,056	158,143	169,995	182,986	209,590	240,222
Annual average salary and wage	$	5,707	5,980	6,466	7,158	7,714	8,501	9,175	10,024

(continued on page 600)

Table 35. (concl'd)

		1964	1965	1966[r]	1967[r]	1968	1969	1970	1971
Total Mining									
Production and related workers	Number	72,337	75,046	74,195	74,230	75,066	71,368	77,208	76,701
Salaries and wages	$000	364,766	396,731	419,496	465,489	510,003	513,708	614,084	646,901
Annual average salary and wage	$	5,043	5,286	5,654	6,271	6,794	7,198	7,954	8,434
Administrative and office workers	Number	24,120	25,774	27,868	28,448	29,850	30,720	32,886	33,709
Salaries and wages	$000	165,961	185,370	209,736	235,189	262,450	291,131	329,930	368,760
Annual average salary and wage	$	6,881	7,192	7,526	8,267	8,792	9,477	10,033	10,940
Total Mining Employees	Number	96,457	100,820	102,063	102,678	104,916	102,088	110,094	110,410
Salaries and wages	$000	530,727	582,101	629,232	700,678	722,453	804,839	944,014	1,015,661
Annual average salary and wage	$	5,502	5,774	6,165	6,824	7,363	7,883	8,575	9,199

[1]According to the revised Standard Industrial Classification. Does not include cement and lime manufacturing and clay products (domestic clays) manufacturing. These industries are included in Table 36 under Nonmetallic mineral products industries.

See Table 27 for detail of industries covered.

[r] Revised.

Table 36. Canada, employment, salaries and wages in the mineral manufacturing industries, 1964-71

		1964	1965	1966	1967	1968	1969	1970	1971
Primary Metal Industries									
Production and related workers	Number	77,770	83,443	87,748	86,784	86,237	83,564	88,839	86,452
Salaries and wages	$000	427,710	478,482	518,347	541,970	570,183	583,498	680,779	714,600
Annual average salary and wage	$	5,550	5,734	5,907	6,245	6,612	6,982	7,663	8,266
Administrative and office workers	Number	20,010	21,189	22,555	23,294	23,702	24,300	27,706	27,862
Salaries and wages	$000	133,866	148,752	169,686	185,800	202,683	219,807	277,728	303,113
Annual average salary and wage	$	6,690	7,020	7,523	7,976	8,551	9,045	10,024	10,879
Total Primary Metal Industries Employees	Number	97,780	104,632	110,303	110,078	109,939	107,864	116,545	114,314
Salaries and wages	$000	561,576	627,234	688,033	727,770	772,866	803,305	958,507	1,017,713
Annual average salary and wage	$	5,743	5,995	6,238	6,611	7,030	7,447	8,224	8,903
Nonmetallic Mineral Products Industries									
Production and related workers	Number	35,598	38,246	39,561	37,467	37,796	38,107	36,045	38,035
Salaries and wages	$000	164,302	188,351	206,120	207,204	223,173	246,196	244,201	281,046
Annual average salary and wage	$	4,615	4,925	5,210	5,569	5,919	6,461	6,775	7,389
Administrative and office workers	Number	11,273	11,044	11,583	11,793	16,191	11,781	13,383	13,256
Salaries and wages	$000	64,890	66,970	73,851	79,464	106,557	94,243	117,163	124,085
Annual average salary and wage	$	5,756	6,064	6,376	6,738	6,581	7,999	8,754	9,361

Table 36. (concl'd)

		1964	1965	1966	1967	1968	1969	1970	1971
Total Nonmetallic Mineral Products									
Employees	Number	46,871	49,290	51,144	49,260	53,987	49,888	49,428	51,291
Salaries and wages	$000	229,192	255,321	279,971	286,668	329,730	340,439	361,364	405,131
Annual average salary and wage	$	4,890	5,180	5,474	5,819	6,108	6,824	7,311	7,899
Petroleum and Coal Products Industries									
Production and related workers	Number	7,168	6,825	6,832	6,839	6,876	6,590	6,686	6,557
Salaries and wages	$000	44,784	43,387	48,780	52,462	56,703	61,217	64,745	68,215
Annual average salary and wage	$	6,248	6,357	7,140	7,671	8,247	9,289	9,684	10,403
Administrative and office workers	Number	3,478	3,090	3,173	3,264	3,130	3,145	8,961	8,960
Salaries and wages	$000	24,884	25,472	26,540	28,287	29,422	32,134	95,908	104,378
Annual average salary and wage	$	7,155	8,243	8,364	8,666	9,400	10,217	10,703	11,649
Total Petroleum and Coal Products									
Employees	Number	10,646	9,915	10,005	10,103	10,006	9,735	15,647	15,517
Salaries and wages	$000	69,668	68,859	75,320	80,749	86,125	93,351	160,653	172,593
Annual average salary and wage	$	6,546	6,945	7,528	7,993	8,607	9,589	10,267	11,123
Total Mineral Manufacturing Industries									
Production and related workers	Number	120,536	128,514	134,141	131,090	130,909	128,261	131,570	131,044
Salaries and wages	$000	636,796	710,220	773,247	801,636	850,059	890,911	989,725	1,063,861
Annual average salary and wage	$	5,283	5,526	5,764	6,115	6,494	6,945	7,522	8,118
Administrative and office workers	Number	34,761	35,323	37,311	38,351	43,023	39,226	50,050	50,078
Salaries and wages	$000	223,640	241,194	270,077	293,551	338,662	346,184	490,799	531,576
Annual average salary and wage	$	6,434	6,828	7,239	7,654	7,872	8,825	9,806	10,615
Total Mineral Manufacturing Industries									
Employees	Number	155,297	163,837	171,452	169,441	173,932	167,487	181,620	181,122
Salaries and wages	$000	860,436	951,414	1,043,324	1,095,187	1,188,721	1,237,095	1,480,524	1,595,437
Annual average salary and wage	$	5,541	5,807	6,085	6,464	6,834	7,386	8,151	8,809

Note: See footnote Table 35.
See Table 28 for detail of industries covered.

Table 37. Canada, number of wage earners, surface, underground and mill, mining industry[1], 1968-71

	1968	1969	1970	1971
Metals				
Surface	14,061	13,269	14,724	14,316
Underground	25,146	22,996	25,317	24,907
Mill	10,031	9,758	11,061	10,898
Total	49,238	46,023	51,102	50,121
Nonmetals				
Surface	7,575	7,381	7,515	7,650
Underground	1,483	1,817	1,954	1,733
Mill	6,400	6,735	6,776	6,772
Total	15,458	15,933	16,245	16,155
Fuels				
Surface	5,222	4,292	5,091	5,798
Underground	5,148	5,120	4,770	4,627
Total	10,370	9,412	9,861	10,425
Total mining industry				
Surface	26,858	24,942	27,330	27,764
Underground	31,777	29,933	32,041	31,267
Mill	16,431	16,493	17,837	17,670
Total	75,066	71,368	77,208	76,701

[1]See Table 27 for coverage.

Table 38. Canada, labour costs in relation to tons mined, metal mines, 1969-71

Type of Metal Mine	Number of Wage Earners	Total Wages	Average Annual Wage	Ore Mined	Average Annual Tons Mined Per Wage Earner	Wage Cost Per Ton Mined
		($000)	($)	(000 st)	(st)	($)
1971						
Auriferous quartz	5,138	32,571	6,339	7,338	1,428	4.44
Copper-gold-silver	11,868	100,358	8,456	47,837	4,031	2.10
Nickel-copper	17,664	159,779	9,045	34,484	1,952	4.63
Silver-cobalt	228	1,637	7,180	165	724	9.92
Silver-lead-zinc	4,640	39,224	8,453	16,186	3,488	2.42
Iron ore	7,493	72,172	9,632	107,222	14,310	0.67
Miscellaneous metals	3,090	28,481	9,217	19,876	6,432	1.43
Total	50,121	434,222	8,665	233,108	4,651	1.86
1970						
Auriferous quartz	5,990	36,235	6,049	7,781	1,299	4.66
Copper-gold-silver	11,826	90,980	7,693	43,067	3,642	2.11
Nickel-copper	16,691	149,303	8,945	34,492	2,067	4.33
Silver-cobalt	339	2,203	6,499	230	679	9.58
Silver-lead-zinc	4,987	39,235	7,868	15,839	3,176	2.48
Iron ore	7,609	74,031	9,729	108,260	14,228	0.68
Miscellaneous metals	3,660	29,906	8,171	25,200	6,885	1.19
Total	51,102	421,893	8,256	234,869	4,596	1.80
1969						
Auriferous quartz	6,959	39,149	5,626	9,048	1,300	4.33
Copper-gold-silver	10,627	73,721	6,937	33,847	3,185	2.18
Nickel-copper	12,425	94,999	7,646	22,244	1,790	4.27
Silver-cobalt	430	2,599	6,044	286	665	9.09
Silver-lead-zinc	4,772	34,191	7,164	14,192	2,974	2.41
Iron ore	7,058	66,960	9,487	88,142	12,488	0.76
Miscellaneous metals	3,752	29,876	7,962	21,819	5,815	1.37
Total	46,023	341,495	7,420	189,578	4,119	1.80

Table 39. Canada, man-hours paid, production and related workers, tons of ore mined and rock quarried, metal mines and nonmetallic mineral operations, 1965-71

	Unit	1965	1966	1967	1968	1969	1970	1971
Metal mines[1]								
Ore mined	million st	166.5	162.8	186.5	206.1	189.6	234.9	233.1
Man-hours paid[2]	million	106.4	101.4	103.8	105.2	95.8	108.2	102.1
Man-hours paid per ton mined	number	0.64	0.62	0.56	0.51	0.51	0.46	0.44
Tons mined per man-hour paid	st	1.56	1.61	1.80	1.96	1.98	2.17	2.28
Nonmetallic mineral operations[3]								
Ore mined and rock quarried	million st	144.0	171.3	177.9	173.4	179.9	178.0	182.9
Man-hours paid[2]	million	23.2	24.7	25.3	25.9	28.4	28.6	27.3
Man-hours paid per ton mined	number	0.16	0.14	0.14	0.15	0.16	0.16	0.15
Tons mined per man-hour paid	st	6.19	6.93	7.04	6.69	6.33	6.22	6.70

[1] Excludes placer mining. [2] Man-hours paid for production and related workers only. [3] Excludes salt, cement, clay products, stone for cement and lime manufacture, and peat.

Table 40. Canada, basic wage rates per hour in metal mining industry on October 1, 1972 and 1973

	Gold Mines		Iron Mines		Other Metal Mines	
	1972	1973p	1972	1973p	1972	1973p
	$	$	$	$	$	$
Underground workers						
Cage and skiptender	2.88	..	..	..	4.07	..
Cageman	..	3.31	..	..	..	4.30
Car dropper	..	3.31	..	..	..	4.48
Chute blaster	2.80	..	..	..	4.26	..
Deckman	2.75	..	..	..	3.84	..
Dinkey-engine operator	..	3.23	..	..	..	3.87
Grizzly worker	..	2.92	..	..	..	4.52
Hoist operator	3.06	3.58	..	..	4.34	4.70
Labourer	2.69	3.14	..	..	3.85	4.15
Mechanical shovel operator	..	3.35	..	..	..	4.33
Miner	2.91	3.27	..	..	4.08	4.46
Miner's helper	2.53	3.12	..	..	3.24	3.56
Motorman	2.68	..	..	..	3.77	..
Mucker and trammer	2.78	..	..	..	3.97	..
Mucking machine operator	2.79	..	..	..	3.88	..
Timberman	2.93	3.30	..	..	3.97	4.38
Trackman	2.78	3.08	..	..	3.96	4.41
Open-pit workers						
Blaster	..	..	4.21	4.41	..	..
Bulldozer operator	..	..	4.30	4.38	..	..
Driller machine	..	..	4.36	4.57	..	..
Dumptruck driver	..	..	4.38	4.39	..	..
Oiler	..	..	4.00	4.21	..	..
Shovel operator (power)	..	..	4.85	5.07	..	..
Surface and mill workers						
Bit-sharpener tender	..	3.57	..	..	..	4.16
Blacksmith	..	..	..	..	4.30	4.54
Carpenter, maintenance	3.04	3.71	4.71	4.91	4.25	4.61
Crusher tender	2.76	3.24	4.18	4.37	3.91	4.16
Diesel mechanic	..	..	4.84	4.96	4.76	5.01
Electrician	3.12	3.57	4.85	5.11	4.65	4.92
Filter operator	..	..	..	..	3.88	4.13
Flotation operator	..	..	..	..	4.00	4.30
Hoistman	..	..	..	..	..	..
Grinder	..	..	4.19	4.38	3.96	4.17
Labourer	2.59	3.08	3.70	3.84	3.52	3.65
Leaching operator	..	..	..	..	..	4.50
Maintenance machinist	3.48	3.55	3.94	5.18	4.62	4.79
Maintenance-man helper	..	3.04	..	4.09	..	4.03
Maintenance mechanic	2.95	..	4.73	..	4.50	..
Millman[1]	2.91	3.54	..	..	..	..
Millwright	..	..	4.76	5.02	4.62	4.81
Pipefitter, maintenance	3.02	3.44	4.72	4.95	4.19	4.55
Solution man	..	..	..	..	3.96	..
Steel sharpener	2.98	..	..	..	3.88	..
Trademan's helper	2.74	..	3.99	..	3.79	..
Truckdriver, light and heavy	2.74	3.28	4.17	4.57	4.00	4.25
Welder, maintenance	3.05	3.60	4.73	4.97	4.55	4.85

[1]Includes filter operator, grinding-mill operator, ball-mill operator, rod-mill operator, tubeman and solution man.
pPreliminary; . . Not available or not applicable.

Table 41. Canada, average weekly wages and hours of hourly-rated employees in mining, manufacturing and construction industries, 1966-73

	1965	1967	1968	1969	1970	1971	1972	1973p
Mining								
Average hours per week	42.3	41.9	41.8	41.4	41.0	40.4	40.3	40.9
Average weekly wage	110.29	119.09	128.28	135.94	152.10	163.22	174.94	196.82
Metals								
Average hours per week	41.6	41.3	41.2	40.7	40.3	39.3	39.0	39.6
Average weekly wage	112.99	112.79	131.55	137.68	154.68	164.27	174.69	195.69
Mineral fuels								
Average hours per week	42.3	42.5	41.9	41.9	42.0	41.4	41.0	41.0
Average weekly wage	95.68	101.24	109.96	122.88	146.68	161.46	176.36	198.12
Nonmetals								
Average hours per week	42.1	42.3	42.4	41.9	41.3	41.4	41.3	41.3
Average weekly wage	104.00	112.35	121.24	129.05	139.21	151.52	158.30	173.11
Manufacturing								
Average hours per week	40.8	40.3	40.3	40.0	40.0	40.3	40.4	39.8
Average weekly wage	91.65	96.84	104.00	111.69	119.69	130.22	141.53	152.69
Construction								
Average hours per week	42.2	41.3	40.5	39.8	39.2	39.2	40.1	39.5
Average weekly wage	118.23	128.76	134.84	146.90	165.04	186.20	206.43	223.71

pPreliminary.

Table 42. Canada, average weekly wages of hourly-rated employees in mining industry in current and 1949 dollars, 1966-73

	1966	1967	1968	1969	1970	1971	1972	1973p
Current Dollars								
All mining	110.29	119.09	128.28	135.94	152.10	163.22	174.47	196.82
Metals	112.99	122.79	131.55	137.68	154.68	164.27	174.69	195.69
Gold	91.12	95.72	101.26	107.69	113.72	124.61	131.92	151.73
Mineral fuels	95.68	101.24	109.96	122.88	146.68	161.46	176.36	198.12
Coal	85.53	90.63	97.41	108.58	130.37	144.26	158.18	181.28
Nonmetals except fuel	104.00	112.35	121.24	129.05	139.21	151.52	158.30	173.10
1949 Dollars								
All mining	76.64	79.92	82.65	83.86	90.81	94.73	96.61	101.30
Metals	78.52	82.40	84.76	84.94	92.35	95.34	96.73	100.71
Gold	63.32	64.24	65.24	66.43	67.89	72.32	73.05	78.09
Mineral fuels	66.49	67.94	70.85	75.81	87.57	93.71	97.65	101.97
Coal	59.44	60.83	62.76	66.98	77.83	83.73	87.59	93.30
Industrial minerals	72.27	75.40	78.12	79.61	83.11	87.94	87.65	89.09

pPreliminary.

Table 43. Canada, industrial fatalities per thousand workers, by industry groups, 1971-73

	Fatalities number			Number of Workers 000's			Rate per 1,000 Workers		
	1971	1972	1973	1971	1972	1973	1971	1972p	1973
Agriculture	21	30	25	510	481	467	0.04	0.06	0.06
Forestry	93	76	94	72	71	80	1.29	1.07	1.18
Fishing	11	10	15	22	22	25	0.50	0.45	0.60
Mining	162	171	166	129	124	123	1.26	1.38	1.35
Manufacturing	181	247	234	1,795	1,857	1,968	0.10	0.13	0.12
Construction	225	208	201	495	501	549	0.45	0.42	0.37
Transportation	203	225	241	702	730	773	0.29	0.31	0.31
Trade	79	70	78	1,330	1,410	1,498	0.06	0.05	0.05
Finance	4	6	6	385	385	410	0.01	0.02	0.02
Service	70	109	78	2,118	2,194	2,284	0.03	0.05	0.03
Public administration	67	63	89	520	553	582	0.13	0.11	0.15
Total	1,116	1,215	1,227	8,078	8,328	8,759	0.14	0.15	0.14

See footnotes to Table 44.

Table 44. Canada, industrial fatalities per thousand workers, by industry groups, 1963-1973

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973P
Agriculture	0.08	0.11	0.08	0.10	0.05	0.05	0.06	0.03	0.04	0.06	0.06
Forestry	1.53	1.89	1.40	1.45	1.25	1.28	1.10	1.31	1.29	1.07	1.18
Fishing[1]	1.36	1.42	1.74	1.42	1.32	0.79	0.86	1.25	0.50	0.45	0.60
Mining[2]	2.26	1.85	1.31	1.21	1.61	1.15	1.40	1.20	1.26	1.38	1.35
Manufacturing	0.14	0.14	0.14	0.13	0.11	0.10	0.11	0.10	0.10	0.13	0.12
Construction	0.58	0.61	0.60	0.59	0.43	0.46	0.49	0.41	0.45	0.42	0.37
Transportation[3]	0.35	0.40	0.47	0.40	0.34	0.26	0.30	0.27	0.29	0.31	0.31
Trade	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05
Finance[4]	0.01	0.01	0.01	0.00	0.02	–	0.01	0.01	0.01	0.02	0.02
Service[5]	0.02	0.04	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.05	0.03
Public administration	0.29	0.14	0.13	0.07	0.08	0.14	0.14	0.16	0.13	0.11	0.15
Total	0.19	0.20	0.19	0.17	0.15	0.13	0.14	0.13	0.14	0.15	0.14

[1]Includes trapping and hunting; [2]Includes quarrying and oil wells; [3]Includes storage, communication, electric power and water utilities; [4]Includes insurance and real estate; [5]Includes community, business and personal service.
PPreliminary; – Nil.

1960-1974 - 250 working days
1975- 250 working days
kl. Workers
7-2980

Table 45. Canada, number of strikes and lockouts, by industries, 1972-73

	1972			1973P		
	Strikes and Lockouts	Workers Involved	Duration in Man-Days	Strikes and Lockouts	Workers Involved	Duration in Man-Days
Forestry	12	6,004	120,330	25	7,031	16,000
Fishing and trapping	–	–	–	3	8,000	55,950
Mines	32	13,410	334,680	33	11,560	220,570
Manufacturing	290	117,699	2,042,500	382	149,957	3,370,750
Construction	82	50,649	1,420,460	61	24,161	517,360
Transportation and utilities	59	72,151	1,387,130	73	90,774	1,076,470
Trade	47	12,104	95,620	67	12,528	163,930
Finance, insurance and real estate	2	231	1,770	2	17	260
Service	37	341,659	1,553,710	52	43,877	248,480
Public administration	37	92,567	797,330	23	4,332	99,020
All industries	598	706,474	7,753,530	721	352,237	5,768,790

– Nil; PPreliminary.

Table 46. Canada, ore mined and rock quarried, mining industry, 1969-71

	1969	1970	1971
	(short tons)		
Metals			
Gold quartz	9,048,327	7,781,571	7,337,407
Copper-gold-silver	33,847,436	43,067,354	47,837,400
Silver-cobalt	286,097	229,704	164,690
Silver-lead-zinc	14,191,584	15,838,543	16,185,964
Nickel-copper	22,243,976	34,492,189	34,484,304
Iron	88,142,291	108,259,551	107,221,930
Miscellaneous metals	21,818,907	25,199,823	19,876,406
Total	189,578,618	234,868,735	233,108,101
Nonmetals			
Asbestos	88,438,106	90,531,936	84,475,059
Feldspar, nepheline syenite	791,053	626,833	706,240
Quartz (exclusive of sand)	1,268,446	1,368,952	1,495,943
Gypsum	6,625,859	5,892,699	6,735,651
Talc soapstone	74,178	67,021	73,851
Rock salt	3,406,901	4,368,015	4,581,429
Other nonmetallics	15,257,175	14,304,219	15,893,105
Total	115,861,718	117,159,675	113,961,278
Structural materials			
Stone, all kinds quarried	67,477,012	65,322,840	73,514,842
Stone used to make cement	10,774,284	11,774,537	14,367,599
Stone used to make lime	2,981,494	3,118,403	2,973,392
Total	81,232,790	80,215,780	90,855,833
Total ore mined and rock quarried	386,673,126	432,244,190	437,925,212

Table 47. Canada, ore mined and rock quarried, mining industry, 1937-1971

	Metals	Nonmetals*	Total
		(million short tons)	
1937	28.1	17.7	45.8
1938	31.4	14.9	46.3
1939	35.9	16.5	52.4
1940	39.6	20.3	59.9
1941	43.0	21.6	64.6
1942	42.5	21.7	64.2
1943	38.7	20.7	59.4
1944	35.3	19.3	54.6
1945	31.3	20.6	51.9
1946	28.9	24.8	53.7
1947	33.3	30.4	63.7
1948	36.9	33.5	70.4
1949	43.3	32.9	76.2
1950	45.9	41.8	87.7
1951	48.8	43.8	92.6
1952	52.3	44.2	96.5
1953	54.4	47.2	101.6
1954	59.0	61.5	120.5
1955	69.2	63.5	132.7
1956	77.4	73.0	150.4
1957	84.3	82.2	166.5
1958	78.8	78.5	157.3
1959	99.1	90.7	189.8
1960	101.6	97.8	199.4
1961	99.4	106.7	206.1
1962	114.3	114.5	228.8
1963	124.3	132.8	257.1
1964	141.1	147.8	288.9
1965	166.5	161.5	328.0
1966	162.8	189.4	352.2
1967	186.5	195.7	382.2
1968	206.1	190.3	396.4
1969	189.6	197.1	386.7
1970	234.9	197.3	432.2
1971	233.1	204.8	437.9

*Includes nonmetallic mineral mining and all stone quarried, including stone used to make cement and lime. Excludes coal. Coverage is the same as in Table 46.

Table 48. Canada, exploration and capital expenditures in the mining industry[1], by provinces, 1971-73

		Capital						Repair						
		On-Property Exploration	On-Property Development	Structures	Total	Machinery and Equipment	Total Capital	Construction	Machinery & Equip.	Total Repair	Total Capital & Repair	Outside or General Exploration	Land & Mining Rights	Total All Expenditures
		(millions of dollars)												
Atlantic Provinces	1971	. .	. .	. .	80.7	29.0	109.7	5.3	49.6	54.9	164.6	2.9	–	167.5
	1972	1.6	10.4	10.9	22.9	71.5	94.4	6.2	48.3	54.5	148.9	2.7	0.1	151.7
	1973p	2.0	11.8	25.9	39.7	58.9	98.6	10.4	66.1	76.5	175.1	4.5	0.2	179.8
Quebec	1971	6.4	25.5	112.7	144.6	106.0	250.6	7.3	71.8	79.1	329.7	11.0	2.7	343.4
	1972	3.2	29.2	123.6	156.0	159.6	315.6	6.4	74.5	80.9	396.5	9.9	2.0	408.4
	1973p	3.3	44.7	153.1	201.1	137.2	338.3	7.7	102.7	110.4	448.7	12.1	. .	. .
Ontario	1971	8.7	72.5	43.5	124.7	92.6	217.3	19.0	121.1	140.1	357.4	21.3	2.4	381.1
	1972	5.9	55.7	24.9	86.5	79.0	165.5	8.0	122.4	130.4	295.9	15.3	1.7	312.9
	1973p	6.8	69.6	16.1	92.5	46.5	139.0	19.2	116.4	135.6	274.6	18.9	2.5	296.0
Manitoba	1971	4.1	17.8	8.3	30.2	9.5	39.7	4.6	14.8	19.4	59.1	9.4	–	68.5
	1972	. .	. .	. .	31.1	15.6	46.7	2.4	13.2	15.6	62.3	5.6	–	67.9
	1973p	. .	. .	. .	29.8	13.0	42.8	3.4	18.6	22.0	64.8	5.9	. .	. .
Saskatchewan	1971	–	4.8	1.8	6.6	6.0	12.6	3.6	19.0	22.6	35.2	5.6	0.1	40.9
	1972	. .	. .	. .	9.1	12.7	21.8	1.9	21.7	23.6	45.4	3.7	. .	. .
	1973p	. .	. .	. .	12.2	14.6	26.8	1.3	26.7	28.0	54.8	6.4	. .	. .
Alberta	1971	. .	. .	. .	8.5	8.1	16.6	0.5	5.9	6.4	23.0	5.1	0.5	28.6
	1972	. .	. .	. .	7.4	5.0	12.4	0.3	5.5	5.8	18.2	1.8	. .	. .
	1973p	. .	. .	. .	12.3	3.5	15.8	0.4	6.3	6.7	22.5	2.5	. .	. .
British Columbia	1971	3.8	32.7	173.0	209.5	138.9	348.4	3.7	53.4	57.1	405.5	27.7	1.2	434.4
	1972	2.2	22.9	46.9	72.0	48.0	120.0	6.4	59.4	65.8	185.8	27.2	. .	. .
	1973p	5.4	19.5	16.7	41.6	32.7	74.3	10.9	81.0	91.9	166.2	26.4	1.4	194.0
Yukon and Northwest Territories	1971	1.7	14.3	4.5	20.5	5.4	25.9	1.2	14.0	15.2	41.1	8.3	0.4	49.8
	1972	2.8	16.2	1.5	20.5	2.9	23.4	1.0	13.8	14.8	38.2	6.3	. .	. .
	1973p	2.0	14.2	6.8	23.0	5.8	28.8	2.5	15.9	18.4	47.2	8.6	0.3	56.1
Canada	1971	27.2	188.3	409.8	625.3	395.5	1,020.8	45.2	349.6	394.8	1,415.6	91.3	7.3	1,514.2
	1972	16.6	157.9	231.0	405.5	394.3	799.8	32.6	358.8	391.4	1,191.2	72.5	12.7	1,276.4
	1973p	23.2	184.7	244.3	452.2	312.2	764.4	55.8	433.7	489.5	1,253.9	85.3	8.9	1,348.1

[1] Excludes the petroleum and natural gas industries and the smelting and refining industries. Industry coverage is the same as in Table 49.
. . Not available for publication because of confidentiality. pPreliminary; – Nil.

Table 49. Exploration and capital expenditures[1] in the mining industry by type of mining 1971-73

		Capital						Repair						
		On-Property Exploration	On-Property Development	Structures	Total	Machinery and Equipment	Total Capital	Construction	Machinery and Equipment	Total Repair	Total Capital and Repair	Outside or General Exploration	Land and Mining Rights	Total all Expenditures
Metal Mining														
Gold	1971	0.4	6.8	2.2	9.4	2.4	11.8	0.6	3.8	4.4	16.2	1.2	–	17.4
	1972	0.6	8.4	0.3	9.3	1.6	10.9	0.4	4.8	5.2	16.1	1.0	–	17.1
	1973[p]	1.1	11.1	2.0	14.2	3.4	17.6	0.4	4.6	5.0	22.6	1.1	0.1	23.8
Copper-gold-silver	1971	4.9	48.9	159.5	213.3	127.4	340.7	5.1	43.4	48.5	389.2	3.2	0.5	392.9
	1972	4.0	43.7	73.9	121.6	105.2	226.8	7.5	51.6	59.1	285.9	7.2	0.5	293.6
	1973[p]	6.3	47.1	29.4	82.8	68.8	151.6	13.9	80.8	94.7	246.3	6.2	0.2	252.7
Silver-lead-zinc	1971	2.8	12.6	3.2	18.6	7.3	25.9	1.6	15.4	17.0	42.9	2.2	0.1	45.2
	1972	3.4	12.4	3.2	19.0	7.0	26.0	1.8	16.2	18.0	44.0	1.3	0.4	45.7
	1973[p]	2.8	14.5	8.7	26.0	13.9	39.9	3.0	17.4	20.4	60.3	1.3	–	61.6
Uranium[2]	1971	–	3.7	0.3	4.0	1.9	5.9	1.3	4.2	5.5	11.4	1.8	–	13.2
	1972	..	..	..	..	..	..	..	..	..	..	..	..	..
	1973[p]	..	..	..	..	..	..	..	..	..	..	..	..	..
Iron[3]	1971	..	..	..	..	..	..	9.6	86.9	96.5	..	0.6	–	..
	1972	..	..	..	127.6	..	..	9.1	82.8	91.9	..	0.7	–	..
	1973[p]	..	..	..	192.7	..	..	14.4	117.9	132.3	..	1.5	–	..
Other metal mining	1971	13.6	91.6	187.1	292.3	150.3	442.6	19.1	88.7	107.8	646.9	6.7	0.2	653.8
	1972	..	..	..	65.2	..	..	7.6	86.9	94.5	..	7.4	0.3	..
	1973[p]	..	..	..	66.0	..	..	17.3	76.7	94.0	..	5.6	0.1	..
Total metal mining	1971	21.7	163.6	352.3	537.6	289.3	826.9	37.3	242.4	279.7	1,106.6	15.7	0.8	1,123.1
	1972	14.1	122.9	205.7	342.7	312.4	655.1	26.4	242.3	268.7	923.8	17.6	1.2	942.6
	1973[p]	18.0	147.4	216.3	381.7	230.0	611.7	49.0	297.4	346.4	958.1	15.7	0.4	974.2
Nonmetal mining														
Asbestos	1971	2.7	14.2	19.4	36.3	29.3	65.6	1.9	35.2	37.1	102.7	0.3	..	..
	1972	0.3	19.4	9.7	29.4	27.9	57.3	2.5	32.8	35.3	92.6	0.2	..	..
	1973[p]	0.2	20.9	7.1	28.2	21.5	49.7	2.8	39.8	42.6	92.3	0.1	..	..
Miscellaneous nonmetal mining[4]	1971	0.2	3.6	2.6	6.4	11.8	18.2	3.3	20.2	23.5	41.7	0.2	..	..
	1972	0.5	14.5	15.4	30.4	53.4	83.8	3.7	83.6	87.3	171.1	0.8	..	..
	1973[p]	3.8	14.6	20.7	39.1	59.4	98.5	3.7	96.1	99.8	198.3	1.5	..	..

Table 49. (concl'd)

		Capital						Repair						
		On-Property Exploration	On-Property Development	Structures	Total	Machinery and Equipment	Total Capital	Construction	Machinery and Equipment	Total Repair	Total Capital and Repair	Outside or General Exploration	Land and Mining Rights	Total all Expenditures
Other nonmetal mining[5]	1971	1.5	5.1	35.3	41.9	64.5	106.4	2.7	51.7	54.4	160.8	3.8	..	..
	1972[6]	..	..	..	..	..	..	..	..	..	..	..	..	..
	1973[p]	..	..	..	..	..	..	..	..	..	..	..	..	..
Total nonmetal	1971	4.4	22.9	57.3	84.6	105.6	190.2	7.9	107.1	115.0	305.2	4.3	4.8	314.3
	1972	0.8	33.9	25.1	59.8	81.3	141.1	6.2	116.4	122.6	263.7	1.0	9.0	273.7
	1973[p]	4.0	35.5	27.8	67.3	80.9	148.2	6.5	135.9	142.4	290.6	1.6	6.6	298.8
Metal and nonmetal mining exploration	1971	1.1	1.8	0.2	3.1	0.6	3.7	–	0.1	0.1	3.8	71.3	1.7	76.8
	1972	1.7	1.1	0.2	3.0	0.6	3.6	–	0.1	0.1	3.7	53.9	2.5	60.1
	1973[p]	1.2	1.8	0.2	3.2	1.3	4.5	0.3	0.4	0.7	5.2	68.0	1.9	75.1
Total mining	1971	27.2	188.3	409.8	625.3	395.5	1,020.8	45.2	349.6	394.8	1,415.6	91.3	7.3	1,514.2
	1972	16.6	157.9	231.0	405.5	394.3	799.8	32.6	358.8	391.4	1,191.2	72.5	12.7	1,276.4
	1973[p]	23.2	184.7	244.3	452.2	312.2	764.4	55.8	433.7	489.5	1,253.9	85.3	8.9	1,348.1

[1]Excludes expenditures in the petroleum and natural gas industries. [2]Not available separately for uranium mines in 1972, 1973 included under "other metal mining". [3]Not completely available for iron mining in 1971, 1972, 1973. Confidential figures are included under "total metal mining". [4]Includes SIC 079 "Miscellaneous nonmetal mining". [5]Includes coal, gypsum and salt mines, stone quarries and sand pits for 1971 also potash mines and other nonmetal mines for 1972, 1973. [6]Included under "miscellaneous nonmetal mines" in 1972, 1973.

– Nil; . . Not available for publication due to confidentiality; [p]Preliminary.

Table 50. Canada, diamond drilling in the mining industry by mining companies with own equipment and by drilling contractors, 1970-71

		1970			1971		
		Exploration	Other	Total	Exploration	Other	Total
		(footage)					
Metal mining							
Gold quartz	own equipment	72,373	–	72,373	118,594	93,487	212,081
	contractors	540,754	91,328	632,082	361,432	60,645	422,077
	Total	613,127	91,328	704,455	480,026	154,132	634,158
Copper-gold-silver	own equipment	41,103	103,606	144,709	16,699	119,716	136,415
	contractors	1,563,346	128,386	1,691,732	1,456,478	174,678	1,631,156
	Total	1,604,449	231,992	1,836,441	1,473,177	294,394	1,767,571
Nickel-copper	own equipment	56,567	346,123	402,690	88,660	321,458	410,118
	contractors	939,468	538,316	1,477,784	860,068	535,417	1,395,485
	Total	996,035	884,439	1,880,474	948,728	856,875	1,805,603
Silver-lead-zinc and silver cobalt	own equipment	30,821	502,908	533,729	25,921	436,357	462,278
	contractors	670,289	26,362	696,651	550,841	–	550,841
	Total	701,110	529,270	1,230,380	576,762	436,357	1,013,119
Molybdenum	own equipment	–	–	–	–	–	–
	contractors	65,082	–	65,082	20,789	–	20,789
	Total	65,082	–	65,082	20,789	–	20,789
Iron mines	own equipment	–	–	–	1,047	–	1,047
	contractors	118,622	7,778	126,400	99,908	13,084	112,992
	Total	118,622	7,778	126,400	100,955	13,084	114,039
Miscellaneous metal mining	own equipment	3,032	–	3,032	33,981	–	33,981
	contractors	131,513	–	131,513	106,294	–	106,294
	Total	134,545	–	134,545	140,275	–	140,275
Total metal mining	own equipment	203,896	952,637	1,156,533	284,902	971,018	1,255,920
	contractors	4,029,074	792,170	4,821,244	3,455,810	783,824	4,239,634
	Total	4,232,970	1,744,807	5,977,777	3,740,712	1,754,842	5,495,554

Table 50. (concl'd)

		1969			1970		
		Exploration	Other	Total	Exploration	Other	Total
		(footage)					
Nonmetal mining							
Asbestos	own equipment	–	11,388	11,388	–	–	–
	contractors	76,092	–	76,092	95,091	–	95,091
	Total	76,092	11,388	87,480	95,091	–	95,091
Feldspar and quartz	own equipment	–	–	–	–	–	–
	contractors	6,917	–	6,917	2,500	–	2,500
	Total	6,917	–	6,917	2,500	–	2,500
Gypsum	own equipment	–	–	–	–	–	–
	contractors	5,325	–	5,325	10,945	–	10,945
	Total	5,325	–	5,325	10,945	–	10,945
Salt	own equipment	6,578	–	6,578	2,000	–	2,000
	contractors	–	–	–	–	–	–
	Total	6,578	–	6,578	2,000	–	2,000
Miscellaneous non-metal mining	own equipment	6,702	–	6,702	6,932	–	6,932
	contractors	6,150	–	6,150	10,710	–	10,710
	Total	12,852	–	12,852	17,642	–	17,642
Total nonmetal mining	own equipment	13,280	11,388	24,668	8,932	–	8,932
	contractors	94,484	–	94,484	119,246	–	119,246
	Total	107,764	11,388	119,152	128,178	–	128,178
Total mining industry	own equipment	217,176	964,025	1,181,201	293,834	971,018	1,264,852
	contractors	4,123,558	792,170	4,915,728	3,575,056	783,824	4,358,880
	Total	4,340,734	1,756,195	6,096,929	3,868,890	1,754,842	5,623,732

– Nil.

Table 51. Canada, total diamond drilling on metal deposits by mining companies with own equipment and by drilling contractors, 1958-71

	Gold-Quartz Deposits	Copper-Gold-Silver and Nickel-Copper Deposits	Silver-Lead-Zinc and Silver Cobalt Deposits	Other Metal Bearing Deposits*	Total Metal Deposits
			(footage)		
1958	1,794,164	3,028,302	977,009	941,503	6,740,978
1959	1,831,234	3,643,912	925,486	1,258,106	7,658,738
1960	2,060,419	4,159,424	741,557	1,033,686	7,995,086
1961	1,952,693	3,701,085	836,945	725,325	7,216,048
1962	2,960,265	3,363,019	1,148,886	1,176,768	8,648,938
1963	1,738,710	3,206,225	945,553	487,872	6,378,360
1964	1,505,686	2,328,045	1,315,944	343,631	5,493,306
1965	1,443,637	2,557,535	1,086,923	905,241	5,993,336
1966	1,451,598	2,392,220	958,737	538,891	5,341,446
1967	1,283,947	3,110,090	755,193	394,851	5,544,081
1968	1,231,179	3,069,935	649,731	186,288	5,137,133
1969	900,297	3,029,700	648,525	359,557	4,938,079
1970	704,455	3,716,915	1,230,380	326,027	5,977,777
1971	634,158	3,573,174	1,013,119	275,103	5,495,554

*Includes iron, titanium, uranium, molybdenum and other metal deposits.
Note: Non-producing companies not included since 1964.

Table 52. Canada, exploration diamond drilling, metal deposits, 1958-71

	By Mining Companies with Own Personnel and Equipment	By Diamond Drill Contractors	Total
		(footage)	
1958	777,994	3,939,059	4,717,053
1959	786,701	4,485,109	5,271,810
1960	880,515	4,624,067	5,504,582
1961	993,099	4,387,051	5,380,150
1962	548,603	5,734,983	6,283,586
1963	1,184,977	3,836,262	5,021,239
1964	469,205	3,520,293	3,989,498
1965	685,704	3,861,537	4,547,241
1966	536,022	3,428,021	3,964,043
1967	305,657	3,684,833	3,990,490
1968	522,775	3,250,298	3,773,073
1969	443,936	3,518,138	3,962,074
1970	203,896	4,029,074	4,232,970
1971	284,902	3,455,810	3,740,712

Note: Non-producing companies are not included since 1964.
See footnote to Table 53.

Table 53. Canada diamond drilling, other than for exploration, on metal deposits, by companies with own equipment and by drilling contractors, 1959-71

	By Mining Companies with Own Personnel and Equipment	By Diamond Drill Contractors	Total
		(footage)	
1959	1,603,618	783,310	2,386,928
1960	1,477,185	1,013,319	2,490,504
1961	1,261,262	574,636	1,835,898
1962	1,734,581	630,771	2,365,352
1963	1,273,714	83,407	1,357,121
1964	1,265,636	238,172	1,503,808
1965	1,292,479	153,616	1,446,096
1966	747,929	629,474	1,377,403
1967	611,755	941,836	1,553,591
1968	403,056	961,004	1,364,060
1969	287,247	688,758	976,005
1970	952,637	792,170	1,744,807
1971	971,018	783,924	1,754,842

Note: Non-producing companies not included since 1964.
The total footage drilled shown in Tables 52 and 53 equals the total footage drilled reported in Table 51.

Table 54. Canada, total contract diamond drilling operations*, 1960-72

Year	Footage Drilled feet	Income from Drilling $Million	Average No. of Employees Number	Total Salaries and wages $Million
1960	5,521,211	17.1	1,912	8.0
1961	5,290,813	16.2	2,025	7.8
1962	5,549,733	17.9	1,926	8.0
1963	5,702,168	20.1	2,201	9.0
1964	6,479,096	23.7	2,401	11.2
1965	7,404,834	30.7	2,776	14.1
1966	7,466,264	33.7	2,887	15.1
1967	6,957,269	31.3	2,669	14.9
1968	7,615,175	38.7	2,985	18.8
1969	7,766,957	44.8	3,109	21.3
1970	7,627,493	53.2	3,207	24.3
1971	6,195,715	38.1	2,514	18.9
1972	5,177,882	35.9	2,083	16.6

*Includes contract diamond drilling in mining and in other industries.

Table 55. Canada, contract drilling for oil and gas, 1961-72

	Footage Drilled				Gross Income from Drilling	No. of Employees	Total Salaries and wages
	Rotary	Cable	Diamond	Total	$Million	Number	$Million
1961	12,616,950	170,098	–	12,787,048	68.6	4,144	21.7
1962	12,459,736	252,467	–	12,712,203	62.2	3,800	20.8
1963	13,783,110	361,979	–	15,145,089	75.9	4,179	22.9
1964	14,803,776	229,726	6,230	15,039,732	81.9	4,158	25.2
1965	15,997,276	340,345	–	16,337,621	100.2	4,648	31.7
1966	13,394,413	210,104	–	13,604,517	95.8	4,428	33.9
1967	12,717,419	168,035	–	12,885,454	94.7	4,249	32.9
1968	13,300,766	230,443	–	13,531,209	109.5	4,434	36.9
1969	13,038,137	280,323	–	13,318,460	115.5	4,821	39.5
1970	11,500,845	165,042	–	11,665,887	112.6	4,267	37.9
1971	11,650,353	134,522	–	11,784,875	109.5	4,093	38.0
1972	14,213,386	138,983	–	14,352,369	154.6	4,817	53.5

– Nil.

Table 56. Canada, crude minerals transported by Canadian railways, 1971-72

	1971	1972
	(000 short tons)	
Metallic Minerals		
Alumina and bauxite	3,235	2,774
Copper ores and concentrates	2,182	2,749
Iron ores and concentrates	47,840	37,850
Iron pyrite	243	133
Lead ores and concentrates	701[r]	725
Lead-zinc ores and concentrates	76[r]	111
Manganese ores	7	11
Nickel-copper ores and concentrates	3,295[r]	2,856
Nickel ores and concentrates	1,125	1,183
Zinc ores and concentrates	2,263[r]	2,464
Metallic ores and concentrates, nes	664	499
Total metallic minerals	61,631[r]	51,355
Nonmetallic Minerals		
Abrasives, natural	131	90
Asbestos	1,120[r]	1,199
Barite	47	115
Clay	630[r]	663
Gravel	2,291[r]	1,644
Gypsum	3,912	5,041
Limestone, agricultural	112	134
Limestone, industrial	416	388
Limestone, nes	3,182[r]	3,651
Nepheline syenite	482	424
Phosphate rock	2,058	2,097
Potash (KCl)	5,982	6,353
Refractory materials, nes	22[r]	16
Salt, rock	1,655	1,261
Salt, nes	410	223
Sand, industrial	1,236	1,570
Sand, nes	1,284	1,366
Silica	3	6
Sodium carbonate	686[r]	669
Sodium sulphate	498[r]	526
Stone, building, rough	76	108
Stone, nes	1,302	1,661
Sulphur, liquid	1,234	1,313
Sulphur, nes	1,835	2,143
Nonmetallic minerals, nes	337	376
Total nonmetallic minerals	30,941[r]	33,037
Mineral Fuels		
Coal, anthracite	535	384
Coal, bituminous	11,202	12,816
Coal, lignite	845	794
Coal, nes	17	17
Natural gas and other crude bituminous subtances	4	4
Petroleum, crude	201	185
Total mineral fuels	12,804	14,200
Total crude minerals	105,376[r]	98,592
Total all revenue freight moved by Canadian railways	236,410[r]	237,910
Per cent crude minerals of total all revenue freight	44.6[r]	41.4

[r] Revised.
nes not elsewhere specified.

Table 57. Canada, crude minerals transported by Canadian railways, 1963-72

Year	Total Revenue Freight	Total Crude Minerals	Crude Minerals as a % of Total Revenue Freight
	(millions of short tons)		
1963	170.4	69.3	40.7
1964	198.4	82.3	41.5
1965	205.2	89.2	43.5
1966	214.4	88.9	41.5
1967	209.5	89.5	42.7
1968	215.4	95.6	44.4
1969	208.3	90.3	43.4
1970	233.3	107.5	46.1
1971[r]	236.4	105.4	44.6
1972	237.9	98.6	41.4

[r]Revised.

Table 58. Canada, fabricated mineral products transported by Canadian railways, 1971-72.

	1971[r]	1972
	(thousand short tons)	
Metallic mineral products		
Ferrous mineral products		
Ferroalloys	167	146
Pig iron	212	192
Ingots, blooms, billets, slabs of iron and steel	956	904
Other primary iron and steel	70	45
Castings and forgings, iron and steel	304	296
Bars and rods, steel	824	729
Plates, steel	416	429
Sheet and strip, steel	1,504	1,697
Structural shapes and sheet piling, iron and steel	554	521
Rails and railway track material	284	187
Pipes and tubes, iron and steel	710	769
Wire, iron or steel	52	38
Iron and steel scrap	1,808	1,785
Slags, drosses, etc.	246	154
Total ferrous mineral products	8,107	7,892
Nonferrous mineral products		
Aluminum paste, powder, pigs, ingots, shot	271	210
Aluminum and aluminum alloy fabricated material, nes	379	326
Copper matte and precipitates	8	2
Copper and alloys, in primary forms	603	506
Copper and alloys, n.e.s.	103	71
Lead and alloys	204	206
Nickel and nickel-copper matte	735	487
Nickel and alloys	164	116
Zinc and alloys	509	570
Other nonferrous base metals and alloys	8	17
Nonferrous metal scrap	286	225
Total nonferrous mineral products	3,270	2,736
Total metallic mineral products	11,377	10,628
Nonmetallic mineral products		
Natural stone basic products, chiefly structural	160	201
Bricks and tiles, clay	95	95
Fire brick and similar shapes	221	205
Dolomite and magnesite, calcined	78	86
Refractories, nes	52	43
Glass basic products	112	149
Asbestos and asbestos-cement basic products	34	26
Portland cement, standard	1,636	1,584
Concrete pipe	46	70
Cement and concrete basic products, nes	288	310
Plaster	43	57
Gypsum wallboard and sheathing	82	92
Gypsum basic products, nes	1	1
Lime, hydrated and quick	616	641
Nonmetallic mineral basic products, nes	332	531
Fertilizers and fertilizer materials nes	2,110	2,626
Total nonmetallic mineral products	5,906	6,717
Mineral fuel products		
Gasoline	2,466	2,313
Aviation turbine fuel	116	138
Diesel fuel	3,385	3,293
Kerosene	14	15
Fuel oil, nes	1,141	935
Lubricating oils and greases	428	452
Petroleum coke	58	193
Coke, nes	1,606	1,350
Refined and manufactured gases, fuel type	2,964	3,689
Asphalts and road oils	240	267
Bituminous pressed or molded fabricated materials	17	5
Other petroleum and coal products	482	392
Total mineral fuel products	12,917	13,042
Total fabricated mineral products	30,200	30,387
Total revenue freight moved by Canadian railways	236,410	237,910
Fabricated mineral products as a percentage of total revenue freight	12.8	12.8

[r]Revised; nes – not elsewhere specified.

Table 59. Canada, crude and fabricated minerals transported through the St. Lawrence Seaway, 1972-73

	Montreal-Lake Ontario Section		Welland Canal Section	
	1972	1973	1972	1973
	(short tons)			
Crude minerals				
Bituminous coal	269,164	277,667	9,929,123	8,139,388
Iron ore	12,533,408	15,691,569	13,732,088	17,183,362
Aluminum ores and concentrates	101,080	107,648	101,080	94,298
Clay and bentonite	146,816	193,055	158,216	216,130
Gravel and sand	76	–	131,526	38,411
Stone, ground or crushed	5,789	28,734	1,094,612	1,412,228
Stone, rough	4,976	2,019	3,566	14,130
Petroleum, crude	86,641	799,782	–	134,872
Salt	889,117	903,707	1,623,310	1,529,827
Phosphate rock	102,934	40,812	–	–
Other crude minerals	658,719	816,620	572,915	897,543
Total crude minerals	14,798,720	18,861,613	27,346,436	29,660,189
Fabricated mineral products				
Coke	595,085	815,067	581,930	651,981
Gasoline	339,946	234,608	181,550	125,718
Fuel oil	3,229,339	3,783,946	1,377,832	2,156,600
Lubricating oils and greases	224,517	163,692	213,217	143,479
Other petroleum products	54,798	78,600	21,967	69,924
Tar, pitch, creosote	39,174	45,089	79,823	58,108
Pig iron	181,912	151,623	173,238	143,005
Iron and steel: bars, rods, slabs	286,084	509,908	249,670	478,938
Iron and steel: nails, wire	124,080	13,201	105,757	124,594
Iron and steel: other manufactured products	5,333,410	3,723,202	4,897,691	3,425,347
Scrap iron and steel	417,966	935,078	424,332	887,310
Cement	17,485	53,746	181,752	242,458
Total fabricated minerals	10,843,796	10,507,760	8,488,759	8,507,462
Total crude and fabricated minerals	25,642,516	29,369,373	35,835,195	38,167,651
Grand total all products	53,579,940	57,634,137	64,095,379	67,194,684
Per cent crude and fabricated minerals of grand total	47.9	51.0	55.9	56.8

– Nil.

Table 60. Canada, cargoes of crude minerals loaded and unloaded in coastwise shipping, 1972

	Loaded				Unloaded			
	Atlantic	Great Lakes	Pacific	Total	Atlantic	Great Lakes	Pacific	Total
				(short tons)				
Metallic minerals								
Copper ore and concentrates	29,761	–	–	29,761	29,761	–	–	29,761
Iron ore and concentrates	3,448,940	3,050,508	7,400	6,506,848	998,001	5,501,447	7,400	6,506,848
Manganese ore	73,981	–	–	73,981	–	73,981	–	73,981
Titanium ore	1,663,821	–	–	1,663,821	1,663,821	–	–	1,663,821
Zinc ore and concentrates	–	–	4,271	4,271	–	–	4,271	4,271
Ores and concentrates, nes	24,490	16,000	1,189	41,679	21	40,469	1,189	41,679
Iron and steel scrap	2,947	48	2,250	5,245	2,995	–	2,250	5,245
Nonferrous metal scrap	289	–	180	469	289	–	180	469
Slag, drosses, residues	3	–	5;058	5,061	3	–	5,058	5,061
Total metals	5,244,232	3,066,556	20,348	8,331,136	2,694,891	5,615,897	20,348	8,331,136
Nonmetallic minerals								
Asbestos	651	768	–	1,419	19	1,400	–	1,419
Barite	1,503	–	–	1,503	1,503	–	–	1,503
Clays, nes	825	–	973	1,798	825	–	973	1,798
Dolomite	104	37,195	–	37,299	6,006	31,293	–	37,299
Fluorspar	155,594	–	–	155,594	155,594	–	–	155,594
Gypsum	517,168	–	939	518,107	389,711	127,457	939	518,107
Limestone	13,982	2,086,699	248,676	2,349,357	13,982	2,086,699	248,676	2,349,357
Potash (KCl)	–	–	–	–	–	–	–	–
Salt	229,290	1,422,145	13,430	1,664,865	801,989	849,446	13,430	1,664,865
Sand and Gravel	12,991	17,104	2,293,208	2,323,303	12,971	17,124	2,293,208	2,323,303
Stone, crushed	28	186	3,300	3,514	28	186	3,300	3,514
Stone, crude, nes	667	232,902	3,763	237,332	523	233,046	3,763	237,332
Sulphur	–	–	10,397	10,397	–	–	10,397	10,397
Crude nonmetallic minerals, nes	700	1,263	–	1,963	1,422	541	–	1,963
Total nonmetals	933,503	3,798,262	2,574,686	7,306,451	1,384,573	3,347,192	2,574,686	7,306,451
Mineral Fuels								
Coal, bituminous	9,383	2,997	–	12,380	9,383	2,997	–	12,380
Total crude minerals	6,187,118	6,867,815	2,595,034	15,649,967	4,088,847	8,966,086	2,595,034	15,649,967
Grand total all commodities	20,697,658	26,093,133	14,195,803	60,986,594	28,589,710	18,201,081	14,195,803	60,986,594
% crude minerals of grand total	29.8	26.3	18.3	25.7	14.3	49.3	18.3	25.7

nes not elsewhere specified; – Nil.

Table 61. Canada, cargoes of crude minerals loaded and unloaded at Canadian ports in international shipping trade with foreign countries, 1971-72

	1971		1972	
	Loaded	Unloaded	Loaded	Unloaded
	(short tons)			
Metallic minerals				
Alumina, bauxite ore	72,971	3,643,267	6,008	3,591,521
Copper ores and concentrates	693,160	30,592	844,629	–
Iron ore and concentrates	35,892,296	1,664,124	31,520,962	2,003,874
Lead ore and concentrates	162,691	12,851	108,943	–
Manganese ore	121,728	228,260	10,500	153,623
Nickel-copper ore and concentrates	117,418	84,342	113,914	39,922
Titanium ore	287,714	15,694	335,028	10,306
Zinc ore and concentrates	968,424	7,366	971,751	148
Ores and concentrates, nes	94,096	87,028	65,813	80,780
Iron and steel scrap	111,035	4,357	243,023	14,821
Nonferrous metal scrap	8,683	4,411	8,660	392
Slags, drosses, residues	783,291	15,207	849,162	26,346
Total metals	39,313,507	5,797,499	35,078,393	5,921,733
Nonmetallic minerals				
Asbestos	555,206	172,135	487,467	12,556
Barite	69,555	10,122	20,100	292
Bentonite	38,247	161,089	20,725	121,599
China clay	–	28,732	–	46,243
Clays, nes	1,080	46,002	756	40,355
Dolomite	877,476	–	978,076	13,500
Fluorspar	52,252	294,941	60,339	113,040
Gypsum	5,019,161	71,000	6,234,574	60,000
Limestone	1,465,412	1,693,771	1,412,817	1,742,663
Phosphate rock	122	1,075,376	24,180	1,373,169
Potash (KCl)	2,217,641	62,853	1,670,807	75,929
Salt	1,372,512	644,379	888,556	916,373
Sand and gravel	44,092	910,500	116,524	973,722
Stone, crushed	36	24,719	230	135
Stone, crude, nes	54,018	16,559	32,534	15,120
Sulphur	1,311,683	24,127	1,682,375	18,870
Crude, nonmetallic minerals, nes	66,165	21,967	40,432	33,486
Total nonmetals	13,144,658	5,258,272	13,670,492	5,557,052
Mineral fuels				
Coal, bituminous	6,088,427	17,186,827	8,318,546	12,550,259
Coal, nes	–	428,349	33	323,923
Natural gas	–	7,665	–	–
Petroleum, crude	145,983	12,640,074	156,067	19,077,985
Total fuels	6,234,410	30,262,915	8,474,646	31,952,167
Total crude minerals	58,692,575	41,318,686	57,223,531	43,430,952
Grand total, all commodities	105,697,016	60,857,110	109,115,679	68,360,673
Per cent crude minerals of grand total	55.5	67.9	52.4	63.5

nes not elsewhere specified; – Nil.

Table 62. Canada, cargoes of fabricated mineral products loaded and unloaded at Canadian ports in international shipping trade with foreign countries 1971-72

	1971		1972	
	Loaded	Unloaded	Loaded	Unloaded
	(short tons)			
Metallic products				
Aluminum	500,455	8,803	379,093	14,078
Copper and alloys	79,840	7,129	60,844	1,838
Ferroalloys	16,837	49,733	20,424	35,904
Iron and steel, primary	116,943	61,192	12,880	51,266
Iron, pig	495,566	17	566,698	1,154
Iron and steel, other				
bars and rods	31,744	204,550	25,021	264,858
castings and forgings	29,075	26,457	23,081	29,325
pipe and tubes	9,357	183,972	11,419	144,102
plate and sheet	207,219	510,834	265,818	628,315
rails and track material	30,975	6,718	8,425	5,744
structural shapes	52,081	461,419	38,747	291,080
wire	2,984	25,031	10,723	26,972
Lead and alloys	54,072	283	27,467	7,185
Nickel and alloys	19,052	13,353	28,097	16,835
Zinc and alloys	104,823	365	72,940	10,450
Nonferrous metals, nes	11,812	10,339	5,938	10,851
Metal fabricated basic products, nes	20,843	79,847	13,482	59,974
Total metals	1,783,678	1,650,042	1,571,097	1,599,931
Nonmetallic products				
Asbestos basic products	7,822	176	3,635	596
Building brick, clay	1,591	1,760	89	1,484
Bricks and tiles, nes	22,127	22,777	10,525	14,377
Cement	915,182	24,339	1,332,123	14,418
Cement basic products	1,916	1,296	3,729	2,388
Drain tiles and pipes		565	82	56
Glass basic products	2,969	38,469	3,259	42,382
Lime	4,164	713	701	172
Nonmetallic mineral basic products	52,997	13,628	8,805	21,081
Fertilizers, nes	114,568	123,220	261,171	99,870
Total nonmetals	1,123,336	226,943	1,624,119	196,824
Mineral fuel products				
Asphalts, road oils	742	28,688	178	40,989
Coal tar, pitch	27,651	103,920	42,027	68,819
Coke	153,616	807,395	405,976	857,363
Fuel oil	2,097,706	6,928,559	5,604,911	6,883,914
Gasoline	40,288	546,093	117,716	346,068
Lubricating oil and greases	1,950	49,980	780	23,586
Petroleum and coal products, nes	306,978	170,518	654,591	187,237
Total fuels	2,628,931	8,635,153	6,826,179	8,407,976
Total fabricated mineral products	5,535,945	10,512,138	10,021,395	10,204,731
Grand total, all commodities	105,697,016	60,857,110	109,115,679	68,360,673
Per cent fabricated mineral products of grand total	5.2	17.3	9.2	14.9

nes Not elsewhere specified; — Nil.

Table 63. Canada, taxes[1] paid to federal, provincial and municipal governments by important divisions of mineral industry, 1970-71

	1970				1971			
	Federal Income Tax[2]	Provincial Tax[3]	Municipal Tax[4]	Total	Federal Income Tax[2]	Provincial Tax[3]	Municipal Tax[4]	Total
				($000)				
Metal mining								
Auriferous quartz	925	1,089	1,093	3,107	1,161	803	1,009	2,973
Copper-gold-silver mining, smelting and refining	26,994	31,630	4,365	62,989	22,069	65,832	5,044	92,945
Silver-lead-zinc mining, smelting and refining	11,418	4,482	1,134	17,034	6,499	4,708	1,253	12,460
Nickel-copper mining, smelting and refining	13,130	11,837	7,514	32,481	25,320	20,427	8,099	53,846
Iron	5,687	9,795	6,140	21,622	5,286	10,226	6,685	22,197
Miscellaneous metal mining	–	1,252	1,639	2,891	787	865	1,341	2,993
Total metal mining	58,154	60,085	21,885	140,124	61,122	102,861	23,431	187,414
Nonmetal mining								
Asbestos	11,191	8,031	3,009	22,231	9,321	6,557	2,535	18,413
Feldspar, quartz and nepheline syenite mining	75	50	76	201	4	34	109	147
Gypsum	437	320	388	1,145	598	338	448	1,384
Peat	128	97	127	352	258	154	129	541
Salt	–	1,708	387	2,095	–	1,705	409	2,114
Talc and soapstone mining	31	21	7	59	13	32	13	58
Stone quarries	866	456	552	1,874	1,213	516	609	2,338
Sand and gravel pits	875	663	578	2,116	1,179	958	589	2,726
Miscellaneous nonmetal mining	3,527	793	337	4,657	273	248	147	668
Total nonmetal mining	17,130	12,139	5,461	34,730	12,859	10,542	4,988	28,389
Total of divisions covered	75,284	72,224	27,346	174,854	73,981	113,403	28,419	215,803

[1] Taxes reported are actual payments made within the calendar years, and do not reflect tax assessments.
[2] Includes tax on non-operating revenue.
[3] Includes mining tax, corporation income tax, acreage taxes and royalties.
[4] Taxes based on property valuation.
–Nil.

Table 64. Canada, taxes* paid by six important divisions of the mineral industry, 1965-71

	1965	1966	1967	1968	1969	1970	1971
			($ millions)				
Auriferous quartz mining	4.4	5.2	4.9	4.2	4.9	3.1	3.0
Copper-gold-silver mining, smelting and refining	34.9	34.3	49.3	52.1	55.2	63.0	92.9
Silver-lead-zinc mining, smelting and refining	27.9	22.9	18.7	15.5	20.7	17.0	12.5
Nickel-copper mining, smelting and refining	77.7	70.7	44.9	50.2	39.5	32.5	53.8
Iron mining	11.6	15.0	13.0	17.2	18.6	21.6	22.2
Asbestos mining	22.5	26.3	26.2	19.9	26.0	2.9	3.0
Total	179.0	174.4	157.0	159.1	164.9	140.1	187.4

Note: *See footnotes to Table 63.

Table 65. Canada, provision for income taxes, current and future period, mining and mineral manufacturing industries, 1971-73

	1971			1972			1973		
	Current	Future	Total	Current	Future	Total	Current	Future	Total
					($ millions)				
Mining									
Metal mining	82	37	119	112	19	131	311	65	376
Mineral fuels	39	30	69	58	29	87	123	40	163
Other mining	24	13	37	28	6	34	46	19	65
Total mining	145	80	225	198	54	252	480	124	604
Mineral manufacturing									
Primary metals	85	26	111	66	22	88	65	67	132
Nonmetallic mineral products	52	2	54	60	5	65	62	25	87
Petroleum and coal products	123	35	158	117	50	167	208	88	296
Total mineral manufacturing	260	63	323	243	77	320	335	180	515
Total, mining and mineral manufacturing	405	143	548	441	131	572	815	304	1,119
Total all industries*	2,218	282	2,500	2,540	446	2,986	3,420	774	4,194
Per cent mining and mineral manufacturing of total, all industries	18.3	50.7	21.9	17.4	29.4	19.2	23.8	39.3	26.7

*Excludes agriculture, fishing, trapping and construction.

Table 66. Canada, capital and repair expenditures in mining[1] and mineral manufacturing industries, 1972, 1973, 1974

	1972			1973p			1974f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
				($ millions)					
Mining Industry									
Metal mines									
Gold	10.9	5.2	16.1	14.8	4.6	19.4	17.4	4.7	22.1
Silver-lead-zinc	26.0	18.0	44.0	34.8	19.8	54.6	50.1	22.7	72.8
Iron	278.2	91.9	370.1	273.0	111.8	384.8	169.3	119.6	288.9
Other metal mines	343.6	153.7	497.3	254.8	181.0	435.8	297.9	186.8	484.7
Total metal mines	658.7	268.8	927.5	577.4	317.2	894.6	534.7	333.8	868.5
Nonmetal mines									
Quarries and sandpits	19.8	21.6	41.4	20.7	20.9	41.6	20.9	19.6	40.5
Other nonmetal mines[2]	121.3	101.0	222.3	124.3	101.8	226.1	196.0	111.9	307.9
Total nonmetal mines	141.1	122.6	263.7	145.0	122.7	267.7	216.9	131.5	348.4
Mineral fuels									
Petroleum and gas[3]	820.5	142.4	962.9	961.9	148.7	1,110.6	1,326.8	163.2	1,490.0
Total mining industries	1,620.3	533.8	2,154.1	1,684.3	588.6	2,272.9	2,078.4	628.5	2,706.9
Mineral Manufacturing									
Primary metal industries									
Iron and steel mills	207.1	216.2	423.3	216.0	242.6	458.6	323.9	263.5	587.4
Steel pipe and tube mills	16.4	13.4	29.8	25.5	14.3	39.8	8.6	16.0	24.6
Iron foundries	9.6	12.1	21.7	13.2	14.7	27.9	20.6	15.4	36.0
Smelting and refining	121.7	158.9	280.6	95.7	150.7	246.4	188.6	156.1	344.7
Aluminum rolling, casting and extruding	9.0	8.3	17.3	14.6	6.6	21.2	17.8	8.0	25.8
Other primary primary metal industries	8.1	9.6	17.7	12.7	9.8	22.5	33.3	10.0	43.3
Total primary metal industries	371.9	418.5	790.4	377.7	438.7	816.4	592.8	469.0	1,061.8

Table 66. (concl'd)

	1972			1973P			1974f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
	($ millions)								
Nonmetallic mineral products									
Cement	46.5	21.4	67.9	68.8	20.9	89.7	69.1	23.5	92.6
Lime	2.0	2.4	4.4	1.1	3.4	4.5	5.4	3.1	8.5
Gypsum products[4]	–	–	–	–	–	–	–	–	–
Concrete products and ready mix	43.9	41.5	85.4	53.9	50.6	104.5	51.3	50.3	101.6
Clay products	3.6	4.1	7.7	5.2	4.1	9.3	7.7	4.3	12.0
Refractories[4]	–	–	–	–	–	–	–	–	–
Asbestos[4]	–	–	–	–	–	–	–	–	–
Glass and glass products	15.5	6.5	22.0	16.6	8.7	25.3	18.3	11.0	29.3
Abrasives	2.3	5.0	7.3	3.3	5.1	8.4	7.4	5.2	12.6
Other nonmetallic mineral products	16.1	13.3	29.4	33.0	14.3	47.3	26.8	13.6	40.4
Total nonmetallic mineral products	129.9	94.2	224.1	181.9	107.1	289.0	186.0	111.0	297.0
Petroleum and coal products	243.8	75.9	319.7	314.3	74.2	388.5	478.1	82.6	560.7
Total mineral manufacturing industries	745.6	588.6	1,334.2	873.9	620.0	1,493.9	1,256.9	662.6	1,919.5
Total mining and mineral manufacturing industries	2,365.9	1,122.4	3,488.3	2,558.2	1,208.6	3,766.8	3,335.3	1,291.1	4,626.4

[1]Does not include cement, lime and clay products (domestic clay) manufacturing, smelting and refining.
[2]Includes coal mines, asbestos, gypsum, salt, and miscellaneous nonmetals.
[3]The total of capital expenditures shown under "petroleum and gas" is equal to the total capital expenditure under the column entitled "petroleum and natural gas extraction" and under the column "natural gas processing plants" of Table 69.
[4]Shown separately during past years, but included in other nonmetallic mineral products for 1974.
[p]Preliminary; [f]Forecast intentions.

Table 67. Canada, capital and repair expenditures in the mining industry[1], 1964-74

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973p	1974f
	($ millions)										
Metal mines											
Capital											
Construction	147.0	121.4	209.9	238.1	264.8	295.1	335.6	590.8	345.7	326.0	361.6
Machinery	92.8	79.2	138.5	131.3	105.2	98.2	150.3	239.8	313.0	251.4	173.1
Total	239.8	200.6	348.4	369.4	370.0	393.3	485.9	830.6	658.7	577.4	534.7
Repair											
Construction	17.7	21.9	25.1	33.4	47.9	35.7	36.6	38.9	26.4	42.0	44.5
Machinery	84.4	100.5	115.9	116.6	152.2	160.9	220.2	240.9	242.4	275.2	289.3
Total	102.1	122.4	141.0	150.0	200.1	196.6	256.8	279.8	268.8	317.2	333.8
Total capital and repair	341.9	323.0	489.4	519.4	570.1	589.9	742.7	1,110.4	927.5	894.6	868.5
Nonmetal mines											
Capital											
Construction	36.7	58.1	106.7	121.1	110.2	128.1	107.9	84.6	59.8	65.0	105.9
Machinery	45.0	34.8	68.9	85.4	128.4	113.9	115.9	105.6	81.3	80.0	111.0
Total	81.7	92.9	175.6	206.5	238.6	242.0	223.8	190.2	141.1	145.0	216.9
Repair											
Construction	3.2	3.7	3.4	4.5	4.3	10.4	7.1	7.9	6.2	6.4	6.5
Machinery	37.9	47.2	49.4	57.0	57.5	64.7	99.9	107.1	116.4	116.3	125.0
Total	41.1	50.9	52.8	61.5	61.8	75.1	107.0	115.0	122.6	122.7	131.5
Total capital and repair	122.8	143.8	228.4	268.0	300.4	317.1	330.8	305.2	263.7	267.7	348.4
Mineral fuels											
Capital											
Construction	270.6	419.2	450.0	403.0	407.4	465.3	552.6	639.4	729.3	877.6	1,130.1
Machinery	40.5	22.1	55.8	71.8	58.0	76.6	86.2	101.3	91.2	84.3	196.7
Total	311.1	441.3	505.8	474.8	465.4	541.9	638.8	740.7	820.5	961.9	1,326.8
Repair											
Construction	23.6	25.4	28.6	34.2	56.3	73.7	93.5	102.7	106.8	108.7	113.7
Machinery	10.8	24.0	21.3	14.7	19.2	19.0	22.5	28.7	35.6	40.0	49.5
Total	34.4	49.4	49.9	48.9	75.5	92.7	116.0	131.4	142.4	148.7	163.2
Total capital and repair	345.5	490.7	555.7	523.7	540.9	634.6	754.8	872.1	962.9	1,110.6	1,490.0

Table 67. (concl'd)

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973p	1974f
						($ millions)					
Total mining											
Capital											
Construction	454.3	598.7	766.6	762.2	782.4	888.5	996.1	1,314.8	1,134.8	1,268.6	1,597.6
Machinery	178.3	136.1	263.2	288.5	291.6	288.7	352.4	446.7	485.5	415.7	480.8
Total	632.6	734.8	1,029.8	1,050.7	1,074.0	1,177.2	1,348.5	1,761.5	1,620.3	1,684.3	2,078.4
Repair											
Construction	44.5	51.0	57.1	72.1	108.5	119.8	137.2	149.5	139.4	157.1	164.7
Machinery	133.1	171.7	186.6	188.3	228.9	244.6	342.6	376.7	394.4	431.5	463.8
Total	177.6	222.7	243.7	260.4	337.4	364.4	479.8	526.2	533.8	588.6	628.5
Total capital and repair	810.2	957.5	1,273.5	1,311.1	1,411.4	1,541.6	1,828.3	2,287.7	2,154.1	2,272.9	2,706.9

[1]Does not include cement, lime and clay products (domestic clays) manufacturing, smelting and refining.
[2]Includes coal mines, asbestos, gypsum, salt, miscellaneous nonmetals, quarrying and sand pits.
[p]Preliminary estimates of intentions; [f]Forecast intentions.

Table 68. Canada, capital and repair expenditures in the mineral manufacturing industries[1], 1964-74

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973p	1974f
						($ millions)					
Primary metal industries[2]											
Capital											
Construction	58.4	61.6	85.2	82.0	77.5	71.5	114.0	89.0	95.3	75.2	132.2
Machinery	214.4	202.9	300.7	202.8	157.9	221.4	311.2	312.4	276.6	302.5	460.6
Total	272.8	264.5	385.9	284.8	235.4	292.9	425.2	401.4	371.9	377.7	592.8
Repair											
Construction	18.0	18.5	21.8	24.9	27.7	22.6	28.6	28.4	35.3	37.5	43.3
Machinery	194.4	215.0	253.4	258.1	281.4	267.9	324.6	343.5	383.2	401.2	425.7
Total	212.4	233.5	275.2	283.0	309.1	290.5	353.2	371.9	418.5	438.7	469.0
Total capital and repair	485.2	498.0	661.1	567.8	544.5	583.4	778.4	773.3	790.4	816.4	1,061.8

(Continued on page 630)

Table 68. (concl'd)

	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973p	1974f
						($ millions)					
Nonmetallic mineral products[3]											
Capital											
Construction	20.1	30.0	50.9	39.5	19.6	37.1	30.7	21.8	30.7	34.8	40.9
Machinery	61.9	78.3	108.6	80.3	66.5	84.0	104.3	58.5	99.2	147.1	145.1
Total	82.0	108.3	159.5	119.8	86.1	121.1	135.0	80.3	129.9	181.9	186.0
Repair											
Construction	5.4	6.4	7.2	9.3	7.2	7.2	5.4	7.0	8.5	7.6	7.2
Machinery	58.3	66.1	72.1	63.9	73.8	72.1	77.1	80.4	85.7	99.5	103.8
Total	63.7	72.5	79.3	73.2	81.0	79.3	82.5	87.4	94.2	107.1	111.0
Total capital and repair	145.7	180.8	238.8	193.0	167.1	200.4	217.5	167.7	224.1	289.0	297.0
Petroleum and coal products											
Capital											
Construction	20.4	30.3	55.5	78.8	99.0	116.9	213.7	211.3	214.0	301.7	452.8
Machinery	4.3	10.3	9.6	21.4	28.8	12.9	17.4	20.1	29.8	12.6	25.3
Total	24.7	40.6	65.1	100.2	127.8	129.8	231.1	231.4	243.8	314.3	478.1
Repair											
Construction	32.3	29.5	32.6	36.0	46.6	52.1	51.0	51.3	61.3	60.8	68.5
Machinery	5.9	7.0	9.1	10.2	8.6	6.8	9.2	9.8	14.6	13.4	14.1
Total	38.2	36.5	41.7	46.2	55.2	58.9	60.2	61.1	75.9	74.2	82.6
Total capital and repair	62.9	77.1	106.8	146.4	183.0	188.7	291.3	292.5	319.7	388.5	560.7
Total mineral manufacturing industries											
Capital											
Construction	98.9	121.9	191.6	200.3	196.1	225.5	358.4	322.1	340.0	411.7	625.9
Machinery	280.6	291.5	418.9	304.5	253.2	318.3	432.9	391.0	405.6	462.2	631.0
Total	379.5	413.4	610.5	504.8	449.3	543.8	791.3	713.1	745.6	873.9	1,256.9
Repair											
Construction	55.7	54.4	61.6	70.2	81.5	81.9	85.0	86.7	105.1	105.9	119.0
Machinery	258.6	288.1	334.6	332.2	363.8	346.8	410.9	433.7	483.5	514.1	543.6
Total	314.3	342.5	396.2	402.4	445.3	428.7	495.9	520.4	588.6	620.0	662.6
Total capital and repair	693.8	755.9	1,006.7	907.2	894.6	972.5	1,287.2	1,233.5	1,334.2	1,493.9	1,919.5

[1]Industry groups are the same as in Table 28.
[2]Includes smelting and refining.
[3]Includes cement, lime, and clay products manufacturing.
pPreliminary estimates of intentions; fForecast intentions

Table 69. Canada, capital expenditures in the petroleum and natural gas and allied industries[1], 1963-74

	Petroleum and natural gas extraction[2]	Transportation including rail, water and pipelines	Marketing (chiefly outlets of oil companies)	Natural gas distribution	Petroleum refining including lubricants	Natural gas processing plants	Total capital expenditures
				($ millions)			
1963	297.1	107.9	53.0	84.1	44.2	38.6	624.9
1964	336.7	164.0	48.3	68.3	23.9	40.6	681.8
1965	381.0	112.1	55.2	72.5	39.8	41.5	702.1
1966	453.5	154.0	64.0	92.3	64.8	50.1	878.7
1967	385.1	204.9	86.8	76.4	99.6	89.7	942.5
1968	374.3	247.9	87.6	117.4	127.6	91.1	1,045.9
1969	438.1	220.6	103.6	117.0	128.9	103.8	1,112.0
1970	449.3	246.5	100.0	100.4	229.8	189.5	1,315.5
1971	489.6	352.0	99.2	115.2	227.0	251.1	1,534.1
1972	690.2	440.9	111.8	141.7	239.1	130.3	1,754.0
1973[p]	865.9	380.1	137.3	136.2	310.2	96.0	1,925.7
1974[f]	1,175.6	246.1	149.9	145.0	474.3	151.2	2,342.1

[1]The petroleum and natural gas industries in this table include all companies engaged, in whole or in part, in oil and gas activities.
[2]Includes capital expenditures by oil and gas drilling contractors back to 1963. Does not include expenditures for geological and geophysical operations. See also footnote 3 to Table 66.
[p]Preliminary; [f]Forecast intentions.

Table 70. Canada, financial statistics of corporations in the mining industry*,

	Corporations		Assets	
	Number	%	$ millions	%
Metal mines				
Reporting corporations				
50 per cent and over non-resident	48	24.3	3,994	51.8
Under 50 per cent non-resident	123	62.1	3,618	47.0
Government business enterprise	1	0.5	. .	. .
Other corporations	26	13.1	. .	. .
Total, all corporations	198	100.0	7,704	
Mineral fuels				
Reporting corporations				
50 per cent and over non-resident	260	31.1	5,176	80.8
Under 50 per cent non-resident	200	24.0	1,201	18.7
Government business enterprise	1	0.1	. .	. .
Other corporations	374	44.8	. .	. .
Total, all corporations	835	100.0	6,408	
Other mining (including mining services)				
Reporting corporations				
50 per cent and over non-resident	199	7.3	1,861	60.3
Under 50 per cent non-resident	890	32.9	1,238	38.0
Government business enterprise	2	0.1	. .	. .
Other corporations	1,616	59.7	. .	. .
Total, all corporations	2,707	100.0	3,254	
Total mining				
Reporting corporations				
50 per cent and over non-resident	507	13.6	11,031	63.5
Under 50 per cent non-resident	1,213	32.4	6,057	34.9
Government business enterprise	4	0.1	104	0.6
Other corporations	2,016	53.9	175	1.0
Total, all corporations	3,740	100.0	17,367	100.0

*Classification of the industry is the same as in Table 27.
Note: Footnotes to Table 71 apply to this Table.
– Nil; . . Not available.

by degree of non-resident ownership, 1971

Equity		Sales		Profits		Taxable Income	
$ millions	%	$ millions	%	$ millions	%	$ millions	%
2,009	46.5	1,537	56.7	322	62.2	43.0	47.2
2,260	52.4	1,170	43.2	200	38.6	48.0	52.7
..	..	..	..	..	..	..	..
..	..	..	..	..	..	.1	.1
4,316		2,711		518		91.1	100.0
3,483	81.5	1,714	90.8	279	85.6	71.8	92.7
788	18.4	162	8.9	50	15.3	4.6	5.9
..	..	..	..	..	..	..	..
..	..	..	..	..	..	1.1	1.4
4,274		1,887		326		77.5	100.0
1,052	54.4	732	65.1	111	100.0	30.4	57.8
795	41.1	322	28.6	11	9.9	18.0	34.2
..	..	..	..	..	..	..	..
..	..	..	..	..	..	4.2	8.0
1,935		1,125		111		52.6	100.0
6,544	62.2	3,983	69.6	712	74.6	145.1	65.6
3,843	36.5	1,654	28.9	262	27.4	70.7	32.0
59	0.6	4	0.1	−2	−0.2	..	..
79	0.7	82	1.4	−17	−1.8	5.3	2.4
10,525	100.0	5,723	100.0	955	100.0	221.1	100.0

Table 71. Canada, financial statistics of corporations in the mineral manufacturing industries*

	Corporations[1]		Assets[4]	
	Number	%	$ millions	%
Primary metal products				
Reporting corporations[1]				
50% and over non-resident	65	17.8	1,963	41.9
under 50% non-resident	151	41.4	2,494	53.3
Government business enterprises[2]	3	0.8	213	4.5
Other[3]	146	40.0	14	0.3
Total all corporations	365	100.0	4,684	100.0
Nonmetallic mineral products				
Reporting corporations[1]				
50% and over non-resident	83	8.7	1,164	59.2
under 50% non-resident	386	40.2	741	37.7
Government business enterprises[2]	2	0.2	. .	. .
Other[3]	488	50.9	. .	. .
Total all corporations	959	100.0	1,967	96.9
Petroleum and coal products				
Reporting corporations[1]				
50% and over non-resident	22	43.1	6,096	96.2
under 50% non-resident	17	33.4	236	3.7
Government business enterprises[2]	–	–	–	–
Other[3]	12	23.5	2	0.1
Total all corporations	51	100.0	6,334	100.0
Total mineral manufacturing industries				
Reporting companies[1]				
50% and over non-resident	170	12.3	9,223	71.0
under 50% non-resident	554	40.3	3,471	26.7
Government business enterprises[2]	5	0.4	. .	. .
Other[3]	646	47.0	. .	. .
Total all corporations	1,375	100.0	12,985	100.0

*Classification of industries is the same as in Table 28.

[1] Corporations reporting under the Corporations and Labour Unions Returns Act. A corporation is considered to be foreign controlled if 50% or more of its voting rights are known to be held outside Canada, and/or by one or more Canadian corporations which are, in turn, foreign controlled. Each corporation is classified according to the percentage of its voting rights which are owned by non-residents, either directly or through other Canadian corporations, and the whole of the corporation is assigned to this particular degree of foreign ownership.

[2] Non-taxable federal and provincial Crown Corporations and municipally owned corporations.

[3] Corporations exempt from reporting under the Corporations and Labour Unions Returns Act. These include corporations reporting under other acts, small companies and corporations and non-profit organizations.

[4] Assets – Included are cash, marketable securities, accounts receivable, inventories, fixed assets, investments in affiliated corporations and other assets. The amounts tabulated are those shown on the balance sheets of corporations after deducting allowances for doubtful accounts, amortization, depletion and depreciation.

[5] Equity – This represents the shareholders interest in the net assets of the corporation and includes the total amount of all issued and paid up share capital, earnings retained in the business and other surplus accounts such as contributed and capital surplus.

[6] Sales – For non-financial corporations, sales are gross revenues from non-financial operations. For financial corporations sales include income from financial as well as non-financial sources.

[7] Profits – The net earnings from operations, investment income and net capital gains. Profits are tabulated after deducting allowances for amortization, depletion and depreciation, but before income tax provisions or declaration of dividends.

[8] Taxable Income – The figures are as reported by corporations prior to assessment by the Department of National Revenue. They include earnings in the reference year after the deduction of applicable losses of other years.

– Nil; . . Not available.

by degree of non-resident ownership, 1971

Equity[5]		Sales[6]		Profits[7]		Taxable Income[8]	
$ million	%	$ million	%	$ million	%	$ million	%
879	38.6	1,329	38.2	78	25.4	21.5	19.2
1,301	57.2	1,949	56.1	232	75.6	90.0	80.1
90	4.0	175	5.0	−4	−1.3	. .	. .
6	0.2	25	0.7	1	0.3	.8	.7
2,276	100.0	3,478	100.0	307	100.0	112.3	100.0
651	73.0	763	47.0	88	68.2	60.5	65.2
280	31.4	783	48.2	39	30.2	29.3	31.5
. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	3.1	3.3
958	104.4	1,625	95.2	129	98.4	92.9	100.0
3,739	95.7	5,217	97.9	519	97.2	221.7	99.5
166	4.2	109	2.0	14	2.6	1.1	.5
—	—	—	—	—	—	. .	. .
1	0.1	2	0.1	1	0.2	.1	—
3,906	100.0	5,328	100.0	534	100.0	222.9	100.0
5,269	78.7	7,309	70.1	685	70.6	303.7	71.0
1,747	24.7	2,841	27.2	285	29.4	120.4	28.1
. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	4.0	0.9
7,140	100.0	10,431	100.0	970	100.0	428.1	100.0

Table 72. Canada, financial statistics of corporations in non-financial industries,

		Agriculture, Forestry, Fishing and Trapping		Mining		Manufacturing	
		1970	1971	1970	1971	1970	1971
Number of corporations							
Foreign control	Number	88	95	483	507	2,385	2,308
Canadian control	Number	1,418	1,574	1,260	1,213	7,235	7,528
Other corporations	Number	5,131	5,354	2,030	2,020	12,461	12,162
Total corporations	Number	6,637	7,023	3,773	3,740	22,081	21,998
Assets							
Foreign control	$ Millions	203	222	9,690	11,031	27,576	28,953
Canadian control	$ Millions	815	902	5,310	6,057	18,138	19,596
Other corporations	$ Millions	497	529	281	279	1,611	1,580
Total corporations	$ Millions	1,515	1,653	15,281	17,367	47,325	50,129
Equity							
Foreign control	$ Millions	145	146	5,912	6,544	14,306	15,151
Canadian control	$ Millions	269	303	3,677	3,843	8,286	8,958
Other corporations	$ Millions	124	119	151	138	577	543
Total corporations	$ Millions	538	568	9,740	10,525	23,169	24,652
Sales							
Foreign control	$ Millions	86	99	3,849	3,983	29,474	33,115
Canadian control	$ Millions	633	697	1,770	1,654	21,866	23,547
Other corporations	$ Millions	420	435	112	86	2,217	2,118
Total corporations	$ Millions	1,139	1,231	5,731	5,723	53,557	58,780
Profits							
Foreign control	$ Millions	15	9	788	712	1,770	2,340
Canadian control	$ Millions	26	35	460	262	1,061	1,313
Other corporations	$ Millions	10	7	−12	−19	45	30
Total corporations	$ Millions	51	51	1,236	955	2,876	3,683
Taxable income							
Foreign control	$ Millions	3.7	2.5	191.6	−26.6	1,206.0	1,717.7
Canadian control	$ Millions	16.3	15.8	68.5	49.2	747.9	782.5
Other corporations	$ Millions	7.4	5.1	−7.9	−11.9	34.0	37.3
Total corporations	$ Millions	27.4	23.4	252.2	10.7	1,987.9	2,537.6

Figures may not add to total due to rounding.

by major industry group and by control, 1970 and 1971.

Construction		Transportation, Communication and Other Utilities		Trade		Services		Total	
1970	1971	1970	1971	1970	1971	1970	1971	1970	1971
177	178	244	251	1,825	1,865	503	522	5,705	5,726
4,368	4,749	1,601	1,774	13,012	13,879	3,788	4,217	32,682	34,934
15,429	16,366	6,980	7,037	42,332	43,207	24,373	26,044	108,736	112,190
19,974	21,293	8,825	9,062	57,169	58,951	28,664	30,783	147,123	152,850
1,000	1,188	1,881	2,385	5,144	6,404	1,394	1,562	46,888	51,745
4,493	4,975	14,182	15,104	11,364	12,607	3,281	3,731	57,583	62,973
1,097	1,141	23,454	25,072	4,237	4,212	1,546	1,642	32,722	34,455
6,590	7,304	39,517	42,561	20,745	23,223	6,221	6,935	137,193	149,172
165	234	643	858	1,961	2,510	557	567	23,689	26,010
1,049	1,104	6,075	6,386	4,480	4,794	1,100	1,217	24,936	26,606
355	370	5,987	6,282	1,226	1,298	488	510	8,908	9,260
1,569	1,708	12,705	13,526	7,667	8,602	2,145	2,294	57,533	61,976
1,178	1,410	957	1,105	10,677	12,293	1,094	1,163	47,315	53,169
5,927	6,462	5,629	6,182	28,195	30,995	2,669	3,119	66,688	72,655
2,007	2,085	5,063	5,503	7,776	8,228	2,047	2,198	19,643	20,652
9,112	9,957	11,649	12,790	46,648	51,516	5,810	6,480	133,646	146,476
30	44	129	154	327	436	111	122	3,170	3,817
143	254	832	938	637	819	136	189	3,295	3,810
57	72	140	149	677	790	86	106	1,003	1,136
230	370	1,101	1,241	1,641	2,045	333	417	7,468	8,763
33.7	39.7	121.7	157.8	288.3	375.4	72.4	78.9	1,917.3	2,345.4
82.2	160.9	431.8	397.6	556.8	672.2	93.4	119.3	1,996.9	2,197.5
58.0	68.2	25.1	22.8	147.8	167.3	86.1	114.3	350.5	403.1
173.9	268.8	578.6	578.2	992.9	1,214.9	251.9	312.6	4,264.7	4,946.0

Company Index