CANADA

MINERAL REPORT 20

CANADIAN MINERALS YEARBOOK 1970

MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
OTTAWA

1972

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Foreword

This issue of the Canadian Minerals Yearbook is a report of developments in the industry for 1970. The 53 chapters dealing with specific commodities, were issued in advance under the title Preprints, Canadian Minerals Yearbook 1970 to provide information as soon as possible to interested persons. Chapter One, General Review, 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 69 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 the Dominion Bureau of Statistics, 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.

W. Keith Buck
Director
Mineral Resources Branch

October 1971

Editor: G. E. Thompson

Graphics and Cover: N. Sabolotny

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Readers wishing more recent information than that contained in the present volume should obtain the 1971 series of preprints: complete set available from Information Canada, Ottawa, $5. Individual copies are available from the Distribution Office, Mineral Resources Branch, Department of Energy, Mines and Resources, at 25¢ each.

Frontispiece:

South Roberts open pit, showing engineers on pit rim and shovel and drill on bench.

(Photo by Hunter)

Contents

General Review†

THE CANADIAN ECONOMY IN 1970

Canada's Gross National Product (GNP) in 1970 reached $84.5 billion compared with $78.6 billion in 1969 and $71.4 billion in 1968. Figure 1 depicts these totals, the GNP in constant dollars, and the GNP per capita.* In the period 1955 to 1970 the GNP grew threefold from $27.9 billion, or about 7.7 per cent a year. Growth in real terms, that is in constant 1961 dollars, was about 4.8 per cent. The actual increase in Canadian prosperity, measured by the GNP in constant dollars per head, rose from $1,980 in 1955 to nearly $2,957 in 1970, representing an annual rate of increase of about 2.7 per cent.

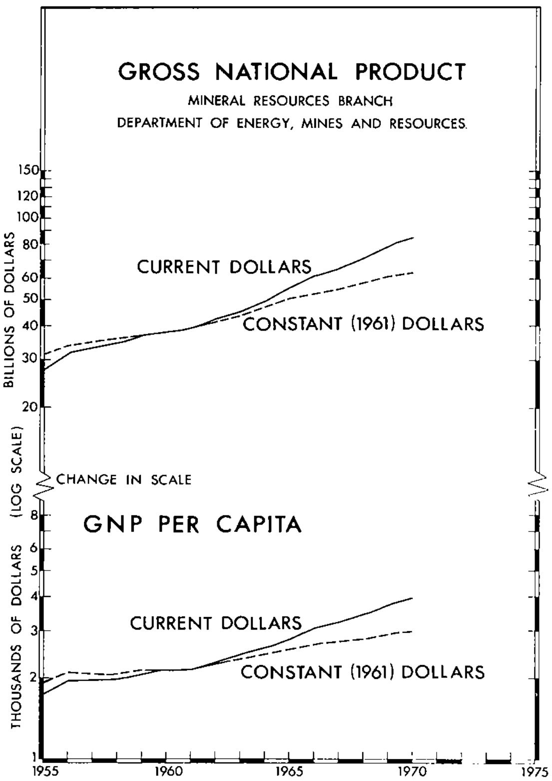


Figure 1

*This figure and others in this review are drawn with a logarithmic, or ratio, scale on the ordinate. Equal vertical distances thus represent equal rates of change; slope of curves represent annual growth rates.

†Prepared by P. W. Andrews and Staff, Mineral Resources Branch.

Behaviour of major sectors comprising real domestic product are shown in Figure 2 and illustrate that from 1955 to 1970 growth in output among sectors was not uniform. The index of mining output climbed from 66 to 173, an annual rate of 6.6 per cent; the manufacturing index grew at 4.8 per cent a year from 82 in 1955 to 167 in 1970; and the agricultural index from 115 to 124, or 0.8 per cent. The total index of real domestic product grew at 4.6 per cent a year. The slowdown in the Canadian economy in 1970 is evidenced by the indexes of manufacturing and construction; both declined for the first time in a decade.

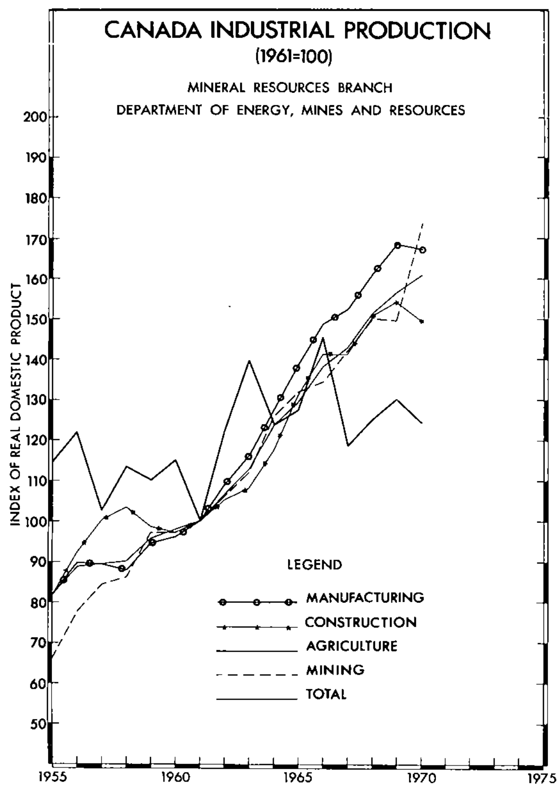


Figure 2

The estimated population of Canada in mid-1970 was 21.4 million people. The labour force averaged 8,374 thousand an increase of 212,000 during the year. The number of people employed in the year increased by only 99,000 and as a result, the unemployment rate rose to 5.9 per cent, its highest since 1962. The trend in these series between 1955 and 1970 is shown in Figure 3.

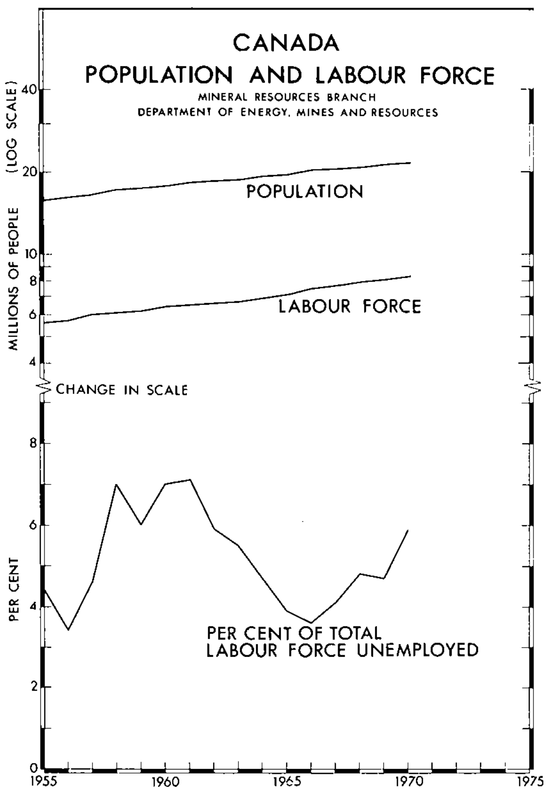


Figure 3

Total capital expenditure on plant and equipment in Canada during 1970 exceeded $23 billion, almost $1 billion, or 4.5 per cent, more than in 1969. Forecasts indicate that the increase from 1970 to 1971 will be almost $2 billion. Total investment and investment in the four major sectors of the economy are shown in Figure 4. In 1970 investment in the mining sector, which does not include the mineral manufacturing industries, rose to $1.66 billion; investment in manufacturing reached $4.51 billion with one quarter of it representing investment in mineral manufacturing.

Canadian exports increased again in 1970. Merchandise exports reached a record $16,458 million, up $1,954 million from 1969; at the same time merchandise imports fell by $175 million to $13,839 million. In non-merchandise trade, or services, Canadian exports increased by $485 million to $4,252 million, and imports increased $526 million to $5,848 million. The trend of these four sectors of Canadian trade is illustrated in Figure 5; growth in merchandise trade was much more rapid during the 1960's than growth in non-merchandise trade.

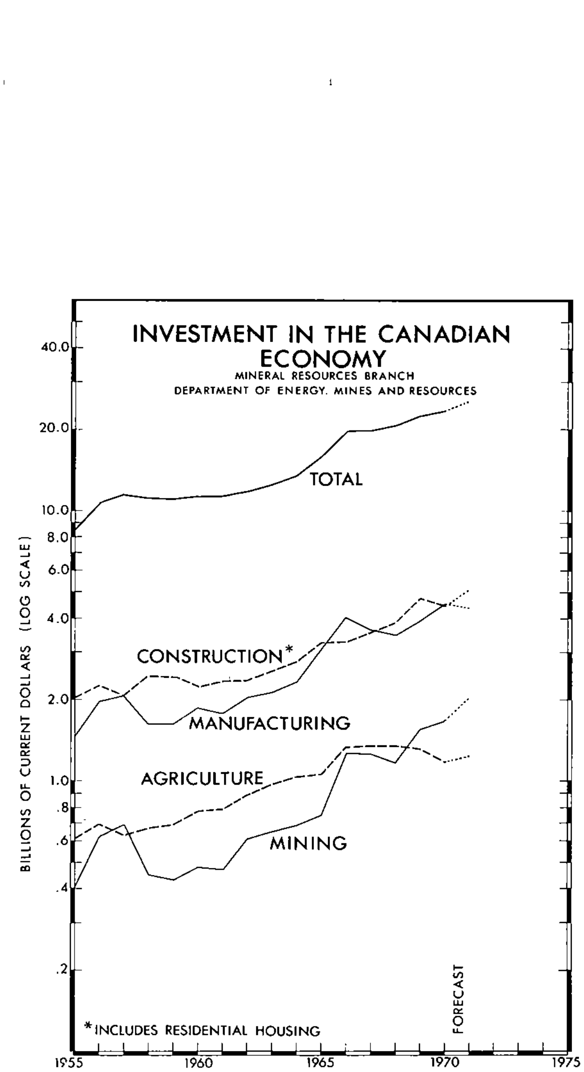


Figure 4

The very considerable increase in Canadian merchandise exports during 1970 led to a surplus on the total current account balance of international trade for the first time since 1952 as shown in Figure 6. The merchandise trade balance, also shown in Figure 6 was a record $3,002 million. This balance was achieved by increased exports to western Europe and Japan, coupled with a decline in imports as a result of a slowdown in economic activity in Canada. Figure 6 also illustrates the continuing increase in the deficit on non-merchandise trade made up, in large part, by the continuous flow of interest and dividends out of Canada.

Figure 7 shows the behaviour of Net Capital Movement and the major components of the Capital Account from 1955 to 1970. The large surplus in net capital movement indicates inflow of capital into Canada that was partly responsible for the rapid growth of the mineral industry. It was also responsible for the action taken by the Government of Canada on May 31, 1970 when it was announced that the Canadian dollar would no longer be pegged within one per cent of its par value of 92½ United States cents. The two major components of this capital flow are: Net Direct Investments, i.e. the difference between investment in Canada by foreigners and investment abroad by Canadians; and Trade in Securities.

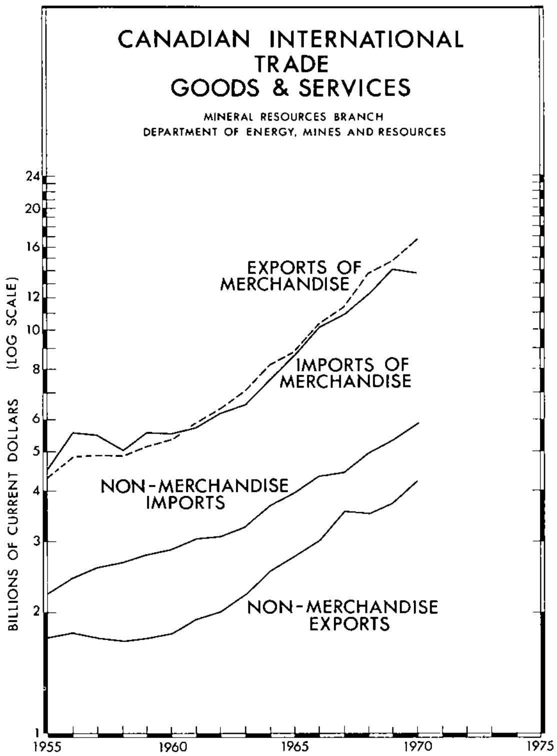


Figure 5

A REVIEW OF THE MINERAL ECONOMY

Canadian mineral production was valued at $5.77 billion in 1970, up $1.03 billion from 1969 when labour strikes in the copper, nickel, and iron ore sectors caused production cutbacks. Since 1955, as may be seen in Figure 8, total Canadian mineral output has grown more than threefold, at an annual rate of nearly 8 per cent. The figure also illustrates the rates of growth of the four sectors of the mineral industry. The business slowdown in the late 1950's affected output of metallic and nonmetallic minerals and their products; however, as business conditions in Canada and major overseas markets improved, output of both of these sectors accelerated sharply in the 1960's. Output of structural materials, which is chiefly dependent upon domestic demand has been about $440 million a year since 1968.

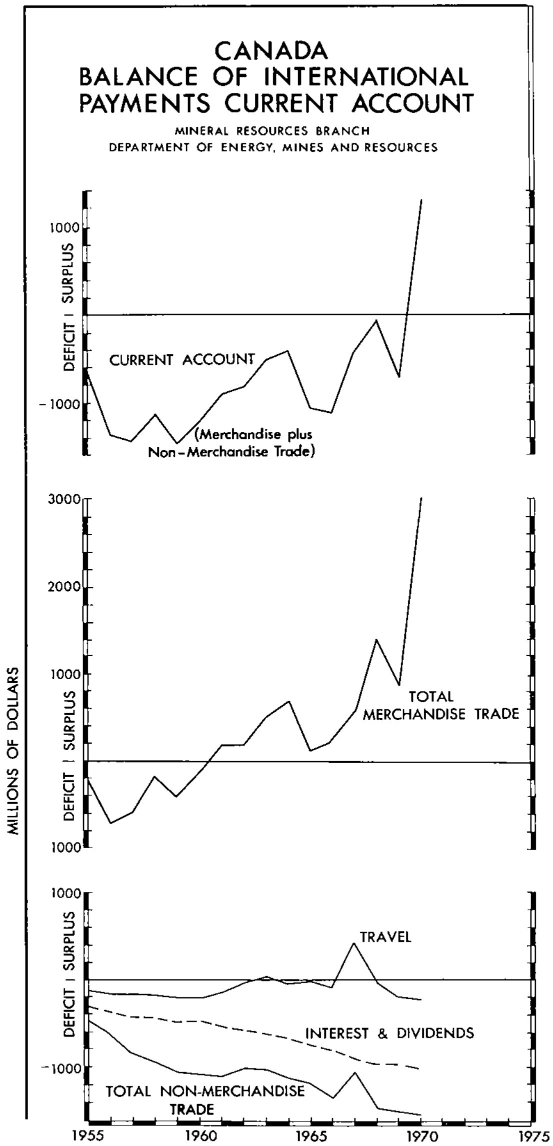


Figure 6

Canada continues to enjoy the highest value of mineral industry output per head of any country with a diversified mineral economy. In 1970 this value was almost $270 per head of the total population.

Output of the various sectors of both the mining and the mineral manufacturing industries is shown in Figures 9 and 10. The curves in these figures are weighted, physical volume indexes as published by DBS and are based on 1961 output being equal to 100.* In terms of physical output in 1961, nonmetal

*DBS Catalogue No. 61-506 series, updated.

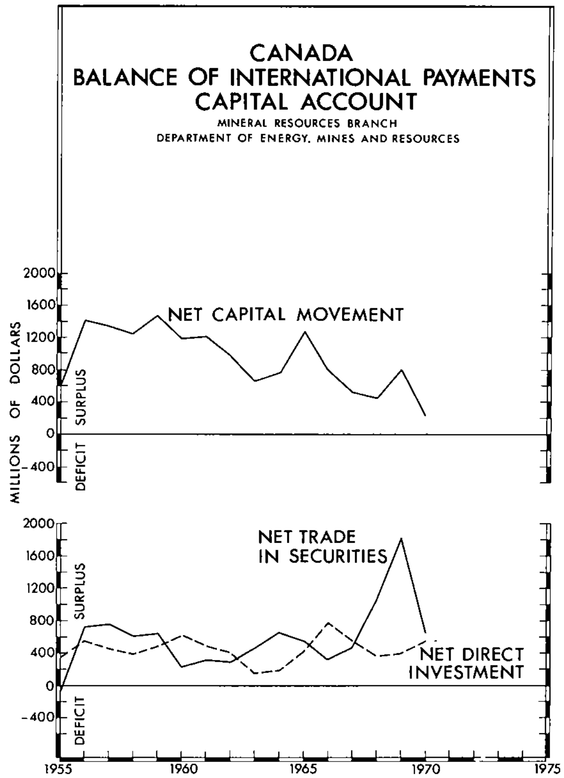


Figure 7

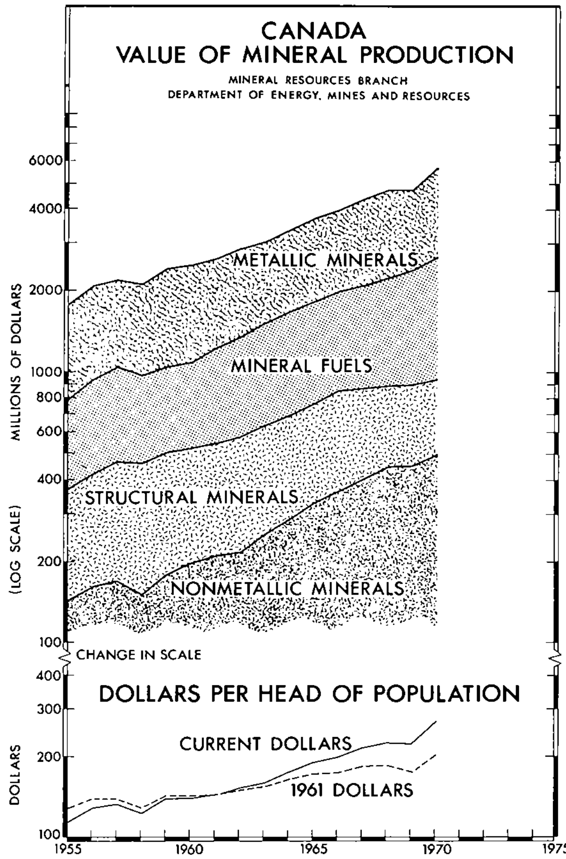


Figure 8

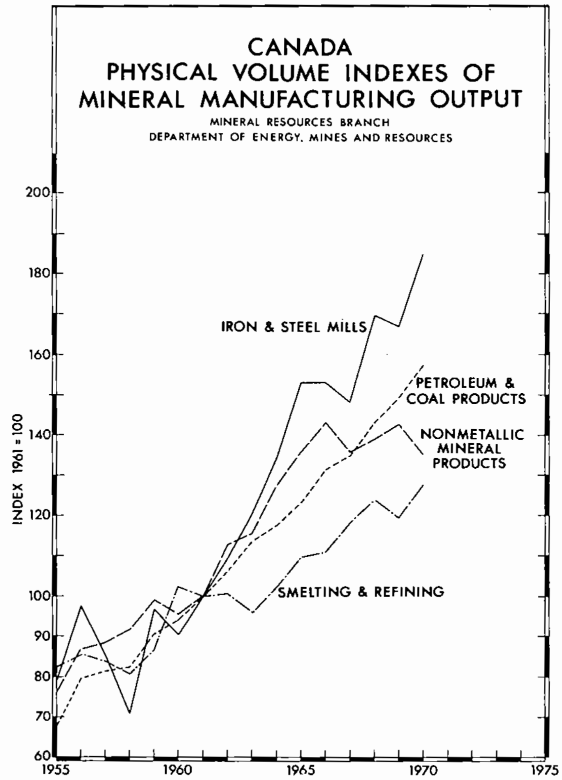
mining has shown the most rapid growth since 1955, followed by mineral fuels; the metal mines' index has advanced less rapidly from 1955 to 1970. The physical volume indexes of mineral manufacturing have increased somewhat uniformly between 1955 and 1970 with that for iron and steel mills showing the greatest rate of growth.

Petroleum was the dominant mineral commodity in terms of value of output in 1970 with nearly 20 per cent of the total (Figure 11). The four leading metals–nickel, copper, iron ore and zinc–accounted for nearly one half of Canadian mineral production value in 1970. Figure 11 also shows mineral production in terms of provincial output with Ontario and Alberta accounting for more than one half of the total and Quebec and British Columbia together contributing a further 22.5 per cent.

The relation between output and employment in mining and in manufacturing for Canada and for the United States is shown in Figure 12. Each graph represents the ratio:

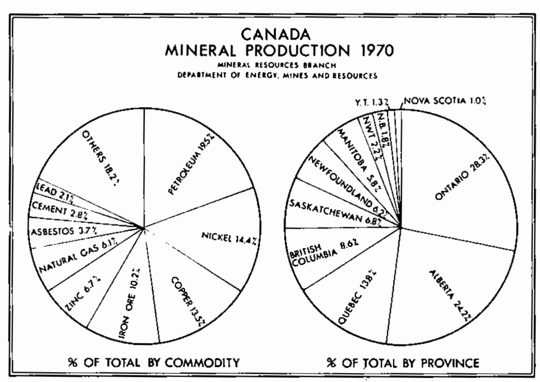
Index of Industrial Production, by Sector
Index of Employment, by Sector

The Canadian and United States ratios should not be correlated directly since their statistical bases are not necessarily the same. However, the series have statistical continuity within themselves and the figure illustrates the different rates of growth between sectors. The manufacturing series in Canada and the United States exhibit a similar growth rate during most of the period 1955 to 1970, but in the last three years the Canadian manufacturing ratio has grown considerably faster than its United States counterpart. The United States mining ratio shows a similar pattern to manufacturing in the two countries; the Canadian mining ratio shows a much faster growth than that of the United States. The surge in output in 1970 and the strike-depressed value in 1969 stands out.



▲ Figure 9

Figure 10 ▼



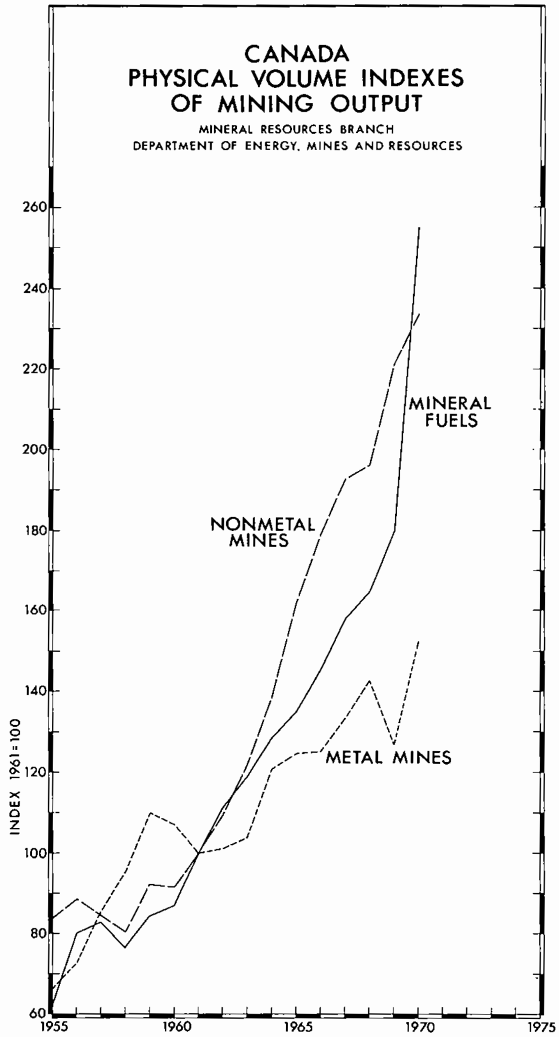


Figure 11

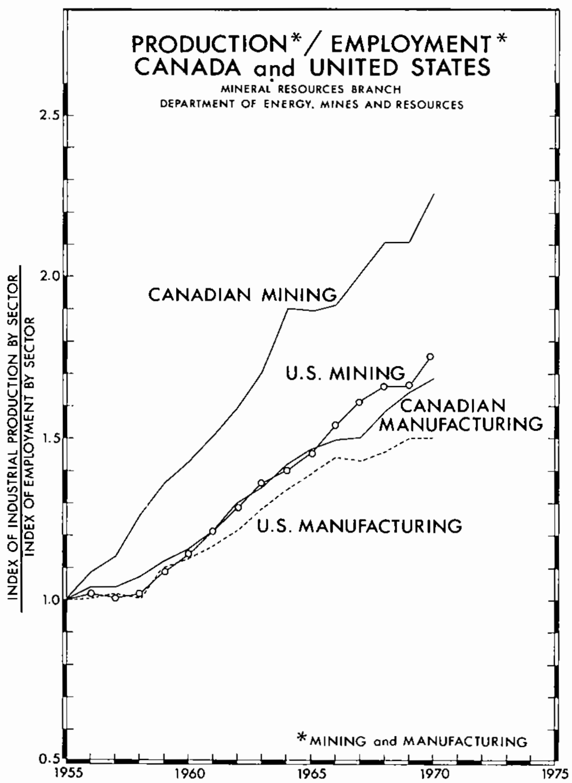


Figure 12

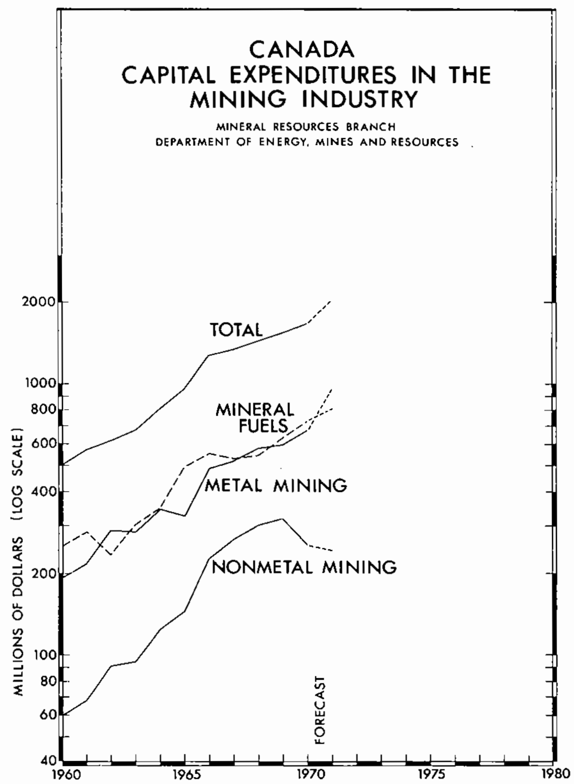


Figure 13

CAPITAL EXPENDITURES

Capital expenditures in the Canadian mining industry have been rising steadily from about $512 million in 1960 to a forecast total of $2,000 million in 1971. Figure 13 indicates that capital expenditures have been the fastest growing in the nonmetal sector up to 1969; in 1970 they continued to rise but in the 1971 forecast they decline. Capital expenditures in mineral fuels are high because they incorporate oil and gas well drilling, including wildcatting, and field pipelines whereas in the case of metal mines these expenditures cover development and on-site exploration but they do not include "off-property" exploration costs.

Capital expenditures in the three mineral manufacturing sectors of the manufacturing industry are shown in Figure 14. Primary metals, which includes iron and steel mills in addition to nonferrous smelting and refining, shows strong growth in 1970 and forecasts of continued large investments in 1971. Nonmetallic mineral products have a less buoyant forecast.

METAL AND MINERAL PRICES

Prices received for Canadian iron ore were generally higher in 1970. Among the additive minerals the price of molybdenum, cobalt, columbium, vanadium, titanium and manganese rose during 1970. The price of chromite which has been increasing since 1967, also continued to rise during 1970. Tungsten prices fell during the year to recover somewhat by mid-December.

Price behaviour of nonferrous metals was mixed. The aluminum price in Canada was unchanged throughout 1970 at 29.5 cents a pound although in the United States it rose by one cent to 29 cents. Copper prices rose in early 1970 to 60 cents a pound in the United States and 59 cents in Canada. However, both fell in October and again in December to 53 cents in the United States and 54 cents in Canada. The price of nickel in Canada was unchanged during 1970 but it rose 5 cents to 133 cents a pound in the United States. Zinc prices, stable for nearly two years, fell in both Canada and the United States by 0.5 cent in August 1970 to 15 cents a pound and remained at that level the remainder of the year. The price of lead in Canada moved from 16.5 cents a pound to 14.5 cents in three steps during the year. Silver prices declined during 1970 to $1.609 a troy ounce in December.

In the nonmetallic minerals field, asbestos prices were raised 3 per cent in January 1970 with an announcement at the end of the year that a further 4 to 6 per cent increase would become effective early in January 1971. The markets for sulphur and potash remained depressed and prices continued at low levels.

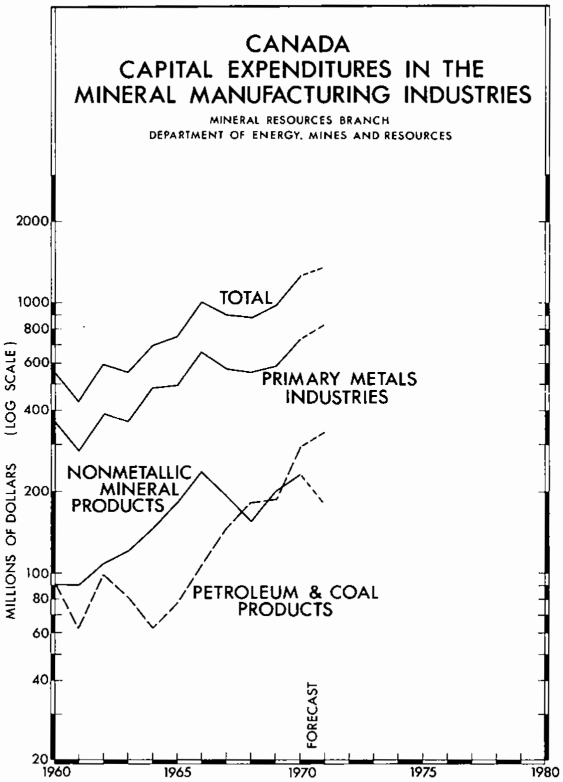


Figure 14

MINERAL TRADE

Mineral exports rose sharply in 1970 compared with the previous year in which both mineral production and exports had been reduced by labour strikes. Figure 15 shows the trend since 1955 in both crude mineral exports, and in crude and fabricated mineral exports; detailed statistics by groups are given in Table 13 in the statistical tables of this Review. In total, mineral exports increased $1,138 million to $5,202 million, or by 28 per cent, compared with those of 1969. Crude ferrous materials increased $140 million or 38 per cent; increases were spread among the three main classes of crude ferrous exports—direct shipping ore, concentrates and agglomerates—and among all major destinations. Fabricated ferrous exports increased by $114 million, or 32 per cent.

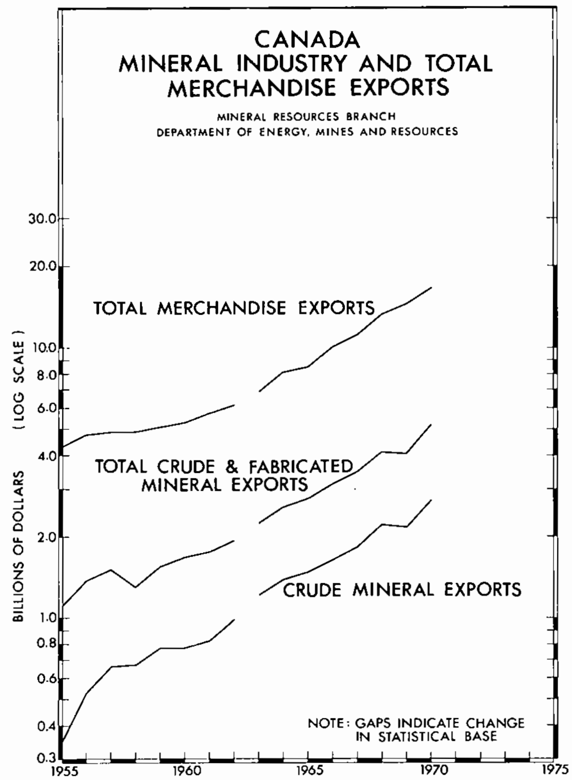


Figure 15

Nonferrous metal exports rose by 30 per cent to $2,684 million during 1970 of which $994 million was exported as crude material, up $119 million from 1969. Fabricated nonferrous metal exports rose by $404 million to $1,690 million. Large increases in nonferrous material exports included nickel in crude form, up $143 million to $368 million, and nickel in refined form, up $208 million to $434 million. Refined copper exports rose $175 million to $475 million with $70 million going to Britain and $55 million to the European Economic Community.

Value of exports of crude nonmetallic minerals fell by $5 million in 1970 but fabricated nonmetallic mineral exports rose by $43 million to give a 7 per cent increase in total nonmetallic mineral exports to $553 million.

Mineral fuel exports rose by $199 million to $970 million. The increase in crude mineral fuel exports of $173 million was comprised of increases of $123 million in crude oil and about $30 million in natural gas exports to the United States and about $19 million in coal exports to Japan. Exports of fabricated mineral fuels, chiefly fuel oils and propane gas to the United States, increased $26 million.

Total imports of crude and fabricated mineral materials into Canada in 1970 were $2,237 million, $45 million or 2 per cent higher than in 1969. The only group of imports to show a marked increase was crude mineral fuels, up $77 million to $571 million; processed mineral fuels declined about $18 million. Total ferrous group imports were down about $5 million to $766 million, and total nonferrous material imports declined $9 million to $464 million. Nonmetallic material imports were virtually unchanged at $230 million.

As a proportion of total Canadian export trade, crude and fabricated mineral exports normally account for about 31 per cent of the total. In 1969 this proportion was lower than normal at 28 per cent but in 1970 it rose to 31.6 per cent. Crude and fabricated mineral imports accounted for 16.0 per cent of total Canadian imports in 1970 and 15.5 per cent in 1969.

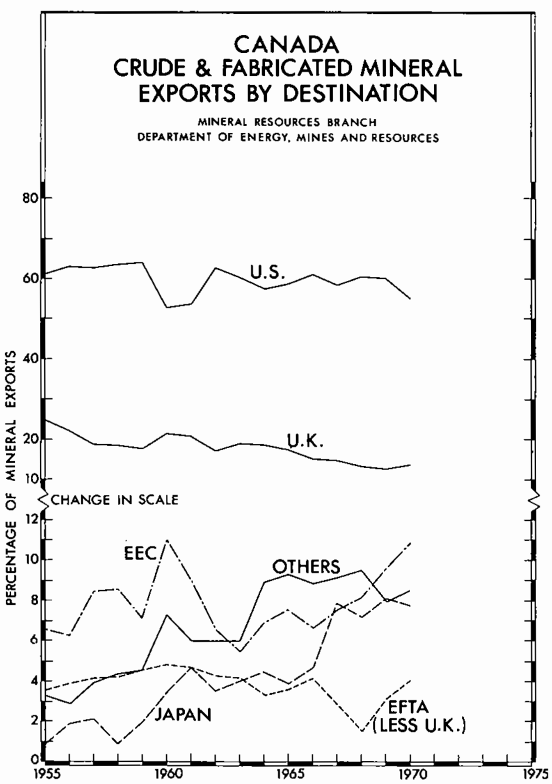


Figure 16

The United States remained by far the most important market for Canadian mineral exports in 1970 and the absolute value of mineral exports to this market increased even though as a proportion of total mineral exports its share fell to 55.1 from 60 per cent in 1969. The proportion of mineral exports to the United Kingdom rose to 13.9 per cent from the low of 11.3 per cent the previous year. The proportion shipped to Japan declined slightly to 7.7 per cent and that to the European Economic Community (EEC) rose to 10.8 per cent with the fourth successive yearly advance from 6.7 per cent in 1966 (Figure 16).

REVIEW BY PROVINCES

BRITISH COLUMBIA

In 1970 the value of mineral production reached a record $497.1 million, a gain of 14.5 per cent from $434.3 million the previous year. Copper continued to be the leading commodity. Its production value increased significantly by 47.9 per cent and constituted the largest proportion of the total output, 25.6 per cent. The second leading commodity was crude petroleum, output of which increased slightly, representing 11.8 per cent of the total. Molybdenum output increased by 20.2 per cent to become the third-ranking in value of output for the first time. British Columbia is responsible for Canada being the second largest world producer of molybdenum.

During 1970, the four new mines that started up, including the large Brenda Mines Ltd. operation, increased the number of copper producers to fourteen and three large potential copper-molybdenum mines have been prepared for production. The rated year-end molybdenum production capacity increased one third from 1969 to some 40 million pounds of molybdenum a year as a result of the addition of two new producers to the previous four. Although there were no major developments in crude petroleum and natural gas, production continued to increase from the Fort St. John-Fort Nelson area of northeastern British Columbia. Owing to a general decrease in demand for zinc, particularly by the United States, the value of zinc output dropped in 1970. Cominco Ltd. contributed most of the province's output of zinc and lead from company mines. Concentrates from its mines, with concentrates from many other mines, are converted at the company's metallurgical plants to refined zinc, lead and silver; byproduct recovery is made of antimony, bismuth, cadmium, tin, iron and sulphur compounds.

Significant developments continued in the coal industry during 1970 such that coal will rapidly provide a higher proportion of the province's mineral production. Coal production increased more than threefold during the year mainly as the result of the opening of the large Kaiser Resources Ltd. mine in the East Kootenay area of southeastern British Columbia.

Most of the province's output of coal will continue to be exported to Japan for metallurgical purposes and, as a result, further major developments are taking place in the handling and transportation of this bulk commodity. During the year, the large Roberts Bank bulk-handling port facilities south of Vancouver were opened to receive the first unit-train shipments of Canadian coal. Continuing significant developments in coal mining, its beneficiation, transportation and use will have a long-term buoyant effect on the economy of western Canada, particularly that of British Columbia and Alberta.

YUKON TERRITORY AND NORTHWEST TERRITORIES

Of all the regions of Canada, the Yukon Territory experienced the largest percentage gain in value of mineral production, increasing by 125 per cent from $35.4 million in 1969 to $79.6 million. Eighty per cent of the value of production was from the metallic minerals sector and most of that through the output of zinc and lead, each of which quadrupled in value. Most of the increase was the result of continued phasing-in of production at the new zinc-lead operation of Anvil Mining Corporation Limited at Ross River and from a major expansion of the original facilities. The output was exported to Japan as concentrates whose silver content contributed to a significant rise in the shipments of silver also. Copper shipments also increased in value. Nonmetallic mineral production was comprised of asbestos shipped from the Clinton Creek operation of Cassiar Asbestos Corporation Limited. Shipments of asbestos increased 27.2 per cent in value and production capacity was being expanded.

In the Northwest Territories, mineral output increased in value to $125.1 million from $119.2 million in 1969. Zinc and lead, the leading commodities, comprised 85.2 per cent of the 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 $71.7 million, accounted for 57.3 per cent of the total value of minerals. The Northwest Territories remained as the leading lead-producing region in Canada and recorded a small gain in shipments. Gold output from mines in the Yellowknife area continued to decrease in value to $11.7 million while the value of silver production from Echo Bay Mines Ltd. and as a byproduct from Pine Point increased by 19.4 per cent. Crude petroleum, the fifth-leading commodity, represented less than one per cent of mineral production value but it, along with natural gas, has spurred considerable exploration activity, particularly on the Arctic Islands and near the Arctic coast. This activity has accelerated since 1967 when a major oil discovery was made at Prudhoe Bay in Alaska, near the Northwest Territories. It gained additional impetus when Panarctic Oils Ltd., an industry-government company, made a major gas discovery on Melville Island in 1969 and an even larger one during the latter part of 1970 on King Christian Island in the northern Arctic. Coincidentally, consortia of oil, gas and pipeline companies accelerated the investigation of the feasibility of transporting oil and gas by pipeline from the Arctic to existing pipeline networks to the south.

ALBERTA

This province increased the value of its mineral output to $1,410.9 million, 17.1 per cent more than in 1969. It continued as the leading producer of crude petroleum, natural gas and its byproducts, and elemental sulphur. Those commodities accounted for 95.2 per cent of the total value, with crude petroleum providing 61.3 per cent of the total, showing a significant increase and heading the list at $864.1 million. Natural gas and natural gas byproducts were next in importance and experienced substantial gains to $296.4 and $153.3 million, respectively. The production value of structural materials was lower in 1970 than in 1969. Shipments of sulphur were greater than those of the previous year as new plants came on stream. However, the value of sulphur shipments was down by 50.5 per cent because of extremely low prices resulting from an international oversupply situation. Coal output almost doubled in value and Alberta became the leading provincial producer of this commodity mainly as the result of the contribution of two new producers, McIntyre Porcupine Mines Limited and Cardinal River Coals Ltd.

During the latter part of 1970, two significant decisions were made by the Canadian and United States governments that will assure new growth for the Canadian oil and gas industry with which the economy of Alberta is so closely associated. The National Energy Board approved the export of additional natural gas to the United States that could represent increased sales valued at over $1.5 billion during the next 20 years. In addition, the United States government agreed in principle to allow Canada to have full access to oil markets in the United States east of the Rockies.

SASKATCHEWAN

Saskatchewan's mineral production reached $392.5 million in 1970, up 13.8 per cent from 1969 with some mineral commodities experiencing either significant advances or reverses. However, crude petroleum, the leading commodity, advanced only slightly in value to $201.3 million but represented 51.3 per cent of the total. Potash followed in order of value with an increase of 67.8 per cent from 1969 to account for 29.7 per cent of the provincial total. This province produces all of Canada's potash and is responsible for this country being the leading world producer. Two new potash operations, costing $160 million, officially started production–Central Canada Potash Co. Limited at Viscount and Sylvite of Canada Division of Hudson Bay Mining and Smelting Co., Limited at Rocanville. Cominco Ltd. temporarily suspended production from its newly-opened Vanscoy plant as a result of flooding. In order to allocate markets for its rapidly expanding production capacity, the Saskatchewan government put into effect The Potash Conservation Regulations during the year and established a procedure for the allocation of maximum shipments from each plant as well as a minimum base price for each grade.

Copper, the next commodity in importance, decreased slightly in value and accounted for 4.6 per cent of the provincial total. The value of uranium production dropped by 25.6 per cent from 1969 during the second year of a five-year program of Eldorado Nuclear Limited to reduce production from the Beaverlodge area. Production will eventually be cut to 50 per cent of rated capacity in order to closely correspond to sales commitments. Gulf Minerals Canada Limited announced that it will start constructing a mining complex in 1971 at its Rabbit Lake uranium deposit in the Wollaston Lake area for production in 1974. Structural materials were 17.4 per cent lower in value, natural gas increased by 10.1 per cent, and the production of coal almost doubled in value from that of 1969.

MANITOBA

The value of mineral output in Manitoba reached $331.8 million in 1970, an increase of 34.7 per cent from the previous year. Large gains were made by the two leading commodities to $212.6 million for nickel and $59.7 million for copper that together accounted for 82.1 per cent of the total mineral value of output. There were slight changes in the output value of structural materials and crude petroleum, the commodities next in importance. Other mineral commodities such as zinc, tantalum, cobalt and gold contributed in that order to the value of provincial mineral output, but to rather a minor extent.

The International Nickel Company of Canada, Limited (Inco) operated two nickel mines, a smelter and a refinery in the Thompson area and continued to develop two other mines for production. Sherritt Gordon Mines, Limited continued to ship nickel and copper from its Lynn Lake operation and started production at its new copper-zinc mine at Fox Lake. Falconbridge Nickel Mines Limited is preparing one prospective nickel mine for production in 1971. Hudson Bay Mining and Smelting Co., Limited operated seven copper-zinc mines in the province including two that started operating in 1970. Mineral concentrates shipped from those mines are smelted and refined, along with concentrates received on a custom basis, at the company's copper-zinc smelter at Flin Flon. Exploration for metallic minerals continued at a high level in the northern part of the province, particularly in the Thompson area.

ONTARIO

More than $400 million was added to Ontario's value of mineral production in 1970 to provide a 33.4 per cent increase from that of 1969 to a record $1,631.7 million. This was in contrast to a decline in 1969 that was caused mainly by labour strikes in the nickel-copper industry. During 1970, nickel and copper accounted for 58.3 per cent of the total value of the province's mineral output with nickel increased 85.8 per cent to $611.5 million and the value of copper rose 38.8 per cent to $339.0 million. In decreasing order of value, the other leading mineral commodities were structural materials, iron ore, zinc, platinum metals, gold, and silver.

Inco operated 14 nickel-copper mines, four mills, two smelters, a copper refinery and byproduct recovery plants in the Sudbury area as well as a nickel refinery at Port Colborne. It brought two new nickel-copper mines into production in the Sudbury area in 1970 and is developing four more there as well as one near Shebandowan in northwestern Ontario. In addition to continuing work in the Sudbury area on the expansion of iron and sulphuric acid recovery and pollution control, this company continued the construction of a nickel refinery which is scheduled to start production in 1972. Falconbridge operated seven mines, four mills, a copper smelter and byproduct recovery plants in the Sudbury area and is developing two more mines for production. Copper is produced by many other mines in the province, often as a co-product with zinc. Of these, the Timmins mine of Ecstall Mining Limited and the Manitouwadge mine of Noranda Mines Limited are the largest. Ecstall Mining Limited started construction of Canada's fifth zinc smelter-refinery complex, near Timmins. It is to be completed in early 1972 at a cost of $50 million and will process about half the zinc concentrates now being exported from the province. Sulphuric acid and cadmium will be byproducts of the operation.

In 1970 Eldorado Nuclear Limited started the first commercial production of uranium hexafluoride in Canada at Port Hope. This uranium refinery has already been committed to the processing of uranium oxide from other countries.

QUEBEC

The production value of minerals in Quebec increased by 11.3 per cent from that of 1969 to reach a new high of $798.6 million. Copper continued to be the dominant commodity and its value rose by 22.4 per cent to $201.5 million, or one quarter of the province's total value of mineral output. This increase was due mainly to new capacity that was brought on stream during 1969 but which was not apparent in that year because of lost production resulting from a 14-week labour strike at the large copper-producing complex of Gaspé Copper Mines, Limited. Many mines produced copper during the year and except for some increases in mine capacity, the usual development work, and a few mine closures and openings, there was no major development relating to this commodity.

Asbestos was the second commodity in importance and increased moderately in value to provide one fifth of the province's total. Considerable expansion activity was under way at the existing operations of Canadian Johns-Manville Company, Limited, Bell Asbestos Mines, Ltd. and at the King-Beaver operation of Asbestos Corporation Limited. In addition, Asbestos Corporation continued to develop the Penhale property for production and started to prepare the Asbestos Hill deposit near Ungava Bay for production. These developments will assure Quebec's continued world prominence as a source of asbestos.

Iron ore output was valued at 18.1 per cent more than in the previous year mainly as a result of the recovery from labour strikes of 1969. Three major projects were announced during the year: Iron Ore Company of Canada plans to construct a new concentrator and a new pellet plant at Sept-Iles and Quebec Cartier Mining Company is planning to construct a concentrator at Mt. Wright. The expenditure for these projects will be in the order of $440 million.

Structural materials decreased slightly and accounted for 13.0 per cent of the province's value of mineral production. Other leading commodities were zinc, titanium dioxide and gold, in that order. Quebec produces many other mineral commodities and has pioneered such industries in Canada as those relating to titanium dioxide, columbium and lithium. Exploration activity continued at a generally high level during 1970 and was related to a diversity of minerals.

NEW BRUNSWICK

The mineral output of New Brunswick is closely related to the production of zinc and its co-products. In 1970, the total value of mineral production increased by 7.0 per cent from the previous year to a total of $101.2 million. Zinc accounted for approximately half of the total and, along with its co-products lead, copper, silver, cadmium, bismuth and gold, it represented 87.2 per cent of the overall mineral value. Zinc experienced a normal increase, whereas the second and third most significant commodities, lead and copper, made gains in value of 26.8 and 31.9 per cent, respectively. The gain for the co-product silver closely followed that for zinc.

These increases took place despite a five-week labour strike at the operations of the largest producer, Brunswick Mining and Smelting Corporation Limited. The added output of these metals, and of copper in particular was due mainly to the doubling of the capacity of Heath Steele Mines Limited. Brunswick Mining and Smelting is by far the province's largest producer of base-metals and operated two zinc-lead-copper mines and two mills near Bathurst and a related company East Coast Smelting and Chemical Company Limited, operated a zinc-lead smelter at Belledune. Toward the end of the year the new Caribou copper mine and mill were being tuned up for production by The Anaconda Company (Canada) Ltd.

Structural materials decreased slightly in value in 1970 and accounted for 7.4 per cent of the total. The output of coal continued to diminish appreciably as the result of a gradual phasing-out of the non-economic coal mines at Minto. This program is now being managed by a provincial company, N.B. Coal Limited, so that the necessary adjustments can be co-ordinated in as efficient a manner as possible. Coal production was reduced 47.5 per cent in value during the year to represent about 2.9 per cent of the provincial total.

NOVA SCOTIA AND PRINCE EDWARD ISLAND

Nova Scotia's mineral output was valued at $58.9 million in 1970, about the same as for 1969. About 99 per cent of the total was provided by fuels, structural materials and nonmetallic minerals. Coal, the leading commodity, accounted for 37.7 per cent and increased slightly to $22.2 million. Nine coal mines and a coking plant were in operation. Two new mines are being developed; the large Lingan mine in the Sydney area by Cape Breton Development Corporation (DEVCO) and a mine in the Springhill area by Springhill Coal Mines Limited. Greatly increased prices and the demand for coal low in sulphur have recently provided increased opportunities for the development of the coal resources of this province.

Although structural materials declined slightly in value from 1969, they accounted for 28.5 per cent of the provincial total. Gypsum retained its position and provided 18.3 per cent of the overall value. Nova Scotia provides about 70 per cent of Canada's gypsum and is one of the leading gypsum-producing areas in the world. Salt experienced a significant increase in its value of output to provide 12.3 per cent of the province's value of production. Barite and lead shipments were relatively small and both were reduced to a considerable extent in 1970. The mining of celestite, the main source of strontium, was started on Cape Breton Island by Kaiser Celestite Mining Limited. Celestite concentrates from the company's mill will be shipped to the Point Edward chemical plant of Kaiser Strontium Products Limited for processing into strontium carbonate and byproducts such as sodium sulphate.

Besides the new developments relating to coal, the major activity during 1970 centred around the offshore drilling for oil and gas. Shell Canada Limited continued its extensive drilling program and is now using two drilling rigs.

Prince Edward Island's mineral production has historically been confined to structural materials. It increased moderately during the year to about $500,000 and was confined solely to the output of sand and gravel.

NEWFOUNDLAND

Iron ore continued to play a major role in the mineral industry of Newfoundland and marked improvements in that sector were mainly responsible for a 39.5 per cent increase in the provincial value of mineral production which reached $358.4 million. Labour agreements in 1969 paved the way for uninterrupted output of iron ore during 1970 which gained 52.2 per cent in value over the previous year and accounted for 82.8 per cent of the province's total value. 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 (IOC) and Wabush Mines. The expansion under way at year-end at the IOC's Labrador City concentrator will increase production capacity from about 11 million tons a year between 21 and 22 million tons a year by 1973.

Copper, the mineral commodity second in value of output, declined in value by 15.0 per cent to account for 5.0 per cent of the provincial total. Most of this decline resulted from the closing of the mine of Atlantic Coast Copper Corporation Limited during the latter part of 1969. The other leading mineral commodities were asbestos, zinc, structural materials, and lead, in that order. All but lead increased in value of production. During the year the province's only asbestos operation, Advocate Mines Limited at Baie Verte, started producing a second grade of fibre for export. There was increased interest in the oil and gas potential of the extensive region lying offshore Newfoundland island and Labrador as indicated by the large areas now under exploratory permit by major oil and gas companies.

Statistical Tables

GENERAL REVIEW STATISTICAL SUPPLEMENT†

The statistics presented in the statistical supplement are chiefly derived from Statistics Canada (SC) sources. Certain information is obtained from other departments and from recognized international statistical sources.

The purpose of the supplement is to present in a comprehensive manner statistical data pertaining to Canada's mining and mineral industries. This is done within a framework of ten sections, each composed of a number of tables. An attempt is made to present all relevant general statistics which are of importance in understanding the role of the mining and mineral industries in the Canadian economy. Information relating to specific mineral commodities or segments of the mineral industry is found not in the supplement but in separate mineral commodity analyses within this volume.

SECTION 1 PRODUCTION

This section of 12 tables covers various aspects of mineral production. In Table 1 are found production statistics in term of quantities and values, for some 60 individual minerals. This is an historical series, dating back to 1886, and relates to minerals produced from Canadian resources. Recoveries from secondary materials and imported ores and concentrates are not included.

The endeavour, in the computation of the quantities and values of the minerals recorded in this table, is to measure the components as close to the producing operation as feasible. In the case of nonmetallic minerals, quantities shipped plus values f.o.b. mine or mill, as reported by the producer, are taken as production. Mine shipments, with company stated values, are also taken to reflect production in the case of certain metals. The computation of quantity and value production statistics, however, for some metals is more complicated. Some metallic ores and concentrates produced in Canada's mines are treated at smelting and refining operations in Canada. The quantities of metals obtained from the processing of these materials is recorded and valued using average metal prices. However, some ores and concentrates are not treated in Canada but are shipped to foreign smelters for processing. In cases of this nature, the metal contents are computed, and from these quantities certain deductions for smelter and refinery losses are made in order to obtain recoverable metal contents. Average unit metal prices are then used in conjunction with recoverable metal calculations to arrive at production values.

Tables 1 to 7 include the breakdown of mineral production component data, but none are on the Standard Industrial Classification (SIC) or Standard Commodity Classification (SCC) basis. Table 11 is a series showing physical volume indexes of the mining industry. The indexes are computed in a manner that permits a reflection of changes in volume without the distorting influence of price factors. These indexes are compiled on the Standard Industrial Classification of Industry (SIC) basis, and are presented in the table unadjusted for seasonal variation and on the base year 1961 being equal to 100. Table 8 shows Canada's position in the world as a producer of important minerals. Statistics for Canada are production data from the Canada Statistics, and are contained in Table 1 of this section. World totals and individual country totals, other than for Canada, are obtained from recognized international mineral publications, such as the American Bureau of Metal Statistics, United States Bureau of Mines etc. Tables 9 and 10 report values added on the Standard Industrial Classification (SIC) basis. The value added concept enables meaningful inter-industry comparisons, since duplicating cost factors such as cost of materials used, fuel and electricity, etc. are removed.

SECTION 2 TRADE

This section of seven tables covers Canada's trade in minerals and mineral products. These data are extracted from the publications of the External Trade Division of Statistics Canada. The values of exports and imports of crude minerals essentially

†Prepared by B.F. Barch, and Staff, Statistics Section, Mineral Resource Branch.

refer to mine products. Mineral products consist of products of varying degrees of the manufacturing process, from primary refinery products to more advanced products of rolling mills and other processing establishments. This class of mineral products includes fully fabricated products which are used in the construction or fabrication of more advanced end-use products. Fully fabricated end-use products of a mineral origin, such as machines composed of ferrous or nonferrous metals, are not included under the class of fabricated products reported in this section. The values are based on information appearing on customs import and export entries. Export entries define the value of imports as the actual amount received or to be received in terms of Canadian dollars, exclusive of all charges such as freight, insurance, handling, etc. Generally this definition gives values, f.o.b. point of consignment. The requirement under the Canadian Customs Act generally is for the evaluation of goods, f.o.b. point of shipment in the country of export.

SECTION 3 CONSUMPTION

In this section, composed of three tables, an attempt is made to relate Canadian consumption of the main crude minerals to domestic production of these minerals. The relationship of consumption as a per cent of production facilitates the determination of surpluses and shortages in the mineral commodities covered. Consumption data in Tables 20 and 21 are summations of quantities reported to Statistics Canada on special annual mineral consumption surveys. The production totals are those reported in Table 1 of Section 1. Table 21 shows, for certain minerals, the relationship between apparent consumption and production. Reported consumption for these minerals is not readily available. Therefore, apparent consumption which consists of an arithmetical calculation of production plus imports less exports, with no adjustments for stocks, indicates Canadian consumption requirements for these minerals. Table 22 gives annual production and consumption of certain important nonferrous refined metals. Consumption of these metals is reported by consumers to Statistics Canada through special consumption surveys. Production of refined metals included metal derived from all sources, including that from domestic ores and concentrates, from imported ores and concentrates and from secondary materials. Refined production of the metals in this table is reported in the respective commodity sections of Canadian Minerals Yearbook.

SECTION 4 PRICES

This section is comprised of four statistical tables. Annual average price data shown in Table 23 are, with the exception of gold, obtained from *Metals Week* and are in United States currency.

The gold price, in Canadian currency, is the average annual Royal Canadian Mint buying price. The wholesale price indexes, reported in Tables 24 and 25 are compiled from the Prices Division of Statistics Canada. Wholesale price indexes (base 1935-39-100) of specific mineral products are shown in Table 24, while an historical series of wholesale price indexes for overall groups of mineral products and non-mineral products are shown in Table 25. Table 26 reports industry selling price indexes. These indexes differ from those of Tables 24 and 25 in that they measure the selling price levels of a number of products within an industry.

SECTION 5 PRINCIPAL STATISTICS

Tables 27 to 33 outline principal statistics in the mining and smelting and refining industries. In Table 27 statistics relating to production and related works, costs of fuel and electricity and materials and supplies are given by types of mining. Gross values of production, together with net values or values added of production, are shown. The values added totals are gross values with certain cost factors, such as costs of fuel and electricity, and cost of materials and supplies, removed. The mineral manufacturing industries are covered in Table 28, which includes the same statistical coverage as in Table 27. The values added totals for the mining industry are reported in Table 11. Tables 31 to 33 report component detail on the consumption of fuel and electricity by the mining and mineral manufacturing industries.

SECTION 6 LABOUR, LABOUR COSTS, WAGE RATES

Tables 34 and 35 of this section show employment and salaries and wage data foe the mining industry. Table 37 reports employment data for wage earners only. These employment figures are included in the overall totals of Tables 34 and 35. Table 38 shows productivity information in respect to tons mined per worker and wage cost per ton mined for certain types of metal mining.

In Table 39 man-hours paid per ton mined in metal and industrial mineral operations is presented for a number of years. These are calculated totals, with the basic statistics being obtained from relevant Statistics Canada reports, and also, where necessary, from mining schedules received by SC. The wage rates shown in Table 40 are obtained from mining operators by the Department of Labour and reported in the publication "Wage Rates, Salaries and Hours of Labour". The index numbers of average wage rates reported in Table 41 are also obtained from this source. Average weekly wages and hours of hourly rated employees shown in Tables 42 and 43 are obtained from SC monthly and annual publications on man-hours and average earnings by industries. Information contained in Tables 44 and 45 on industrial fatalities and strikes and lockouts, by industries, are obtained from *"Labour Gazette"* a publication of the federal Department of Labour.

SECTION 7 MINING, EXPLORATION, DRILLING

In this section, operations of the mines is brought into perspective by showing tonnages of ore mined and rock quarried by types of mining operations. Amounts expended in mining exploration and development by province are shown in Tables 48 and 49. These amounts are reported by provinces and this reflects where both exploration and development funds are being expended. Table 50 reports, in footages by main types of mineral deposits, diamond drilling carried out both by drilling contractors and by mining companies with their own equipment. From 1964 those mining companies that are not yet in production have been excluded from the tabulation. Exploration diamond drilling only by producing companies and by contractors is reported in Table 51, and drilling other than exploration is covered in Table 52. Data in these tables are included in the totals of Table 50. Table 53 covers operations of diamond drilling contractors only. The footages reported here represent total drilling by the contractors in mining operations and, to some extent, in non-mining operations. Contract drilling for oil and gas by type of drilling and also gross income and employment are reported in Table 54. Data for the tables in this section are obtained from the SC mining publications and, in some cases, from basic schedules. The SC report "Contract Drilling for the Mining Industry" is the basis of statistical data presented on contract drilling.

SECTION 8 TRANSPORTATION

In this section an endeavour has been made to emphasize the role that minerals and mineral products have in various types of transportation. For example, in Tables 55 and 56 the tonnages of crude minerals products moved by Canadian railways is shown, while Table 57 shows the importance of fabricated mineral products in total railway revenue freight. Crude and fabricated minerals transported through Canadian canals, in relation to total freight moved, is shown in Table 58. Tables in this section were derived from published data of the Transportation and Public Utilities Division of Statistics Canada.

SECTION 9 TAXES PAID

Tables 59 and 60 report the taxes paid by the main sectors of the mining industry to the three levels of government, federal, provincial and municipal. These data are extracted from the published mining industry reports of Statistics Canada and also, where necessary, from annual census of mines schedules. Data in Tables 61 and 62, reporting taxes paid by mining and mineral fabricating companies was extracted from "Corporation Taxation Statistics" a publication of the Corporations and Labour Unions Return Division of Statistics Canada. Taxes shown in Table 61 and 62 will not necessarily agree with those of Tables 59 and 60, chiefly because of differences in coverage and interpretation. Amounts shown in Tables 59 and 60 refer to actual payments made, while those of 61 and 62 are expressions of taxation levies.

SECTION 10 INVESTMENT, FINANCE

Tables 63 to 65 of this section are various breakdowns on capital and repair expenditures of the mining and mineral fabricating industries.

Capital invested on new construction and machinery and amounts expended on repair of existing structures and machinery are reported for the mining and mineral fabricating industries. These data are extracted from the Statistics Canada publication "Private and Public Investment in Canada". Information shown in Table 66 refers to investment in all aspects of the oil and gas industries and is from a special tabulation prepared in the Business Finance Division of Statistics Canada. Table 67 pertains to the degree of non-resident ownership of the mining industry in Canada, and is prepared from data appearing in the publication entitled, "Corporations and Labour Unions Returns Act, Part 1", published by the Corporation and Labour Unions Return Division of Statistics Canada. Financial statistics contained in Table 68, are derived from data published in "Corporation Financial Statistics" of the Statistics Canada. The statistics outlined in Table 69 on ownership and control have been prepared from data contained in balance of payments publications of Statistics Canada.

STATISTICAL TABLES

		1950	1951	1952	1953	1954	1955	1956	1957
Gross National Product – current prices	$ millions	17,995	21,060	24,042	25,327	25,233	27,895	31,374	32,907
Gross National Product – 1961 prices	"	23,809	25,004	27,398	28,862	28,283	31,079	33,780	34,710
Value of Manufacturing									
Industry shipments	"	..	..	..	..	..	19,513	21,637	22,178
Value of mineral production	"	1,045	1,245	1,285	1,336	1,488	1,795	2,085	2,190
Merchandise exports	"	3,104	3,897	4,282	4,097	3,860	4,258	4,760	4,789
Merchandise imports	"	3,125	4,005	3,916	4,248	3,967	4,568	5,547	5,473
Balance of trade									
Current account	"	−316	+517	+151	+443	+432	+698	+1,366	+1,455
Corporation profits before taxes	"	2,506	2,800	2,640	2,611	2,290	2,965	3,345	3,056
Capital investment, current prices	"	3,862	4,424	5,424	5,968	5,802	6,531	8,196	8,813
Capital investment, 1961 prices	"	5,029	5,047	6,073	6,682	6,458	7,068	8,439	8,944
Population	000's	13,712	14,009	14,459	14,845	15,287	15,698	16,081	16,610
Labour force	"	5,163	5,223	5,324	5,397	5,493	5,610	5,782	6,008
Employed	"	4,976	5,097	5,169	5,235	5,243	5,364	5,585	5,731
Unemployed	"	186	126	155	162	250	245	197	278
Unemployment rate	%	3.6	2.4	2.9	3.0	4.6	4.4	3.4	4.6
Employment index	1961=100	86.1	92.3	94.7	96.2	93.2	95.4	101.9	100.0
Labour income	$ millions	8,629	10,103	11,208	12,110	12,432	13,215	14,719	15,825
Index industrial production	1961=100	57.3	62.7	65.3	70.1	70.0	77.7	85.8	87.2
Index manufacturing production	"	63.4	68.9	71.5	76.6	74.9	82.2	89.9	89.7
Index mining production	"	38.7	43.6	46.5	50.6	56.1	66.4	77.1	84.6
Index real domestic product	"	62.4	67.3	72.5	75.5	74.3	82.1	89.1	89.5
General wholesale price index	1935-39=100	211.2	240.2	226.0	220.7	217.0	218.9	225.6	227.4
Consumer price index	1961=100	79.6	88.0	90.2	89.4	89.9	90.1	91.4	94.3

.. Not available

Indicators 1950-70

1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
34,094	36,266	37,775	39,080	42,353	45,465	49,783	54,897	61,421	65,722	71,388	78,560	84,468
35,462	36,929	37,994	39,080	41,778	43,996	47,050	50,149	53,650	55,407	58,041	61,214	63,210
22,171	23,353	23,444	24,428	26,713	28,741	31,560	33,889	37,303	38,955	41,997	45,114	45,313
2,101	2,409	2,493	2,603	2,840	3,027	3,365	3,715	3,981	4,380	4,722	4,736	5,768
4,791	5,022	5,256	5,755	6,179	6,799	8,094	8,525	10,071	11,112	13,220	14,504	16,458
5,050	5,509	5,482	5,769	6,258	6,558	7,487	8,633	9,866	11,075	12,358	14,130	13,939
+1,131	+1,504	−1,243	−982	−830	−521	−424	−1,130	−1,162	−499	−107	−751	+1,297
3,075	3,504	3,359	3,427	3,819	4,188	4,819	5,199	5,145	5,020	5,877	6,530	5,956
8,488	8,500	8,328	8,292	8,769	9,398	10,980	12,935	15,088	15,348	15,455	16,927	17,640
8,634	8,568	8,281	8,292	8,632	9,020	10,253	11,515	12,820	12,993	12,880	13,560	13,718
17,080	17,483	17,870	18,238	18,583	18,931	19,290	19,644	20,015	20,405	20,744	21,061	21,377
6,137	6,242	6,411	6,521	6,615	6,748	6,933	7,141	7,420	7,694	7,919	8,162	8,374
5,706	5,870	5,965	6,055	6,225	6,375	6,609	6,862	7,152	7,379	7,537	7,780	7,879
432	372	446	466	390	374	324	280	267	315	382	382	495
7.0	6.0	7.0	7.1	5.9	5.5	4.7	3.9	3.6	4.1	4.8	4.7	5.9
100.4	102.2	100.7	100.0	102.2	104.4	108.2	114.3	120.7	122.6	122.7	126.9	126.9
16,180	18,309	19,303	20,136	21,597	23,057	25,219	28,181	31,907	35,275	38,493	43,203	47,036
86.7	94.2	96.2	100.0	109.5	116.5	128.1	139.1	148.9	151.7	159.8	166.6	170.2
88.0	94.5	96.1	100.0	110.5	118.0	129.2	141.0	151.2	151.7	159.4	168.4	167.3
86.0	97.3	97.4	100.0	104.8	110.6	124.9	131.6	136.5	145.2	152.7	149.5	173.4
91.0	95.7	98.0	100.0	106.9	112.7	120.4	129.0	138.0	142.4	149.3	156.2	160.7
227.8	230.6	230.9	233.3	240.0	244.6	245.4	250.3	259.5	264.1	269.9	282.4	286.4
96.8	97.9	99.1	100.0	101.2	103.0	104.8	107.4	111.4	115.4	120.1	125.5	129.7

TABLE 1

Canada – Value of Mineral Production, Per Capita Values of Mineral Production and Population 1930-1970

	Metallics $ million	Industrial Minerals $ million	Fuels $ million	Total $ million	Per Capita Value of Mineral Production $	Population of Canada 000
1930	143	69	68	280	27.42	10,208
1931	121	55	54	230	22.21	10,376
1932	112	30	49	191	18.20	10,510
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	770	2,840	152.85	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	1,234	4,380	214.66	20,405
1968	2,493	886	1,343	4,722	227.62	20,744
1969	2,378	893	1,466	4,737	224.89	21,061
1970P	3,115	935	1,736	5,786	270.68	21,377

PPreliminary.

TABLE 2

Canada – Mineral Production, 1969 and 1970 and Average 1966-1970

	Unit of Measure	1969		1970P		Average 1966-1970	
		Quantity	$000	Quantity	$000	Quantity	$000
Metals							
Antimony	000 lb	820	508	716	1,131	1,074	734
Bismuth	"	579	2,530	571	3,253	598	2,426
Cadmium	"	5,213	18,350	4,246	16,059	4,509	14,119
Calcium	"	943	954	400	338	521	505
Cobalt	"	3,256	6,851	5,229	11,893	3,926	8,378
Columbium (Cb_2O_5)	"	3,414	3,173	4,919	5,304	3,062	3,220
Copper	000 st	573	588,281	674	782,490	600	602,965
Gold	000 troy oz	2,545	95,925	2,358	86,218	2,790	104,698
Iron ore	000 lt	35,763	454,076	47,509	589,126	39,949	495,536
Iron remelt	000 st	. .	26,643	. .	29,975	. .	22,929
Lead	"	319	96,673	383	121,247	333	97,643
Magnesium	000 lb	21,275	7,264	19,167	6,478	18,304	5,951
Molybdenum	"	29,651	53,387	35,354	62,625	25,888	45,181
Nickel	000 st	214	481,055	308	829,644	252	535,911
Platinum group	000 troy oz	310	30,881	461	42,696	411	37,363
Selenium	000 lb	599	3,429	604	5,161	628	3,595
Silver	000 troy oz	45,531	84,015	44,283	81,923	40,512	75,940
Tantalum	000 lb	130	938	315	2,200	91	628
Tellurium	"	62	401	59	356	67	432
Thorium	"	29	55	–	–	74	148
Tin	"	288	470	281	531	415	608
Uranium	"	7,708	53,151	8,021	50,237	7,694	52,606
Yttrium	"	85	671	73	657	93	798
Zinc	000 st	1,208	367,842	1,211	385,920	1,131	338,794
Total metals		. .	2,377,523	. .	3,115,462	. .	2,451,108
Nonmetals							
Arsenious oxide	000 lb	340	34	200	20	537	37
Asbestos	000 st	1,611	195,211	1,654	215,270	1,560	184,856
Barite	"	143	1,380	131	1,465	161	1,576
Diatomite	"	. .	. .	. .	. .	118	4
Feldspar	"	12	301	11	311	11	271
Fluorspar	"	. .	3,037	. .	4,185	. .	2,764
Gemstones	000 lb	28	45	28	45	29	49
Grindstone	000 st	–	–	–	–	3	1
Gypsum	"	6,374	14,995	6,442	14,956	5,979	13,087
Iron oxide	"	–	–	–	–	211	9
Lithia	000 lb	–	–	–	–	138	105
Magnesite dolomite and brucite	000 st	. .	3,209	. .	3,600	. .	3,464
Mica	"	–	–	–	–	108	4
Nepheline	"	501	5,935	491	6,147	438	5,137
Peat Moss	"	330	9,562	317	9,410	302	8,565
Potash (K_2O)	"	3,492	69,382	3,424	116,402	2,842	76,193
Pyrite pyrophyllite	"	376	2,219	326	1,849	344	1,839
Quartz	"	2,300	6,280	2,902	8,610	2,534	6,328
Salt	"	4,658	30,406	5,052	34,248	4,740	29,496
Soapstone, talc, pyrophyllite	"	76	1,098	75	1,183	73	1,060

TABLE 2 (Cont'd)

	Unit of Measure	1969		1970p		Average 1966-1970	
		Quantity	$000	Quantity	$000	Quantity	$000
Nonmetals (Cont'd)							
Sodium sulphate	"	518	8,052	478	7,611	458	7,115
Sulphur in smelter gas	"	676	7,953	709	7,282	629	7,477
Sulphur, elemental	"	2,974	60,726	3,780	30,711	2,775	56,054
Titanium dioxide, etc.	"	..	30,364	..	34,470	..	27,418
Total nonmetals		..	450,189	..	497,775	..	432,909
Fuels							
Coal	000 st	10,672	50,578	16,604	86,273	12,117	65,824
Natural gas	000 mcf	1,977,838	262,856	2,276,579	347,669	1,752,057	242,392
Natural gas byproducts	000 bbl	66,725	137,919	77,595	159,583	61,106	127,903
Petroleum crude	"	410,990	1,014,571	461,207	1,142,755	384,686	949,982
Total fuels		..	1,465,924	..	1,736,280	..	1,386,101
Structural materials							
Clay products	$000	..	51,166	..	44,059	..	46,252
Cement	000 st	8,250	162,091	8,065	160,440	8,281	154,038
Lime	"	1,635	19,239	1,626	19,019	1,539	18,128
Sand and gravel	"	201,581	122,159	194,100	117,400	206,680	133,568
Stone	"	67,477	88,186	70,700	95,850	78,786	98,910
Total structural materials		..	442,841	..	436,768	..	450,896
Total all minerals		..	4,736,477	..	5,786,285	..	4,721,014

pPreliminary; – Nil; .. Not available or not applicable.
[1] There was no production of mica after 1966, and grindstones, iron oxide and lithia after 1967. [2] The data for indium, mercury, tungsten, helium and nitrogen from 1966 to 1970 are not available for publication.

TABLE 3

Canada—Value of Mineral Production by Provinces and Mineral Classes, 1970P

	Metals		Industrial Minerals		Fuels		Total	
	$000	% of Total	$000	% of Total	$000	% of Total	$000	% of Total
Ontario	1,392,104	44.7	230,328	24.6	9,311	0.5	1,631,743	28.2
Alberta	3	–	69,332	7.4	1,341,522	77.3	1,410,857	24.4
Quebec	479,772	15.4	318,768	34.1	25	–	798,565	13.8
British Columbia	302,428	9.7	70,103	7.5	124,605	7.2	497,136	8.6
Saskatchewan	37,169	1.2	135,725	14.5	219,593	12.6	392,487	6.8
Newfoundland	333,082	10.7	25,268	2.7	–	–	358,350	6.2
Manitoba	293,693	9.4	23,262	2.5	14,864	0.8	331,819	5.7
Northwest Territories	124,004	3.9	–	–	1,055	0.1	125.059	2.2
New Brunswick	88,162	2.8	9,968	1.1	3,094	0.2	101,224	1.7
Yukon	64,470	2.1	15,172	1.6	–	–	79,642	1.4
Nova Scotia	575	0.1	36,117	3.9	22,211	1.3	58,903	1.0
Prince Edward Island	–	–	500	0.1	–	–	500	–
Total	3,115,462	100.0	934,543	100.0	1,736,280	100.0	5,786,285	100.0

PPreliminary; – Nil.

TABLE 4

Canada – Production of Leading Minerals

	Unit of Measure	Nfld.	P.E.I.	N.S.	N.B.	Quebec	Ontario
Petroleum	bbl	–	–	–	9,303	–	1,048,168
	$	–	–	–	12,094	–	2,812,830
Nickel	st	–	–	–	–	829	227,988
	$	–	–	–	–	2,288,000	611,532,800
Copper	st	15,411	–	27	7,933	173,534	291,904
	$	17,898,600	–	31,400	9,213,100	201,542,000	339,022,800
Iron ore	st	24,885,300	–	–	–	14,648,800	11,752,100
	$	296,734,000	–	–	–	131,319,000	144,279,000
Zinc	st	32,126	–	–	156,487	197,969	331,471
	$	10,235,300	–	–	49,856,800	63,073,100	105,606,700
Natural gas	mcf	–	–	–	131,160	165,825	17,081,414
	$	–	–	–	117,354	24,676	6,498,554
Asbestos	st	66,000	–	–	–	1,353,000	38,000
	$	12,373,000	–	–	–	165,454,000	4,961,000
Cement	st	..	–	..	..	2,020,000	3,523,000
	$	2,803,000	–	4,220,000	2,900,000	39,325,000	63,480,000
Lead	st	20,215	–	1,299	62,130	2,109	10,260
	$	6,395,900	–	411,000	19,658,000	667,100	3,246,200
Sand and gravel	st	3,500,000	900,000	9,000,000	7,000,000	35,000,000	85,000,000
	$	3,200,000	500,000	8,500,000	1,900,000	13,500,000	48,400,000
Potash (K_2O)	st	–	–	–	–	–	–
	$	–	–	–	–	–	–
Stone	st	200,000	–	1,250,000	1,200,000	31,500,000	30,000,000
	$	350,000	–	2,500,000	2,200,000	40,000,000	39,000,000
Gold	oz	7,300	–	–	4,920	684,800	1,143,920
	$	266,960	–	–	179,920	25,043,140	41,833,150
Silver	oz	838,560	–	71,670	4,523,840	5,259,000	19,355,700
	$	1,551,340	–	132,590	8,369,100	9,729,150	35,808,050
Coal	st	–	–	2,121,856	395,642	–	–
	$	–	–	22,211,298	2,964,478	–	–
Molybdenum	lb	–	–	–	–	2,493,000	–
	$	–	–	–	–	4,553,000	–
Uranium (U_3O_8)	lb	–	–	–	–	–	–
	$	–	–	–	–	–	40,687,000
Clay products	$	47,000	–	1,570,000	500,000	6,868,000	25,989,000
Platinum metals	oz	–	–	–	–	–	461,200
	$	–	–	–	–	–	42,696,500
Titanium dioxide	st	–	–	–	–	..	–
	$	–	–	–	–	34,470,000	–
Salt	st	–	–	582,000	–	–	3,958,000
	$	–	–	7,300,000	–	–	21,366,000
Sulphur elemental	st	–	–	–	–	–	3,100
	$	–	–	–	–	–	28,200
Lime	st	7,000	–	–	–	357,000	1,133,000
	$	70,000	–	–	–	4,123,000	12,397,000
Cadmium	lb	–	–	–	170,800	275,500	2,321,000
	$	–	–	–	642,200	1,078,000	8,778,000
Gypsum	st	550,000	–	4,856,000	69,000	–	553,000
	$	1,520,000	–	10,800,000	117,000	–	1,371,000
Total leading minerals	$	353,445,100	500,000	57,676,288	98,630,046	743,057,166	1,599,793,784
Total all minerals	$	358,350,100	500,000	58,903,288	101,223,346	798,565,066	1,631,742,884
Leading minerals as % of all minerals		100	100	98	97	93	98

PPreliminary; – Nil; .. Not available.

by Provinces and Territories, 1970[p]

Manitoba	Sask.	Alberta	B.C.	Y.T.	N.W.T.	Total Canada
5,910,108	89,511,262	338,403,241	25,478,973	–	846,003	461,207,058
14,863,684	201,337,412	864,139,002	58,568,435	–	1,021,170	1,142,754,627
78,074	–	–	1,150	–	–	308,041
212,649,000	–	–	3,174,000	–	–	829,643,800
51,446	15,549	–	109,647	7,750	544	673,748
59,748,800	18,058,000	–	127,343,700	9,000,800	631,100	782,490,300
–	–	–	1,923,600	–	–	53,209,800
–	–	–	16,794,000	–	–	589,126,000
39,526	21,155	–	129,577	77,988	225,000	1,211,299
12,592,800	6,739,800	–	41,283,200	24,846,900	71,685,000	385,919,600
–	62,046,483	1,870,507,110	326,564,797	–	81,939	2,276,578,728
–	8,182,855	296,425,322	36,386,719	–	33,740	347,669,220
–	–	–	89,000	108,000	–	1,654,000
–	–	–	17,309,000	15,173,000	–	215,270,000
443,000	142,000	894,000	558,000	–	–	8,065,000
10,244,000	4,153,000	20,165,000	13,150,000	–	–	160,440,000
541	–	–	107,917	68,737	110,000	383,208
171,100	–	–	34,145,100	21,748,500	34,804,000	121,246,900
9,500,000	7,700,000	14,000,000	22,500,000	–	–	194,100,000
6,500,000	3,400,000	10,000,000	21,500,000	–	–	117,400,000
–	3,424,000	–	–	–	–	3,424,000
–	116,402,000	–	–	–	–	116,402,000
1,900,000	–	400,000	4,250,000	–	–	70,700,000
3,200,000	–	1,200,000	7,400,000	–	–	95,850,000
45,200	32,250	70	99,200	20,400	319,560	2,357,620
1,652,960	1,179,380	2,560	3,627,740	746,000	11,686,310	86,218,120
682,300	435,500	10	6,326,100	4,265,000	2,525,000	44,282,680
1,262,260	805,680	20	11,703,290	7,890,250	4,671,250	81,922,980
–	3,819,191	6,783,911	3,483,062	–	–	16,603,662
–	7,399,872	27,618,455	26,078,742	–	–	86,272,845
–	–	–	32,860,500	–	–	35,353,500
–	–	–	58,072,000	–	–	62,625,000
–	–	–	–	–	–	8,021,000
–	9,550,000	–	–	–	–	50,237,000
430,000	1,340,000	3,400,000	3,915,000	–	–	44,059,000
–	–	–	–	–	–	461,200
–	–	–	–	–	–	42,696,500
–	–	–	–	–	–	..
–	–	–	–	–	–	34,470,000
25,000	237,000	250,000	–	–	–	5,052,000
185,000	3,358,000	2,039,000	–	–	–	34,248,000
7,100	32,000	3,625,210	112,440	–	–	3,779,850
63,000	390,500	29,255,900	973,200	–	–	30,710,800
41,000	–	88,000	–	–	–	1,626,000
656,000	–	1,773,000	–	–	–	19,019,000
184,500	91,400	–	1,000,000	63,000	140,000	4,246,200
693,700	343,700	–	3,760,000	236,900	526,400	16,058,900
149,000	–	–	265,000	–	–	6,442,000
418,000	–	–	730,000	–	–	14,956,000
325,330,304	382,640,199	1,256,018,259	485,914,126	79,642,350	125,058,970	5,507,706,592
331,818,504	392,486,799	1,410,857,259	497,136,326	79,642,350	125,058,970	5,786,284,892
98	97	89	98	100	100	95

TABLE 5

Canada–Percentage Contribution of Leading Minerals
to Total Value of Mineral Production, 1961-1970

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970P
Petroleum	19.6	19.8	20.9	20.0	19.4	19.8	19.8	19.8	21.4	19.7
Nickel	13.4	13.6	11.9	11.2	11.6	9.5	10.6	11.1	10.2	14.3
Copper	9.8	9.9	9.3	9.6	10.3	11.4	13.3	12.8	12.4	13.5
Iron ore	7.2	9.2	10.3	12.0	11.1	10.8	10.7	11.2	9.6	10.2
Zinc	4.0	3.9	4.0	5.7	6.7	7.3	7.3	6.9	7.8	6.7
Natural gas	2.8	3.6	4.1	4.3	4.3	4.4	4.5	4.7	5.5	6.0
Asbestos	4.9	4.5	4.5	4.3	3.9	4.1	3.7	4.0	4.1	3.7
Cement	3.9	3.9	3.9	3.8	3.8	3.9	3.3	3.1	3.4	2.8
Lead	1.7	1.5	1.5	1.6	2.4	2.3	2.0	1.9	2.0	2.1
Sand and gravel	4.1	4.1	4.1	3.7	3.6	3.8	3.3	2.7	2.6	2.0
Potash (K_2O)	–	0.1	0.7	0.9	1.5	1.6	1.5	1.8	1.5	2.0
Stone	2.6	2.4	2.6	2.5	2.6	2.7	2.3	2.0	1.9	1.7
Gold	6.0	5.5	5.0	4.3	3.6	3.1	2.5	2.1	2.0	1.5
Silver	1.3	1.2	1.4	1.2	1.2	1.2	1.4	2.2	1.8	1.4
Coal	2.8	2.4	2.4	2.2	2.1	2.1	1.3	1.1	1.1	1.5
Molybdenum	0.04	0.04	0.04	0.06	0.5	0.9	0.9	0.8	1.1	1.1
Uranium (U_3O_8)	7.5	5.5	4.5	2.5	1.7	1.4	1.2	1.1	1.1	0.9
Clay products	1.4	1.3	1.3	1.2	1.2	1.1	1.0	1.0	1.1	0.8
Platinum metals	0.9	1.0	0.7	0.8	0.9	0.8	0.8	0.9	0.7	0.7
Titanium dioxide	0.6	0.4	0.5	0.6	0.6	0.6	0.5	0.6	0.6	0.6
Salt	0.8	0.8	0.7	0.7	0.6	0.6	0.6	0.7	0.6	0.6
Sulphur elemental	0.4	0.3	0.4	0.6	0.7	1.0	1.6	1.7	1.3	0.5
Lime	0.8	0.6	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.3
Cadmium	0.2	0.2	0.2	0.3	0.1	0.2	0.3	0.3	0.4	0.3
Gypsum	0.4	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Other minerals	2.9	4.0	4.1	5.1	4.8	4.7	4.9	4.8	5.1	4.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

PPreliminary; – Nil.

TABLE 6

Canada–Value of Mineral Production by Provinces, 1961-1970
($ millions)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970P
Ontario	944	913	874	904	994	958	1,195	1,356	1,223	1,632
Alberta	496	556	644	709	762	849	974	1,092	1,205	1,411
Quebec	456	519	541	685	716	771	741	725	717	799
British Columbia	188	234	260	269	280	331	380	389	435	497
Saskatchewan	215	242	274	293	329	349	362	357	345	392
Newfoundland	91	102	138	182	208	244	266	310	257	358
Manitoba	101	159	170	174	182	179	185	210	247	332
Northwest Territories	18	18	15	18	77	111	118	116	119	125
New Brunswick	19	22	29	49	83	90	90	88	95	101
Yukon	12	13	14	15	13	12	15	21	35	80
Nova Scotia	62	61	67	66	71	86	53	57	59	59
Prince Edward Island	1	1	1	1	–	1	1	1	–	–
Total	2,603	2,840	3,027	3,365	3,715	3,981	4,380	4,722	4,737	5,786

PPreliminary; –Nil.

TABLE 7

Canada–Percentage Contribution of Provinces to Total Value of Mineral Production, 1961-1970

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970p
Ontario	36.3	32.2	28.9	26.9	26.8	24.1	27.3	28.7	25.8	28.2
Alberta	19.0	19.6	21.3	21.1	20.5	21.3	22.2	23.1	25.4	24.4
Quebec	17.5	18.3	17.9	20.3	19.3	19.4	16.9	15.4	15.2	13.8
British Columbia	7.2	8.2	8.6	8.0	7.5	8.3	8.7	8.2	9.2	8.6
Saskatchewan	8.3	8.5	9.0	8.7	8.9	8.7	8.3	7.6	7.3	6.8
Newfoundland	3.5	3.6	4.6	5.4	5.6	6.1	6.1	6.6	5.4	6.2
Manitoba	3.9	5.5	5.6	5.2	4.9	4.5	4.2	4.4	5.2	5.7
Northwest Territories	0.7	0.6	0.5	0.5	2.1	2.8	2.7	2.4	2.5	2.2
New Brunswick	0.7	0.8	0.9	1.4	2.2	2.3	2.1	1.9	2.0	1.7
Yukon	0.5	0.5	0.5	0.5	0.3	0.3	0.3	0.5	0.8	1.4
Nova Scotia	2.4	2.2	2.2	2.0	1.9	2.2	1.2	1.2	1.2	1.0
Prince Edward Island	0.02	0.02	0.03	0.02	0.02	0.02	0.04	0.02	0.01	0.01
Total Canada	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

	Year		World Production	1
				Canada
Nickel (mine production)	1969	st	530,911	213,325
		% of world total		40
				Canada
Zinc (mine production)	1969	st	5,398,257	1,199,889
		% of world total		22
				Canada
Asbestos	1968	st	3,376,624	1,595,951
		% of world total		47
				Canada
Silver (mine production)	1969	000 troy oz	290,203	43,531
		% of world total		15
				USSR
Potash (K_2O equivalent)	1969	000 st	18,657	3,505
		% of world total		19
				U.S.A.
Uranium (U_3O_8 concentrates) (excludes communist countries)	1969	st	21,261	10,934
		% of world total		51
				U.S.A.
Molybdenum (excludes communist countries)	1969	st	71,080	49,903
		% of world total		70.2
				U.S.A.
Gypsum	1969	000 st	54,697	9,881
		% of world total		18
				U.S.A.
Elemental sulphur	1969	000 st	22,004	9,588
		% of world total		44
				U.S.A.
Titanium concentrate (ilmenite)	1969	st	3,530,745	931,247
		% of world total		26
				U.S.A.
Aluminum (primary metal)	1969	st	10,133,885	3,793,062
		% of world total		37
				USSR
Platinum group metals (mine production)	1969	troy oz	3,431,155	2,100,000
		% of world total		61
				Rep. of S. Africa
Gold (mine production)	1969	troy oz	46,540,088	31,275,882
		% of world total		67
				U.S.A.
Cadmium (smelter production)	1969	000 pounds	40,700	12,646
		% of world total		34
				USSR
Lead (mine production)	1969	st	3,543,877	550,000
		% of world total		16
				U.S.A.
Magnesium	1969	st	220,500	99,886
		% of world total		45
				USSR
Iron ore	1969	000 lt	696,383	183,063
		% of world total		26
				U.S.A.
Copper (mine production)	1969	st	6,396,902	1,535,035
		% of world total		24

[e]Estimated.

of Certain Important Minerals, 1969

Rank of Six Leading Countries with % of World Total				
2	3	4	5	6
USSR	New Caledonia	Cuba	U.S.A.	Rep. of S. Africa
120,000	99,699	40,000	15,125	7,000
23	19	8	3	1
USSR	U.S.A.	Australia	Peru	Japan
585,000	544,131	428,831	347,225	297,485
11	10	8	6	5
USSR	Rep. of S. Africa	China	U.S.A.	Italy
881,848	260,530	165,000	120,690	114,020
26	8	5	4	3
Mexico	U.S.A.	USSR	Peru	Australia
42,904	41,906	37,000	34,147	24,667
15	14	13	12	9
Canada	W. Germany	U.S.A.	E. Germany	France
3,492	2,853	2,804	2,535	2,134
19	15	15	14	11
Canada	Rep. of S. Africa	Australia	Portugal	Sweden
3,854	3,610	330	105	77
18	17	2	0.5	0.3
Canada	Chile	Norway	Japan	Peru
14,825	5,337	330	296	185
20.9	7.5	0.5	0.4	0.3
Canada	France	U.K.	USSR	Spain
6,374	5,622[e]	5,291[e]	5,181[e]	4,409[e]
12	10	9	9	8
Canada	Mexico	France	USSR	Japan
2,974	1,892	1,869	1,763	382
14	9	9	8	2
Australia	**Canada**	Norway	Finland	Malaysia
785,065	749,281	540,903	152,339	143,300
22	21	15	4	4
USSR	**Canada**	Japan	Norway	France
1,400,000	1,078,647	627,000	564,039	409,707
14	11	6	6	4
Rep. of S. Africa	**Canada**	Columbia	U.S.A.	Japan
964,000	310,404	27,805	21,586	7,017
28	9	1	0.6	0.2
USSR	**Canada**	U.S.A.	Australia	Ghana
6,250,000[e]	2,545,109	1,733,176	716,089	706,621
14	6	4	2	2
Japan	USSR	**Canada**	Belgium	W. Germany
6,096	5,070	5,213	1,874	1,746
16	14	13	5	5
U.S.A.	Australia	**Canada**	Mexico	Peru
501,861	466,977	330,781	188,376	177,250
14	13	9	5	5
USSR	Norway	**Canada**	Japan	Italy
45,000	38,720	10,485	10,342	7,092
20	18	5	5	3
U.S.A.	France	Australia	**Canada**	China
89,241	55,129	37,892	35,763	32,479
13	8	5	5	4
USSR	Zambia	Chile	**Canada**	Rep. of Congo
940,000	793,068	757,089	573,245	362,216
15	12	12	9	6

TABLE 9

Canada–Census Value Added, Commodity Producing Industries
1963-1968
($ millions)

	1963	1964	1965	1966	1967	1968
Primary industries						
Agriculture	2,610	2,407	2,635	3,298	2,693	2,864
Forestry	492	556	603	673	685	725
Fishing	130	149	160	176	164	186
Trapping	12	13	12	14	10	12
Mining*	2,023	2,291	2,476	2,613	2,918	3,159
Electric power	912	970	1,036	1,132	1,234	1,360
Total	6,179	6,386	6,922	7,906	7,704	8,306
Secondary industries						
Manufacturing	12,273	13,536	14,928	16,352	17,006	18,252
Construction	3,066	3,391	3,987	4,843	5,148	5,269
Total	15,339	16,927	18,915	21,195	22,154	23,521
Grand Total	21,518	23,313	25,837	29,101	29,858	31,827

Note: Data conforms with revised Canadian Standard Industrial Classification and new establishment concept.
*Excludes Cement, Lime and Clay and Clay Products (from domestic clays) manufacture. These industries in the above tables are included under Manufacturing.

TABLE 10

Canada–Census Values Added, Mining and Mineral Manufacturing
1964-68
($000)

	1964	1965	1966	1967	1968
Mining					
Metallic					
Placer gold	1,706	1,355	1,339	257	264
Gold quartz	100,025	94,529	93,028	85,352	78,032
Copper-gold-silver	177,662	207,118	277,015	357,488	377,800
Silver-cobalt	5,532	4,991	5,715	6,870	7,645
Silver-lead-zinc	138,616	177,317	158,242	138,912	150,565
Nickel-copper	366,082	386,247	314,102	377,487	437,372
Iron	240,079	243,281	250,393	289,595	339,402
Misc. metal mines	63,972	61,845	78,266	78,437	72,306
Total	1,093,674	1,176,683	1,178,100	1,334,398	1,463,386
Industrial Minerals					
Asbestos	120,982	118,896	134,694	136,918	143,591
Feldspar, quartz nepheline	5,773	6,202	6,217	6,784	7,368
Gypsum	7,847	7,858	7,553	7,968	9,277
Peat	6,711	7,023	6,428	7,898	8,857
Salt	17,834	18,251	17,800	21,087	23,484
Sand and gravel	30,175	38,702	38,690	37,182	40,286
Stone	46,049	45,244	48,085	43,428	44,339
Talc soapstone	725	702	748	640	824
Misc. nonmetals	38,165	59,542	61,430	64,268	60,450
Total	274,261	302,419	321,645	326,173	338,476
Fuels					
Coal	55,250	56,475	62,722	73,280	48,988
Petroleum and natural gas	867,871	940,331	1,050,424	1,183,818	1,307,995
Total	923,121	996,806	1,113,146	1,257,098	1,356,983
Total Mining Industry	2,291,056	2,475,908	2,612,891	2,917,669	3,158,845
Mineral Manufacturing					
Primary Metal Industries					
Iron and steel mills	561,049	646,100	648,228	617,092	684,684
Steel pipe and tube mills	57,335	58,232	60,996	56,820	73,844
Iron foundries	74,775	93,622	117,780	108,944	106,610
Smelting and refining	350,699	407,272	416,058	448,124	477,763
Aluminum rolling, casting and extruding	20,905	43,914	41,499	58,410	66,496
Copper and alloy rolling, casting and extruding	40,031	42,443	59,903	51,968	59,105
Metal rolling, casting and extruding, n.e.s.	31,701	41,340	42,739	42,251	46,365
Total	1,136,495	1,332,923	1,387,203	1,383,609	1,514,867
Nonmetallic Mineral Products Industries					
Cement manufacturers	95,402	104,081	111,048	100,496	107,088
Lime manufacturers	10,473	10,791	8,825	7,769	8,573
Gypsum products manufacturers	23,321	24,765	25,036	27,460	32,079
Concrete products manufacturers	90,301	106,130	118,548	116,742	122,789
Ready-mix concrete manufacturers	65,003	81,086	107,035	92,273	106,314
Clay products (domestic clay)	28,324	31,095	30,494	30,906	33,996
Clay products (imported clay)	18,845	21,272	23,814	23,195	24,652
Refractories manufacturers	12,788	14,324	14,895	16,132	16,924

TABLE 10 (Cont'd)

	1964	1965	1966	1967	1968
Mineral Manufacturing (Cont'd)					
Nonmetallic Mineral Products Industries (Cont'd)					
Stone products manufacturers	8,030	8,506	7,080	6,435	6,278
Mineral wool manufacturers	14,924	17,103	18,959	20,540	21,808
Asbestos products manufacturers	24,875	27,188	29,260	23,811	29,359
Glass manufacturers	54,400	56,779	63,651	71,631	93,692
Glass products manufacturers	31,676	38,518	37,471	40,175	43,396
Abrasives manufacturers	26,280	30,264	31,020	28,830	29,198
Other nonmetallic mineral products industries	8,289	8,252	8,487	8,914	9,895
Total	512,931	580,154	635,623	615,309	686,041
Petroleum and coal products industries					
Petroleum refining	264,204	244,108	253,291	270,086	307,298
Manufacturers of lubricating oils and greases	11,910	13,479	14,645	14,338	13,635
Other petroleum and coal products industries	10,608	7,701	8,532	8,367	8,484
Total	286,722	265,288	276,468	292,791	329,417
Total Mineral Manufacturing	1,936,148	2,178,364 5	2,299,292 4	2,291,709	~~2,529,563~~ 2,530,325 R
Total Mining and Mineral Manufacturing	4,227,204	4,654,272	4,912,183	5,209,378	~~5,688,408~~ 5,689,170 R

R - revised

TABLE 11

Canada–Indexes of Physical Volume of Total Industrial Production, Mining and Mineral Manufacturing
1955 - 1970
(1961 = 100)

	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970p
Total Industrial Production	77.7	85.8	87.2	86.7	94.2	96.2	100.0	108.3	115.2	126.6	137.0	146.0	150.8	159.7	166.6	170.4
Total Mining	66.4	77.1	84.6	86.0	97.3	97.4	100.0	106.2	112.1	126.0	131.9	134.2	142.1	150.0	149.5	173.4
Metals																
All metals	66.8	72.7	85.5	95.5	110.0	107.3	100.0	102.2	104.1	120.2	122.8	121.1	129.3	134.7	121.2	145.6
Placer gold and gold quartz mines	102.7	98.4	100.0	104.1	102.2	104.4	100.0	95.1	91.4	90.1	87.4	82.2	73.6	66.1	58.9	55.0
Iron mines	72.7	93.0	97.4	70.7	105.2	103.6	100.0	139.3	170.4	208.6	224.8	241.5	260.7	291.3	248.3	316.5
Miscellaneous metal mines, n.e.s.	..	..	..	..	..	..	100.0	102.1	100.4	125.1	136.9	131.3	143.1	148.8	135.2	122.6
Fuels																
All fuels	63.0	80.0	83.1	76.5	84.1	87.1	100.0	114.3	123.0	133.0	142.0	152.4	166.1	180.1	197.5	232.7
Coal	148.5	149.5	131.1	113.8	103.8	107.0	100.0	97.9	104.5	109.8	111.9	103.7	103.1	93.8	90.6	140.7
Crude petroleum and natural gas	..	..	..	..	..	..	100.0	117.3	126.3	137.2	147.4	161.2	177.5	195.7	216.8	249.3
Nonmetals																
All nonmetals	84.0	88.6	84.8	80.3	92.0	91.5	100.0	108.7	121.4	139.2	151.5	164.2	173.6	180.5	202.4	213.5
Asbestos	86.3	86.4	83.8	79.8	86.4	90.3	100.0	103.2	109.0	121.9	118.2	127.7	125.6	120.2	132.7	147.3
Mineral Manufacturing																
Primary metals	..	..	..	..	..	..	100.0	105.5	114.3	128.4	140.4	146.1	141.1	161.0	159.7	170.2
Nonmetallic mineral products	76.5	86.7	88.4	91.8	99.0	95.8	100.0	115.0	116.7	128.0	139.3	144.9	135.4	147.5	148.1	140.1
Petroleum and coal products	68.1	79.7	81.5	82.3	90.2	94.1	100.0	108.7	117.2	118.5	124.4	129.1	130.5	135.9	138.9	146.7

p Preliminary: .. Not available.

TABLE 12

Canada–Indexes of Real Domestic Product* by Industries 1961-1970
(1961=100)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970p
Real domestic product, all industries	100.0	106.9	112.7	120.4	129.0	138.0	142.4	149.3	156.2	160.7
Agriculture	100.0	122.0	136.9	123.9	127.6	145.9	118.6	125.1	131.0	124.1
Forestry	100.0	106.4	108.3	119.2	122.5	132.7	130.3	131.2	136.8	144.5
Fishing and trapping	100.0	106.9	106.4	108.9	106.6	118.2	112.1	126.1	112.8	112.9
Mining (including milling) quarries and oil wells	100.0	106.2	112.1	126.0	131.9	134.2	142.1	150.0	149.5	173.4
Electric power, gas and water utilities	100.0	105.3	111.6	120.8	129.9	141.4	151.2	162.8	177.9	191.8
Manufacturing	100.0	109.0	116.2	127.4	138.8	148.7	152.3	161.1	168.4	167.3
Construction	100.0	105.6	107.1	117.4	131.6	141.7	141.2	150.6	154.2	149.8
Transportation, storage and communication	100.0	104.1	111.1	120.3	127.6	138.0	145.3	153.0	161.7	171.8
Trade	100.0	106.1	111.2	119.5	129.4	137.6	144.7	150.7	157.9	160.4
Community, business and personal service	100.0	105.4	110.9	119.0	128.8	140.4	150.4	156.9	166.3	174.6
Finance, insurance and real estate	100.0	105.5	110.5	115.0	120.8	125.6	131.4	135.6	143.2	150.5
Public administration and defence	100.0	103.1	104.0	106.3	108.3	112.2	118.2	121.0	123.4	129.3

*Includes physical volume indexes for commodity producing industries.
pPreliminary.

TABLE 13

Canada–Exports of Crude Minerals and Fabricated Mineral Products, by Main Groups, 1966-1970
($ millions)

	1966	1967	1968	1969	1970
Ferrous					
Crude material	379.1	398.2	458.3	363.5	508.9
Fabricated material	273.8	286.0	384.9	352.9	487.3
Total	652.9	684.2	843.2	716.4	996.2
Nonferrous					
Crude material	555.0	617.7	803.9	775.2	993.8
Fabricated material*	1,040.3	1,170.0	1,297.5	1,286.2	1,689.7
Total	1,595.3	1,787.7	2,101.4	2,061.4	2,683.5
Nonmetals					
Crude material	259.4	274.7	320.7	336.7	331.9
Fabricated material	142.4	146.1	166.2	178.5	221.1
Total	401.8	420.8	486.9	515.2	553.0
Mineral fuels					
Crude material	444.2	537.1	621.2	711.7	884.6
Fabricated material	28.7	39.6	50.4	58.9	85.1
Total	472.9	576.7	671.6	770.6	969.7
Total mineral and products					
Crude material	1,637.7	1,827.7	2,204.1	2,187.1	2,719.2
Fabricated material	1,485.2	1,641.7	1,899.0	1,876.5	2,483.2
Total	3,122.9	3,469.4	4,103.1	4,063.6	5,202.4

*Includes gold, refined and unrefined.

TABLE 14

Canada–Value of Imports of Crude Minerals and Fabricated Mineral Products, by Main Groups, 1966-1970
($ millions)

	1966	1967	1968	1969	1970
Ferrous					
Crude material	77.0	48.0	48.7	47.5	54.4
Fabricated material	491.2	551.0	537.1	723.6	711.2
Total	568.2	599.0	585.8	771.1	765.6
Nonferrous*					
Crude material	123.0	131.9	172.5	145.7	188.9
Fabricated material	281.8	269.0	298.2	328.2	275.0
Total	404.8	400.9	470.7	473.9	463.9
Nonmetals					
Crude materials	63.4	66.2	63.6	63.8	63.7
Fabricated material	152.3	149.3	141.2	165.6	166.6
Total	215.7	215.5	204.8	229.4	230.3
Mineral fuels					
Crude material	458.1	521.8	568.8	493.6	571.4
Fabricated material	176.7	198.4	216.0	223.5	205.7
Total	634.8	720.2	784.8	717.1	777.1
Total minerals and products					
Crude material	721.5	767.9	853.6	750.6	878.4
Fabricated material	1,102.0	1,167.7	1,192.5	1,440.9	1,358.5
Total	1,823.5	1,935.6	2,046.1	2,191.5	2,236.9

*Includes gold, refined and unrefined.

TABLE 15

Canada–Value of Exports of Crude Minerals and Fabricated Mineral Products in Relation to Total Export Trade, 1966-1970

	1966		1967		1968		1969		1970	
	$ Millions	% of Total	$ Millions	% of Total	$ Millions	% of Total	$ Millions	% of Total	$ Millions	% of Total
Crude material	1,637.7	16.3	1,827.7	16.4	2,204.1	16.6	2,187.1	15.1	2,719.2	16.5
Fabricated material*	1,485.2	14.7	1,641.7	14.8	1,899.0	14.3	1,876.5	12.9	2,483.2	15.1
Total	3,122.9	31.0	3,469.4	31.2	4,103.1	30.9	4,063.6	28.0	5,202.4	31.6
Total exports* all products	10,070.6	100.0	11,111.6	100.0	13,251.0	100.0	14,503.6[r]	100.0	16,458.2	100.0

*Includes gold, refined and unrefined.
[r] Revised from previously published figure.

TABLE 16

Canada–Value of Imports of Crude Minerals and Fabricated Mineral Products in Relation to Total Import Trade, 1966-1970

	1966		1967		1968		1969		1970	
	$ Millions	% of Total	$ Millions	% of Total	$ Millions	% of Total	$ Millions	% of Total	$ Millions	% of Total
Crude material	721.5	7.3	767.9	6.9	853.6	6.9	750.6	5.3	878.4	6.3
Fabricated material*	1,102.0	11.2	1,167.7	10.5	1,192.5	9.6	1,440.9	10.2	1,358.5	9.7
Total	1,823.5	18.5	1,935.6	17.4	2,046.1	16.5	2,191.5	15.5	2,236.9	16.0
Total imports* all products	9,866.4	100.0	11,075.2	100.0	12,358.0	100.0	14,130.3[r]	100.0	13,939.4	100.0

*Includes gold, refined and unrefined.
[r] Revised from previously published figure.

TABLE 17

Canada–Value of Exports of Crude Minerals and Fabricated Mineral Products by Main Groups and Destination, 1970
($ millions)

	Britain	United States	Other Countries	Total
Ferrous materials and products	83.6	657.1	255.5	996.2
Nonferrous* materials and products	610.6	979.8	1,093.1	2,683.5
Nonmetallic mineral materials and products	27.4	298.2	227.4	553.0
Mineral fuels, materials and products	–	928.6	41.1	969.7
Total	721.6	2,863.7	1,617.1	5,202.4
Percentage	13.9	55.0	31.1	100.0

*Includes gold, refined and unrefined.
– Nil.

TABLE 18

Canada–Value of Imports of Crude Minerals and Fabricated Mineral Products by Main Groups and Destination, 1970
($ millions)

	Britain	United States	Other Countries	Total
Ferrous materials and products	54.0	545.1	166.4	765.5
Nonferrous* materials and products	16.9	249.0	198.0	463.9
Nonmetallic mineral materials and products	12.5	165.8	52.1	230.4
Mineral fuels, material and products	1.6	223.3	552.2	777.1
Total	85.0	1,183.2	968.7	2,236.9
Percentage	3.8	52.9	43.3	100.0

*Includes gold, refined and unrefined.

TABLE 19

Canada–Value of Exports of Crude Minerals and Fabricated Mineral Products, by Commodity and Destination, 1970
($000)

	U.S.A.	Britain	Other[1] E.F.T.A. Countries	E.E.C.[2] Countries	Japan	Other Countries	Total
Aluminum	183,823	109,579	2,154	50,127	40,346	91,976	478,005
Asbestos	76,133	16,928	9,474	43,455	20,805	66,889	233,684
Copper	162,288	167,969	59,200	130,548	163,147	54,188	737,340
Fuels	928,554	77	74	5,720	32,787	2,520	969,732
Iron ore	312,823	53,720	–	84,823	21,640	2,737	475,743
Lead	28,470	15,581	336	11,585	17,179	7,397	80,548
Molybdenum	1	16,011	2,387	28,833	11,173	2,565	60,970
Nickel	330,890	207,104	118,298	71,292	33,844	41,253	802,681
Primary ferrous metals	52,450	9,217	1,455	18,065	18,188	10,094	109,469
Uranium	17,031	8,990	–	–	–	–	26,021
Zinc	78,228	28,141	3,225	58,376	17,924	23,058	208,952
All other minerals[3]	693,028	88,305	10,233	58,498	24,916	144,237	1,019,217
Total	2,863,719	721,622	206,836	561,322	401,949	446,914	5,202,362

[1]Other European Free Trade Association countries: Austria, Denmark, Norway, Portugal, Sweden, and Switzerland; [2]European Economic Community (Common Market) countries: Belgium, France, Italy, Luxembourg, Netherlands and West Germany; [3]Includes gold, refined and unrefined.
– Nil.

TABLE 20

Canada–Reported Consumption of Minerals

Mineral	Unit of Measure	1967 Consumption[1]	1967 Production[2]	1967 Consumption as % of Production	1968 Consumption[1]
Metals					
Aluminum	st	217,484	963,343r	22.6	242,390
Antimony	lb	1,190,179	1,267,686	93.9	1,169,631
Bismuth	lb	47,894	668,476	7.2	59,346
Cadmium	lb	154,761	4,836,317	3.2	125,564
Chromium (chromite)	st	70,549	–	. .	77,075
Cobalt	lb	293,086	3,603,773	8.1	358,098
Copper	st	175,176	613,313	28.6	204,275
Lead	st	93,953	317,963	29.5	94,660
Magnesium	st	5,054	8,887	56.9	5,654
Manganese ore	st	137,395	–	. .	124,904
Mercury	lb	245,121	–	. .	327,939
Molybdenum (Mo content)	lb	1,430,895	21,376,766	6.7	1,543,432
Nickel	st	8,767	248,647	3.5	11,233r
Selenium	lb	21,017	724,573	2.9	21,440
Silver	oz	14,576,608	36,315,189	40.1	13,598,358
Tellurium	lb	981	73,219	1.3	4,605
Tin	lt	4,812	196	2,455.1	4,251
Tungsten (W content)	lb	891,411	–	. .	1,181,541
Zinc	st	110,487	1,111,453	9.9	118,581
Nonmetals					
Barite	st	19,124	172,270	11.1	21,403
Feldspar	st	8,571	10,394	82.5	7,343
Fluorspar	st	155,349	. .	. .	178,901
Mica	lb	2,758,000	. .	. .	3,932,000
Nepheline syenite	st	67,817	401,601	16.9	79,566
Phosphate rock	st	2,275,067	–	. .	2,234,259
Potash (K_2O)	st	178,142[5]	2,383,253	7.5	183,100[5]
Sodium sulphate	st	347,140	428,316	81.0	391,953
Sulphur, elemental	st	843,373	2,499,205	33.7	856,963
Talc, etc.	st	33,893	60,665	55.9	32,931
Fuels					
Coal	st	25,878,083	11,141,334	232.3	26,924,740
Natural gas	Mcf	698,223,437[4]	1,471,735,152	47.4	765,786,814[4]
Petroleum, crude	bbl	387,718,614[6]	351,287,792	110.4	413,471,510[6]

[1]Unless otherwise stated, consumption refers to reported consumption of refined metals or nonmetallic minerals by consumers. [2]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. [3]Producers' domestic shipments of refined metal. [4]Sales. [5]Consumption of potash fertilizers only for year ended June 30. [6]Refinery receipts.
– Nil; . . Not available or not applicable; rRevised; pPreliminary.

and Relation to Production, 1967-1970

1968		1969			1970p		
Production[2]	Consumption as % of Production	Consumption[1]	Production[2]	Consumption as % of Production	Consumption[1]	Production[2]	Consumption as % of Production
979,171r	24.7	266,746	1,078,647r	24.7	235,308[3]	1,071,718	22.0
1,159,960	100.8	1,305,742	820,122	159.2	1,142,009	716,000	159.5
648,232	9.2	33,800	579,059	5.8	24,548	571,000	4.3
5,014,965	2.5	132,136	5,213,054	2.5	124,959	4,246,200	2.9
–	..	68,484	–	..	61,963	–	..
4,029,549	8.9	393,658	3,255,623	12.1	327,030	5,228,900	6.3
633,312	32.2	202,880	573,245	35.4	194,867	673,748	28.9
340,176	27.8	105,915	318,632	33.2	93,437	383,208	24.4
9,929	57.0	5,672	10,637	53.3	4,937	9,584	51.5
–	..	168,485	–	..	169,586	–	..
–	..	258,814r	–	..	340,558	–	..
22,464,273	6.9	1,806,682	29,651,261	6.1	..	35,353,500	..
264,358	4.2	12,094	213,611	5.7	..	308,042	..
635,510	3.4	15,572	599,415	2.6	15,730	604,300	2.6
45,012,797	30.2	5,747,068	43,530,941	13.2	6,034,028	44,282,680	13.6
70,991	6.5	3,532	62,048	5.7	880	58,900	1.5
160	2,656.9	4,280	129	3,317.8	..	125	..
3,600,000	32.8	1,050,824	4,060,940	25.9	..	..	..
1,159,392	10.2	121,420	1,207,625	10.1	108,397	1,211,298	8.9
138,059	15.5	24,151	143,230	16.9	..	131,317	..
10,620	69.1	7,370	12,385	59.5	..	11,000	..
..	..	200,827	..	..	..	..	..
–	..	5,368,000	–	..	..	–	..
426,595	18.7	78,030	500,571	15.6	..	491,000	..
–	..	1,822,069	–	..	..	–	..
2,917,611	6.3	185,527[5]	3,492,001	5.3	194,145[5]	3,424,000	5.7
459,669	85.3	397,167	518,299	76.7	..	478,000	..
2,580,746	33.2	770,846	2,973,506	25.9	..	3,779,850	..
80,589	40.9	37,774	75,850	49.8	..	75,000	..
10,989,007	245.0	26,275,008	10,671,879	246.2	29,716,836	16,603,662	179.0
1,692,300,787	45.3	843,164,967[4]	1,977,838,205	42.6	917,440,879[4]	2,276,578,728	40.3
379,396,276	109.0	432,513,825[6]	410,989,930	105.2	467,588,650[6]	461,207,058	101.4

TABLE 21

Canada – Apparent Consumption** of Some Minerals

Mineral	Unit of Measure	1967			
		Apparent Consumption	Production	Consumption as % of Production	Apparent Consumption
Asbestos	st	117,353	1,452,104	8.1	142,233
Cement	st	7,711,054	7,994,954	96.4	7,850,799
Gypsum	st	1,348,362	5,175,384	26.1	1,532,397
Iron ore	lt	8,777,888	37,783,749	23.2	9,098,962
Lime	st	1,354,887	1,422,899	95.2	1,395,520
Quartz (silica)	st	3,506,999	2,610,740	134.3	3,597,479
Salt	st	4,105,000[e]	4,995,628	82.2	4,056,000[e]

* Production = Producers' shipments.
**Apparent Consumption = Production plus imports less exports.
[e]Estimated; [p]Preliminary.

and Relation to Production* 1967-1970

1968			1969			1970p	
Production	Consumption as % of Production	Apparent Consumption	Production	Consumption as % of Production	Apparent Consumption	Production	Consumption as % of Production
1,595,951	8.9	53,855	1,611,168	3.3	97,401	1,654,000	5.9
8,165,805	96.1	7,669,220	8,250,032	93.0	7,595,670	8,065,000	94.2
5,926,940	25.9	1,584,263	6,373,648	24.9	1,627,576	6,442,000	25.3
42,360,092	21.5	10,116,993	35,762,745	28.3	10,907,742	47,508,750	23.0
1,456,013	95.8	1,480,928	1,634,862	90.6	1,459,171	1,626,000	89.7
2,554,565	140.8	3,504,114	2,300,374	152.3	4,133,592	2,902,000	142.4
4,864,324	83.4	4,338,000e	4,657,765	93.1	4,431,000e	5,052,000	87.7

TABLE 22

Canada–Domestic Consumption of Principal ~~Regined~~ Refined Metals in Relation to Production*, 1961-1970

	Unit of Measure or Percentage	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970[p]
Copper											
Domestic consumption**	st	141,808	151,525	169,750	202,225	224,684	262,557	219,680[r]	250,104[r]	240,256	237,838
Production	st	406,359	382,868	380,075	407,942	434,133	433,004[r]	499,846[r]	524,474[r]	450,154[r]	543,069
Consumption of production	%	34.9	39.6	44.7	49.6	51.8	60.6	43.9	47.7	53.9	43.8
Zinc											
Domestic consumption†	st	63,753	68,074	75,591	91,052	97,345	110,481	110,487	118,581	121,420	108,397
Production	st	268,007	280,158	284,021	337,734[r]	358,498	382,605[r]	405,136[r]	426,915[r]	466,351	460,663
Consumption of production	%	23.8	24.3	26.6	27.0	27.2	28.9	27.3	27.8	26.0	23.5
Lead											
Domestic consumption†	st	73,418	77,286	77,958	82,736	90,168	96,683	93,953	94,660	105,915	93,437
Production	st	171,833	152,217	155,000	151,372	186,484	184,871	193,235[r]	202,100	187,142	204,630
Consumption of production	%	42.7	50.8	50.3	54.7	48.4	52.3	48.6	46.8	56.6	46.2
Aluminum											
Domestic consumption†	st	135,575	151,898[r]	161,833[r]	172,443	213,094	243,301[r]	217,484[r]	242,390	266,746	235,308**
Production	st	663,173	690,297	719,390	842,640	830,505	889,915	963,343[r]	979,171	1,078,647	1,071,718
Consumption of production	%	20.4	22.5	22.5	20.5	25.7	27.3	22.6	24.8	24.7	22.0

* Production of refined metal from all sources, including metal derived from secondary materials at primary refineries.
**Producers' domestic shipments of refined metal.
† Consumption primary and secondary refined metal, reported by consumers.
[r]Revised; [p]Preliminary.

TABLE 23

Annual Averages of Prices of Main Metals* 1966-1970

	Unit of Measure	1966	1967	1968	1969	1970
Aluminum ingot, 99.5%	cents/lb	24.500	25.000	25.500	27.176	28.716
Antimony, R.M.M. f.o.b. Laredo, Texas	cents/lb	44.000	44.000	44.000	55.700	141.733
Bismuth, ton lots, delivered	$/lb	4.000	4.000	4.000	4.625	6.000
Cadmium	cents/lb	246.608	264.722	270.000	327.000	362.000
Calcium, ton lots, crowns	$/lb	0.95	0.95	0.95	0.95	0.95
Chromium metal, 98.5% 0.5%C	$/lb	1.03	0.97	0.96	0.97	1.15
Cobalt metal, 500 lb lots	$/lb	1.650	1.850	1.850	1.910	2.20
Copper, U.S. domestic, f.o.b. refinery	cents/lb	36.170	38.226**	41.847***	47.484	57.904
Gold, Canadian dollars	$/troy oz	37.71	37.75	37.71	37.70	36.57
Iron ore, 51.5% Fe, lower lake ports						
Bessemer						
Mesabi	$/lt	10.70	10.70	10.70	10.69	10.55-10.95
Old Range	$/lt	10.95	10.95	10.95	10.95	10.95-11.20
Non-Bessemer						
Mesabi	$/lt	10.55	10.55	10.55	10.55	10.55-10.80
Old Range	$/lt	10.80	10.80	10.80	10.80	10.80-11.05
Lead, common, New York	cents/lb	15.115	14.000	13.212	14.895	15.619
Magnesium, ingot	cents/lb	35.250	35.250	35.250	35.250	35.250
Mercury	$flask (76 lb)	441.719	489.355	535.555	505.043	407.769
Molybdenum metal	$/lb	3.35	3.66	3.69	3.82	4.00
Molybdenite, 95% MoS_2 contained Mo	$/lb	1.55	1.62	1.62	1.68	1.73
Nickel, f.o.b. Port Colborne (duty free)	cents/lb	78.900	87.774	94.071	105.000	129.079
Platinum	$/troy oz	99.167	108.509	114.500	121.660	130.000
Selenium	$/lb	4.50	4.50	4.50	5.31	8.25
Silver, New York	cents/troy oz	129.300	155.012	214.460	178.975	176.931
Tin, Straits, New York	cents/lb	164.070	153.434	148.151	164.347	174.205
Titanium metal, 500 lb lots 99.3%	$/lb	1.32	1.32	1.32	1.32	1.32
Titanium ore (ilmenite) 54% TiO_2	$/st	22.50	22.50	20.50	20.50	20.50
Tungsten metal	$/lb	2.75	2.75	2.75	2.75	4.50
Zinc, prime western, East St. Louis	cents/lb	14.500	13.843	13.500	14.600	15.416

* These prices, except for gold, are in United States currency, and are from *Metals Week*.
** Average first eight months because of price quote suspension September through December.
*** Average last nine months because of price quote suspension January through March.

TABLE 24

Canada–Wholesale Price Indexes of Minerals and Mineral Products, 1960 and 1968-1970 (1935-39 = 100)

	1960	1968	1969	1970
Iron and products	256.2	276.8	285.8	305.1
Pig iron	295.3	285.1	285.8	304.2
Rolling mill products	251.8	263.0	275.8	291.7
Pipe and tubing	268.3	302.3	304.4	309.2
Wire	294.2	300.2	314.2	347.3
Scrap iron and steel	288.5	252.7	250.0	328.9
Tin plate and galvanized sheet	238.4	257.2	258.8	267.2
Nonferrous metals and products				
Total (including gold)	177.8	250.8	264.0	281.0
Total (excluding gold)	242.9	365.8	389.6	422.9
Copper and products	291.4	455.0	493.1	511.5
Lead and products	224.0	281.2	318.4	330.5
Silver	228.9	602.8	497.5	478.1
Tin	196.8	305.8	338.0	349.6
Zinc and products	291.1	307.7	333.8	349.2
Nonmetallic minerals and products	185.6	206.0	210.0	215.7
Clay and clay products	255.8	259.5	265.8	274.6
Pottery	185.8	261.7	280.8	304.9
Coke	241.6	284.8	288.4	347.4
Petroleum products	162.2	164.1	165.5	170.8
Asphalt	199.5	197.7	197.7	197.7
Asphalt shingles	116.3	115.4	123.7	135.0
Plaster	138.1	171.7	181.3	183.1
Lime	212.0	259.7	273.7	282.1
Cement	162.6	193.1	201.2	207.9
Sand and gravel	145.2	168.8	185.2	196.9
Crushed stone	171.4	165.3	171.9	177.4
Building stone	208.8	256.3	257.7	266.9
Asbestos	302.2	348.8	366.3	375.9
General wholesale price index (all products)	230.9	269.9	282.4	286.4

TABLE 25

Canada–General Wholesale Price Index and Wholesale Price Indexes of Mineral and Nonmineral Products Industries, 1946-1970
(1935-39 = 100)

	Mineral Products Industries			Nonmineral Products Industries					
	Iron Products	Nonferrous Metal Products	Nonmetallic Mineral Products	Vegetable Products	Animal Products	Textile Products	Wood Products	Chemical Products	General Wholesale Price Index
1946	127.4	108.0	114.5	134.2	160.2	137.9	172.1	120.3	138.9
1947	140.7	130.2	129.1	157.3	183.0	179.5	208.8	136.7	163.3
1948	161.4	146.9	150.8	185.7	236.7	216.3	238.3	152.2	193.4
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	250.4
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

TABLE 26

Canada–Mineral Products Industries,
Selling Price Indexes, 1967-1970
Base year, 1961 = 100

	1967	1968	1969	1970
Iron and steel products industries				
Agriculture implements industry	110.2	114.3	118.5	122.1
Hardware, tool and cutlery manufacturers	110.4	115.7	121.0	126.5
Heating equipment manufacturers	100.9	104.5	107.6	111.1
Primary metal industries	118.9	120.5	129.0	136.9
Iron and steel mills	103.4	103.0	106.7	112.6
Steel pipe and tube mills	98.7	95.3	95.5	98.9
Iron foundries	115.3	119.0	122.0	127.7
Wire and wire products manufacturers	106.0	106.1	110.1	119.5
Nonferrous metal products industries				
Aluminum rolling, casting and extruding	106.2	104.3	107.2	109.7
Copper and alloy, rolling, casting and extruding	148.8	150.9	164.7	181.0
Jewellery and silverware manufacturers	128.8	142.3	144.0	148.5
Metal rolling, casting and extruding, n.e.s.	140.1	141.7	158.1	176.0
Nonmetallic metal products industries				
Abrasive manufacturers	108.3	108.9	110.3	112.2
Cement manufacturers	111.8	116.3	121.1	125.8
Clay products manufacturers from imported clay	109.9	112.3	115.5	116.9
Glass manufacturers	111.6	114.2	119.3	125.4
Lime manufacturers	114.0	119.6	124.4	129.1
Gypsum products manufacturers	108.3	112.0	117.0	119.4
Concrete products manufacturers	113.6	116.7	120.5	125.4
Clay products from domestic clay	109.0	112.6	118.3	121.1
Petroleum and coal products industries	96.0	98.1	100.1	103.1
Petroleum refining	95.8	97.8	99.7	102.8
Lubricating oils and greases	110.4	117.0	121.4	122.2
Manufacturers of mixed fertilizers	111.6	116.6	110.0	108.9

Note: Industry selling price indexes reflect wholesale price trends of products or groups of products sold by the industries listed.

TABLE 27

Canada – Principal Statistics of the Mining Industry, 1968

	S.I.C. No.	Estab-lish-ments	Mining Activity: Production and Related Workers			Mining Activity: Cost of Fuel and Elec-tricity	Mining Activity: Cost of Materials and Supplies	Mining Activity: Value of Produc-tion	Mining Activity: Value Added	Total Activity: Employees		Total Activity: Value Added
			Number	Man Hours Paid	Wages					Number	Salaries and Wages	
		Number	Number	000's	$000	$000	$000	$000	$000	Number	$000	$000
Metallics												
Placer gold	051	12	18	36	100	12	69	345	264	18	100	264
Gold quartz	052	42	7,616	15,627	40,493	5,223	27,493	110,748	78,032	8,983	50,495	78,644
Copper-gold-silver	0591	41	10,423	22,266	69,420	12,550	196,882	587,234	377,801	12,950	88,685	380,055
Silver-cobalt	0593	9	470	996	2,675	284	2,248	10,177	7,645	570	3,263	7,635
Silver-lead-zinc	0594	23	4,645	9,946	30,994	6,506	105,249	262,321	150,565	5,750	40,143	149,695
Nickel-copper	0592	10	14,980	32,288	115,264	6,596	267,962	711,929	437,372	17,607	141,377	438,356
Iron	058	20	7,830	17,292	68,179	35,346	127,100	501,848	339,402	11,342	101,756	340,515
Miscellaneous metal mines	059	17	3,256	6,824	23,196	5,184	29,191	106,679	72,305	4,347	30,980	72,910
Sales and head office										1,802	17,973	2,238
Total		174	49,238	105,275	350,321	71,701	756,194	2,291,281	1,463,386	63,369	474,772	1,470,312
Nonmetallic												
Asbestos	071	12	5,831	13,413	41,167	10,909	32,448	186,948	143,591	7,213	53,434	143,900
Feldspar, quartz and nepheline syenite	0792	11	292	670	1,698	501	2,004	9,873	7,368	365	2,197	7,347
Gypsum	073	9	390	875	2,058	391	2,139	11,807	9,277	489	2,758	9,238
Peat	072	66	1,172	2,498	4,203	473	3,489	12,820	8,858	1,306	5,069	8,855
Salt	0793	10	883	1,958	5,057	1,422	5,975	30,881	23,484	1,304	8,223	23,863
Sand and gravel	087	226	1,960	4,396	11,903	3,639	8,800	52,724	40,286	2,496	15,935	41,563
Stone	083	156	2,726	6,337	14,723	4,702	17,328	66,369	44,339	3,340	19,084	44,798
Talc and soapstone	0791	4	81	185	345	63	331	1,218	824	103	461	818
Miscellaneous nonmetallics	079	17	2,123	4,461	13,696	7,499	14,516	82,465	60,449	2,893	20,525	59,982
Total		511	15,458	34,793	94,850	29,599	87,030	455,105	338,476	19,509	127,686	340,364
Fuels												
Coal	061	49	6,903	12,807	37,067	3,367	19,836	72,191	48,988	8,427	46,583	49,081
Petroleum and natural gas	064	814	3,467	7,471	27,765	14,973	37,284	1,360,252	1,307,995	13,611	123,412	1,312,414
Total		863	10,370	20,278	64,832	18,340	57,120	1,432,443	1,356,983	22,038	169,995	1,361,495
Total Mining Industry		1,548	75,066	160,346	510,003	119,640	900,344	4,178,829	3,158,845	104,916	772,453	3,172,171

TABLE 28

Canada–Principal Statistics of the Mineral Manufacturing Industries, 1968

			Manufacturing Activity							Total Activity		
			Production and Related Workers							Employees		
	S.I.C. No.	Establishments		Man Hours Paid	Wages	Cost of Fuel and Electricity	Cost of Materials and Supplies	Value of Production	Value Added		Salaries and Wages	Value Added
		Number	Number	000's	$000	$000	$000	$000	$000	Number	$000	$000
Primary metal industries												
Iron and steel mills	291	43	36,324	76,124	250,865	52,870	630,974	1,367,087	684,684	44,634	323,572	692,767
Steel pipe and tube mills	292	24	4,330	9,464	29,986	4,512	198,064	270,703	73,844	5,441	39,526	74,222
Iron foundries	294	128	9,408	19,638	55,173	5,219	74,171	186,246	106,610	11,131	69,241	108,001
Smelting and refining	295	24	25,572	51,904	172,282	72,387	382,435	932,585	477,763	34,710	250,948	493,024
Aluminum rolling, casting and extruding	296	57	4,111	8,718	24,184	3,167	137,509	205,929	66,496	5,491	35,698	66,770
Copper and alloy, rolling, casting and extruding	297	52	3,073	7,048	20,987	2,488	212,878	274,943	59,105	3,947	28,031	59,141
Metal rolling, casting, and extruding n.e.s.	298	77	3,419	7,205	16,706	2,300	97,377	146,754	46,365	4,585	25,850	49,388
Total, primary metal industries		405	86,237	180,101	570,183	142,943	1,733,408	3,384,247	1,514,867	109,939	772,866	1,543,313
Nonmetallic mineral products industries												
Cement manufacturers	341	24	2,502	5,537	17,715	20,965	22,681	150,814	107,088	6,249	45,728	106,482
Lime manufacturers	343	11	536	1,185	3,102	2,837	2,502	13,942	8,573	1,198	6,446	8,505
Gypsum products manufacturers	345	15	1,250	2,733	7,551	2,349	19,131	53,342	32,079	2,836	9,927	33,005
Concrete products manufacturers	347	473	7,854	17,731	42,847	5,760	75,607	201,633	122,789	10,166	59,557	126,202
Ready-mix concrete manufacturers	348	307	5,405	12,870	33,896	7,574	147,504	261,260	106,314	7,440	47,810	115,209
Clay products manufacturers (domestic)	351	76	2,798	6,140	14,718	6,259	7,980	48,896	33,996	3,363	19,045	34,141
Clay products manufacturers (imported)	351	41	1,689	3,527	8,772	1,082	14,181	39,591	24,652	2,152	11,787	25,327

TABLE 28 (Cont'd)

	S.I.C. No.	Manufacturing Activity: Establishments	Production and Related Workers			Cost of Fuel and Electricity	Cost of Materials and Supplies	Value of Production	Value Added	Total Activity: Employees		Value Added
				Man Hours Paid	Wages						Salaries and Wages	
		Number	Number	000's	$000	$000	$000	$000	$000	Number	$000	$000
Nonmetallic mineral products industries (Cont'd)												
Refractories manufacturers	352	19	650	1,399	3,776	1,109	14.998	33.173	16.924	1.081	7.011	17.348
Stone products manufacturers	353	83	484	1,019	2,272	225	3,726	10,223	6,278	661	3,440	6,312
Mineral wool manufacturers	354	9	780	1,821	5,327	1,571	10,756	34,184	21,808	1,029	7,164	22,043
Asbestos products manufacturers	355	15	1,775	4,143	11,916	1,276	18,099	49,197	29,350	2,505	17,113	31,599
Glass manufacturers	356	15	6,947	14,999	40,979	7,866	31,878	131,272	93,692	8,222	49,508	95,124
Glass products manufacturers	356	110	2,804	6,114	16,506	1,616	54,106	97,392	43,396	3,770	23,810	45,213
Abrasive manufacturers	357	22	1,878	4,027	11,540	6,948	25,111	60,326	29,198	2,617	17,266	29,612
Other nonmetallic	359	40	444	991	2,256	531	8,612	18,924	9,895	698	4,118	10,328
Total, mineral products industries		1,260	37,796	84,236	223,173	67,968	456,872	1,204,169	686,032	53,987	329,730	706,450
Petroleum and coal products industries												
Petroleum refineries	365	58	6,506	14,856	54,508	16,140	1,337,831	1,657,215	320,933	9,488	82,849	328,734
Other petroleum and coal products industries	369	37	370	804	2,195	628	9,589	18,784	8,484	518	3,276	9,805
Total petroleum and coal products industries		95	6,876	15,660	56,703	16,768	1,347,420	1,675,999	329,417	10,006	86,125	338,539
Total mineral manufacturing industries		1,760	130,909	279,997	850,059	227,679	3,537,700	6,264,415	2,530,316	173,932	1,188,721	2,588,302

TABLE 29

Canada–Principal Statistics of the Mining Industry* 1963-1968

	Mining Activity								Total Activity**		
		Production and Related Workers							Employees		
	Estab-lish-ments		Man Hours Paid	Wages	Cost of Fuel and Electricity	Cost of Materials and Supplies	Value of Production	Value Added		Salaries and Wages	Value Added
	Number	Number	000's	$000	$000	$000	$000	$000	Number	$000	$000
1963	1,422	71,862	154,823	349,961	75,407	497,396	2,596,166	2,023,363	95,531	508,816	2,055,552
1964	1,423	72,337	157,227	364,766	82,277	558,369	2,931,700	2,291,054	96,457	530,727	2,325,515
1965	1,467	75,046	162,542	396,731	96,393	650,139	3,222,441	2,475,910	100,820	582,101	2,514,269
1966	1,423	74,195	158,156	419,496	98,867	706,109	3,417,868	2,612,891	102,200	629,580	2,636,524
1967	1,480	74,230	159,182	465,489	107,563	806,577[r]	3,823,358	2,917,669[r]	102,678	700,677	2,943,224[r]
1968	1,548	75,066	160,346	510,003	119,640	900,344	4,178,829	3,158,845	104,916	772,453	3,172,171

*Excludes cement manufacturing, lime manufacturers, clay and clay products (domestic clays). These industries are included in the Mineral Manufacturing Industries.
**Total activity includes sales and head office employees.
[r]Revised.

TABLE 30

Canada–Principal Statistics of the Mineral Manufacturing Industries 1963-1968

	Manufacturing Activity								Total Activity		
		Production and Related Workers							Employees		
	Estab-lish-ments		Man Hours Paid	Wages	Cost of Fuel and Electricity	Cost of Materials and Supplies	Value of Production	Value Added		Salaries and Wages	Value Added
	Number	Number	000's	$000	$000	$000	$000	$000	Number	$000	$000
1963	1,807	113,373	244,239	575,030	156,389	2,533,002	4,393,769	1,730,340	146,830	784,256	1,774,167
1964	1,823	120,536	262,905	636,796	174,568	2,777,039	4,883,688	1,936,148	155,297	860,436	1,990,667
1965	1,842	128,514	279,340	710,220	194,895	2,995,152	5,322,623	2,178,365	163,837	951,414	2,238,542
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	2,530,316	173,932	1,188,721	2,588,302

TABLE 31

Canada-Consumption of Fuel and Electricity in the Mining[1] Industry, 1968

	Unit	Metallic Minerals	Industrial Minerals	Mineral Fuels	Total
Coal and coke	000 st	57	57	..	114
	$000	944	420	2	1,366
Gasoline	000 gal	4,420	9,119	872	14,411
	$000	1,779	3,326	287	5,392
Fuel oil, kerosene, coal oil	000 gal	180,057	65,897	2,110	248,064
	$000	21,923	10,682	376	32,981
Liquified petroleum gas	000 gal	1,597	314	118	2,029
	$000	299	112	12	423
Natural gas	000 Mcf	9,226	14,481	2	23,709
	$000	4,208	3,856	1	8,065
Other fuels[2]	$000	187	52	–	239
Total fuels	$000	29,340	18,448	678	48,466
Electricity purchased	million kwh	7,020	1,290	1,102	9,412
	$000	42,340	10,809	17,662	70,811
Total value of fuels and electricity purchased	$000	71,680	29,257	18,340	119,277
Value of fuels and electricity of small establishments[3]	$000	21	342	–	363
Total value of fuels and electricity purchased, all reporting companies	$000	71,701	29,599	18,340	119,640
Electricity generated by industry for own use	million kwh	381	155	–	536
Electricity generated by industry for sale	million kwh	85	.1	–	85

[1]Excluding cement and lime manufacturing and manufacture of clay products (from domestic clays). These industries are included under mineral manufacturing, Tables 32 and 34. [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 st; – Nil.

TABLE 32

Canada–Cost of Fuel and Electricity Used in the Mining* Industry
1961-1968

		1961	1962	1963	1964	1965	1966	1967	1968
Metals									
Fuel	$million	12.9	13.8	15.5	16.3	19.9	22.1	26.2	29.4
Electricity purchased	million kwh	3,270.0	3,372.8	3,710.5	4,370.9	5,533.2	5,510.8	6,300.2	7,020.3
	$ million	22.1	23.6	25.5	27.8	34.5	35.2	38.2	42.3
Total cost of fuel and electricity	$ million	35.0	37.4	41.0	44.1	54.4	57.3	64.5	71.7
Electricity generated for own use and for sale	million kwh	543.9	598.6	465.2	446.8	482.7	473.4	509.8	466.1
Industrial Minerals									
Fuel	$ million	10.1	11.2	12.0	13.0	15.4	16.2	16.7	18.8
Electricity purchased	million kwh	652.3	702.8	861.4	820.4	938.0	1,022.2	1,127.9	1,289.9
	$ million	6.5	6.8	7.6	7.9	8.7	8.9	9.6	10.8
Total cost of fuel and electricity	$ million	16.6	18.0	19.6	20.9	24.1	25.1	26.3	29.6
Electricity generated for own use and for sale	million kwh	28.0	34.1	35.1	34.4	41.3	122.5	151.1	155.5
Mineral Fuels									
Fuel	$ million	5.1	5.9	6.4	0.8	0.8	0.7	0.7	0.6
Electricity purchased	million kwh	357.4	408.8	601.6	859.4	888.4	955.2	988.5	1,101.5
	$ million	7.0	7.6	7.9	16.5	17.1	15.8	16.1	17.7
Total cost of fuel and electricity	$ million	12.1	13.5	14.3	17.3	17.9	16.5	16.8	18.3
Electricity generated for own use and for sale	million kwh	37.1	34.8	47.0	29.9	34.4	36.7	–	–
Total Mining Industry									
Fuel	$ million	28.1	30.9	33.9	30.1	36.1	39.0	43.6	48.8
Electricity purchased	million kwh	4,279.7	4,484.4	5,173.5	6,050.7	7,359.6	7,488.2	8,416.6	9,411.7
	$ million	35.6	38.0	41.0	52.2	60.3	59.9	64.0	70.8
Total cost of fuel and electricity	$ million	63.7	68.9	74.9	82.3	96.4	98.9	107.6	119.6
Electricity generated for own use and for sale	million kwh	609.0	667.5	547.3	511.1	558.4	632.6	660.9	621.6

*See footnote Table 31.
– Nil.

TABLE 33

Canada–Consumption of Fuel and Electricity in the Mineral Manufacturing Industry * 1968

	Unit	Primary Metals Industries	Nonmetallic Mineral Products Industries	Petroleum and Coal Products Industries	Total
Coal and coke	000 st	1,418	660	..	2,078
	$000	22,290	7,761	4	30,051
Gasoline	000 gal	3,720	18,430	401	22,551
	$000	1,197	6,659	151	8,007
Fuel oil, kerosene, coal oil	000 gal	312,065	129,323	3,269	444,657
	$000	26,626	12,678	352	39,656
Liquified petroleum gas	000 gal	10,155	2,298	1	12,454
	$000	1,589	502	..	2,091
Natural gas	000 Mcf	46,936	41,863	11,081	99,880
	$000	20,697	17,045	3,219	40,961
Other fuels	$000	1,710	1,757	1,575	5,046
Total fuels	$000	74,109	46,402	5,301	125,812
Electricity purchased	million kwh	14,363	3,116	1,818	19,297
	$000	68,834	21,566	11,467	101,867
Total value, fuels and electricity purchased	$000	142,943	67,968	16,768	227,679

Includes industries covered in Tables 28 and 30.
Less than 1,000 units.

TABLE 34

Canada–Employment, Salaries and Wages in the Mining Industry*, 1961-1968

		1961	1962	1963	1964	1965	1966	1967	1968
Metal Mining									
Employees	Number	58,591	58,243	57,119	57,648	60,942	61,670	61,728	63,369
Salaries and wages	$000	298,984	306,004	310,108	321,605	356,855	385,143	429,383	474,772
Average annual salary and wage	$	5,103	5,254	5,429	5,579	5,856	6,245	6,956	7,492
Industrial Minerals									
Employees	Number	16,238	16,922	17,347	17,771	18,364	18,734	18,856	19,509
Salaries and wages	$000	72,258	77,327	81,671	89,048	96,591	104,033	113,151	127,686
Average annual salary and wage	$	4,450	4,570	4,708	5,011	5,260	5,553	6,000	6,545
Mineral Fuels									
Employees	Number	21,486	21,129	21,065	21,038	21,514	21,796	22,094	22,038
Salaries and wages	$000	112,154	115,023	117,037	120,074	128,655	140,404	158,143	169,995
Average annual salary and wage	$	5,220	5,444	5,556	5,707	5,980	6,442	7,158	7,714
Total Mining									
Employees	Number	96,315	96,294	95,531	96,457	100,820	102,200	102,678	104,916
Salaries and wages	$000	483,396	498,354	508,816	530,727	582,101	629,580	700,677	772,453
Average annual salary and wage	$	5,019	5,175	5,326	5,502	5,774	6,160	6,824	7,363

*According to the revised Standard Industrial Classification. Does not include cement and lime manufacturing and clay products (domestic clays) manufacturing.

TABLE 35

Canada–Employment, Salaries and Wages in the Mining* Industry, 1963-1968

		1963	1964	1965	1966	1967	1968
Metals							
Production and related workers	Number	46,250	46,727	49,050	48,276	48,262	49,238
Salaries and wages	$000	235,839	244,549	269,457	284,477	317,978	350,321
Annual average salary and wage	$	5,099	5,234	5,494	5,893	6,589	7,115
Administrative and office workers	Number	10,869	10,921	11,892	13,394	13,466	14,131
Salaries and wages	$000	74,269	77,056	87,398	100,666	111,405	124,451
Annual average salary and wage	$	6,833	7,056	7,349	7,516	8,273	8,807
Industrial Minerals							
Production and related workers	Number	14,158	14,211	14,688	14,916	15,049	15,458
Salaries and wages	$000	62,370	67,134	72,352	77,984	84,756	94,850
Annual average salary and wage	$	4,405	4,724	4,926	5,228	5,632	8,807
Administrative and office workers	Number	3,189	3,560	3,676	3,818	3,807	4,051
Salaries and wages	$000	19,301	21,914	24,239	26,049	28,395	32,836
Annual average salary and wage	$	6,052	6,156	6,594	6,823	7,459	8,106
Mineral Fuels							
Production and related workers	Number	11,454	11,399	11,308	11,003	10,919	10,370
Salaries and wages	$000	51,752	53,083	54,922	57,035	62,756	64,832
Annual average salary and wage	$	4,518	4,657	4,857	5,184	5,747	6,252
Administrative and office workers	Number	9,611	9,639	10,206	10,793	11,175	11,668
Salaries and wages	$000	65,285	66,991	73,733	83,369	95,387	105,163
Annual average salary and wage	$	6,793	6,950	7,224	7,724	8,536	9,013
Total Mining Industry							
Production and related workers	Number	71,862	72,337	75,046	74,195	74,230	75,066
Salaries and wages	$000	349,961	364,766	396,731	419,496	465,490	510,003
Annual average salary and wage	$	4,869	5,043	5,286	5,654	6,271	6,794
Administrative and office workers	Number	23,669	24,120	25,774	28,005	28,448	29,850
Salaries and wages	$000	158,855	165,961	185,370	210,084	235,187	262,450
Annual average salary and wage	$	6,712	6,881	7,192	7,502	8,267	8,792
Total All Employees	Number	95,531	96,457	100,820	102,200	102,678	104,916
Salaries and wages all employees	$000	508,816	530,727	582,101	629,580	700,677	772,453
Average annual salary and wage	$	6,326	5,502	5,774	6,160	6,824	7,363

*See footnote Table 34.

TABLE 36

Canada-Employment, Salaries and Wages in the Mineral Manufacturing* Industries, 1963-1968

	Unit	1963	1964	1965	1966	1967	1968
Primary Metal Industries							
Production and related workers	Number	72,352	77,770	83,443	87,748	86,784	86,237
Salaries and wages	$000	383,356	427,710	478,482	518,347	541,970	570,183
Annual average salaries and wages	$	5,298	5,550	5,734	5,907	6,245	6,612
Administrative and office workers	Number	19,269	20,010	21,189	22,555	23,294	23,702
Salaries and wages	$000	126,067	133,866	148,752	169,686	185,800	202,683
Annual average salaries and wages	$	6,542	6,690	7,020	7,523	7,976	8,551
Nonmetallic Mineral Products Industries							
Production and related workers	Number	33,740	35,598	38,246	39,561	37,467	37,796
Salaries and wages	$000	148,305	164,302	188,351	206,120	207,204	223,173
Annual average salaries and wages	$	4,396	4,615	4,925	5,210	5,569	5,919
Administrative and office workers	Number	10,747	11,273	11,044	11,583	11,793	16,191
Salaries and wages	$000	59,552	64,890	66,970	73,851	79,464	106,557
Annual average salaries and wages	$	5,541	5,756	6,064	6,376	6,738	6,581
Petroleum and Coal Products Industries							
Production and related workers	Number	7,281	7,168	6,825	6,832	6,839	6,876
Salaries and wages	$000	43,369	44,784	43,387	48,780	52,462	56,703
Annual average salaries and wages	$	5,956	6,248	6,357	7,140	7,671	8,247
Administrative and office workers	Number	3,441	3,478	3,090	3,173	3,264	3,130
Salaries and wages	$000	23,607	24,884	25,472	26,540	28,287	29,422
Annual average salaries and wages	$	6,861	7,155	8,243	8,364	8,666	9,400
Total Mineral Manufacturing Industries							
Production and related workers	Number	113,373	120,536	128,141	134,141	131,090	130,909
Salaries and wages	$000	575,030	636,796	710,220	773,247	801,636	850,059
Annual average salaries and wages	$	5,072	5,283	5,526	5,764	6,115	6,494
Administrative and office workers	Number	33,457	34,761	35,323	37,311	38,351	43,023
Salaries and wages	$000	209,226	223,640	241,194	270,077	293,551	338,662
Annual average salaries and wages	$	6,254	6,434	6,828	7,239	7,654	7,872
Total All Employees	Number	146,830	155,297	163,837	171,452	169,441	173,932
Salaries and wages all employees	$000	784,256	860,436	591,414	1,043,324	1,095,187	1,188,721
Annual average salaries and wages	$	5,341	5,541	5,807	6,085	6,464	6,834

*See Table 28 for industries covered.

TABLE 37

Canada—Number of Wage Earners, Surface, Underground, and Mill, Mining Industry* 1965-1968

	1965	1966	1967	1968
Metals				
Surface	14,562	14,176	13,864	14,061
Underground	26,055	25,994	25,482	25,146
Mill	8,433	8,106	8,916	10,031
Total	49,050	48,276	48,262	49,238
Industrial Minerals				
Surface	8,339	8,713	8,310	7,575
Underground	1,060	1,094	1,382	1,483
Mill	5,289	5,109	5,357	6,400
Total	14,688	14,916	15,049	15,458
Mineral Fuels				
Surface	5,247	5,215	5,380	5,222
Underground	6,061	5,788	5,539	5,148
Total	11,308	11,003	10,919	10,370
Total Mining Industry				
Surface	28,148	28,104	27,554	26,858
Underground	33,176	32,876	32,403	31,777
Mill	13,722	13,215	14,273	16,431
Total	75,046	74,195	74,230	75,066

*See footnote Table 34 re coverage.

TABLE 38

Canada–Labour Costs in Relation to Tons Mined, Metal Mines, 1966-1968

Type of Metal Mines	Number of Wage Earners	Total Wages $000	Average Annual Wage $	Tons of ore Mined 000st	Average Annual tons mined per wage earner st	Wage Cost per ton mined $
1968						
Auriferous quartz	7,633	40,602	5,319	9,269	1,214	4.38
Copper-gold-silver	10,486	69,578	6,635	34,909	3,329	1.99
Nickel-copper	14,980	115,264	7,695	29,651	1,979	3.89
Silver-cobalt	487	2,705	5,554	269	552	10.06
Silver-lead-zinc	4,645	30,994	6,673	12,503	2,692	2.48
Iron ore	8,520	74,529	8,748	101,753	11,943	0.73
Miscellaneous metals	3,259	23,215	7,123	17,702	5,432	1.31
Total	50,010	356,887	7,136	206,056	4,120	1.73
1967						
Auriferous quartz	8,683	43,674	5,029	10,290	1,185	4.25
Copper-gold-silver	10,776	65,660	6,093	31,279	2,903	2.10
Nickel-copper	13,699	98,137	7,163	24,796	1,810	3.96
Silver-cobalt	438	2,141	4,888	226	516	9.48
Silver-lead-zinc	4,441	27,536	6,200	11,663	2,626	2.36
Iron ore	7,001	58,312	8,329	90,165	12,878	0.65
Miscellaneous metals	3,209	22,442	6,993	18,118	5,646	1.24
Total	48,247	317,902	6,589	186,537	3,866	1.70
1966						
Auriferous quartz	9,758	46,905	4,807	11,188	1,147	4.19
Copper-gold-silver	9,986	57,442	5,752	23,086	2,312	2.49
Nickel-copper	13,225	76,998	5,822	21,793	1,648	3.53
Silver-cobalt	437	1,966	4,499	270	618	7.28
Silver-lead-zinc	4,604	26,993	5,863	11,755	2,553	2.30
Iron ore	7,339	55,120	7,511	79,819	10,876	0.69
Miscellaneous metals	2,850	18,309	6,424	14,883	5,222	1.23
Total	48,199	283,733	5,887	162,794	3,378	1.74

TABLE 39

Canada – Man-hours Paid, Production and Related Workers, Tons of Ore Mined and Rock Quarried, Metal Mines and Industrial Mineral Operations 1962-1968

	Unit	1962	1963	1964	1965	1966	1967	1968
Metal mines[1]								
Ore mined	million st	114.3	124.3	141.1	166.5	162.8	186.5	206.1
Man-hours paid[2]	million	99.4	99.7	100.7	106.4	101.4	103.8	105.2
Man-hours paid per ton mined	number	0.87	0.80	0.71	0.64	0.62	0.56	0.51
Tons mined per man-hour paid	st	1.15	1.25	1.40	1.56	1.61	1.80	1.96
Industrial mineral operations[3]								
Ore mined and rock quarried	million st	100.9	119.0	132.9	144.0	171.3[r]	177.9[r]	173.4
Man-hours paid[2]	million	22.8	23.1	24.0	23.2	24.7	25.3[r]	25.9
Man-hours paid per ton mined	number	0.22	0.19	0.18	0.16	0.14[r]	0.14[r]	0.15
Tons mined per man-hour paid	st	4.43	5.15	5.54	6.19	6.93	7.04	6.69

[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.

[r] Revised.

TABLE 40

Canada – Basic Wage Rates per Hour in Metal Mining Industry on October 1, 1969 and 1970

	Gold Mining		Iron Mining		Other Metal Mines	
	1969	1970p	1969	1970p	1969	1970p
	$	$	$	$	$	$
Underground workers						
Cage and skiptenders	2.31	2.49	..	..	3.02	3.34
Chute blaster	2.26	2.42	..	..	3.05	3.43
Deckman	2.17	2.37	..	..	2.76	3.12
Hoistman	2.46	2.63	..	..	3.26	3.59
Labourer	2.19	2.42	..	..	2.73	3.15
Miner	2.32	2.49	..	..	3.03	3.36
Miner's helper	2.20	2.27	..	..	2.65	2.91
Motorman	2.17	2.39	..	..	2.93	3.25
Mucking machine operator	2.17	2.39	..	..	2.88	3.21
Mucker and trammer	2.12	2.31	..	..	2.87	3.23
Timberman	2.33	2.53	..	..	3.05	3.29
Trackman	2.27	2.38	..	..	3.02	3.31
Open-pit workers						
Blaster	..	..	3.30	3.49	..	..
Bulldozer operator	..	..	3.36	3.59	..	..
Driller machine	..	..	3.42	3.60	..	..
Dumptruck driver	..	..	3.47	3.75	..	..
Oiler	..	..	3.16	3.33	..	..
Shovel operator (power)	..	..	3.95	4.15	..	..
Surface and mill workers						
Blacksmith	..	..	..	..	3.23	3.54
Carpenter, maintenance	2.43	2.65	3.79	4.02	3.25	3.58
Crusher operator	2.27	2.34	3.21	3.47	2.94	3.28
Electrician	2.56	2.70	3.90	4.14	3.46	3.82
Filter operator	..	..	..	..	2.86	3.19
Flotation operator	..	..	..	..	3.07	3.40
Grinding-mill operator	..	..	3.42	3.57	3.01	3.31
Hoistman	..	..	..	..	..	..
Labourer	2.10	2.29	2.89	3.07	2.64	2.94
Mechanist, maintenance	2.70	2.99	3.95	4.20	3.56	3.84
Mechanic, diesel	..	..	3.83	3.97	3.58	3.95
Mechanic maintenance	2.40	2.53	3.85	4.03	3.31	3.76
Millman*	2.31	2.49	..	..	..	..
Pipefitter, maintenance	2.34	2.61	..	3.99	3.17	3.56
Solution man	..	..	..	..	3.06	3.16
Steel sharpener	2.35	2.53	..	..	2.96	3.27
Trademan's helper	2.13	2.55	3.09	3.30	2.80	3.18
Truck driver, light and heavy	2.21	2.30	3.30	3.50	3.08	3.38
Welder, maintenance	2.50	2.69	3.77	3.99	3.38	3.75
Millwright	..	..	3.73	4.00	3.45	3.84

*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–Index Numbers of Average Wage Rates* by Industries
1965-1969
(base year 1961 = 100)

	1965	1966	1967	1968	1969
Logging	126.4	140.2	156.0	162.5	179.8
Metal mining	113.3	122.7	130.2	138.9	146.2
Gold-quartz	121.6	134.6	142.7	154.5	161.6
Iron	112.2	121.0	129.0	133.2	147.1
Other metal	110.3	118.4	125.6	134.1	140.0
Manufacturing	115.0	121.6	130.5	140.6	151.2
Non-durable	115.5	121.9	131.0	141.4	152.5
Petroleum refineries	112.6	123.1	131.4	139.3	146.2
Durable	114.4	121.2	130.0	139.7	149.7
Primary metal industries	114.8	116.5	123.1	128.5	135.1
Metal fabricating industries	115.7	125.0	131.2	140.4	151.9
Machinery industries	114.9	122.7	131.0	140.5	151.8
Transportation equipment industries	115.4	122.5	131.7	142.1	152.8
Electrical products industries	105.9	112.3	123.4	133.8	141.7
Construction	119.8	129.8	142.0	154.9	167.0
Transportation, communication and other utilities	114.3	122.3	132.8	143.4	154.9
Trade	116.9	123.9	132.5	144.5	155.2
Service	118.4	125.5	133.9	141.8	154.0
Local government (Municipal government only)	118.1	124.6	136.9	146.7	163.4
General Index-All industries	116.5	124.0	133.4	143.8	155.1

*The weighted average of straight-time rates paid on a time basis in an occupation.

TABLE 42

Canada—Average Weekly Wages and Hours of Hourly-Rated Employees in Mining, Manufacturing and Construction Industries, 1963-1970p

	1963	1964	1965	1966	1967	1968	1969	1970p
Mining								
Average hours per week	42.0	42.2	42.5	42.3	41.9	41.8	41.4	41.0
Average weekly wage	93.87	97.43	103.30	110.29	119.09	128.28	135.94	152.15
Metals								
Average hours per week	41.5	41.7	41.9	41.6	41.3	41.2	40.7	40.3
Average weekly wage	96.22	99.48	105.76	112.99	112.79	131.55	137.68	154.39
Mineral fuels								
Average hours per week	42.5	42.1	41.3	42.3	42.5	41.9	41.9	41.9
Average weekly wage	85.10	86.98	89.07	95.68	101.24	109.96	122.88	146.31
Industrial minerals								
Average hours per week	41.1	41.7	42.7	42.1	42.3	42.4	41.9	41.3
Average weekly wage	89.66	94.42	99.49	104.00	112.35	121.24	129.05	139.37
Manufacturing								
Average hours per week	40.8	41.0	41.0	40.8	40.3	40.3	40.0	39.7
Average weekly wage	79.51	82.96	86.89	91.65	96.84	104.00	111.69	119.69
Construction								
Average hours per week	41.2	41.4	41.3	42.2	41.3	40.5	39.6	38.9
Average weekly wage	92.20	97.39	104.45	118.23	128.76	134.84	146.90	163.94

pPreliminary.

TABLE 43

Canada—Average Weekly Wages of Hourly-Rated Employees in Mining Industry in Current and 1949 Dollars, 1963-1970p

	1963	1964	1965	1966	1967	1968	1969	1970p
Current Dollars								
All mining	93.87	97.43	103.30	110.29	119.09	128.28	135.94	152.15
Metals	96.22	99.48	105.76	112.99	122.79	131.55	137.68	154.39
Gold	77.38	80.27	84.71	91.12	95.72	101.26	107.69	113.84
Mineral fuels	85.10	86.98	89.07	95.68	101.24	109.96	122.88	146.31
Coal	79.25	80.84	80.68	85.53	90.63	97.41	108.58	130.11
Industrial minerals	89.66	94.42	99.49	104.00	112.35	121.24	129.05	139.37
1949 Dollars								
All mining	70.58	71.96	74.48	76.64	79.92	82.65	83.86	90.84
Metals	72.35	73.47	76.25	78.52	82.40	84.76	84.9	92.17
Gold	58.18	59.28	61.07	63.32	64.24	65.24	66.43	67.96
Mineral fuels	63.98	64.24	64.22	66.49	67.94	70.85	79.46	87.35
Coal	59.59	59.70	58.17	59.44	60.83	62.76	66.98	77.68
Industrial minerals	67.41	69.73	71.73	72.27	75.40	78.12	79.61	83.21

pPreliminary.

TABLE 44

Canada–Industrial Fatalities per Thousand Paid Workers in Main Industry Groups 1960-1970[p]

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970[p]
Agriculture	0.62	0.61	0.56	0.48	0.72	0.48	0.54	0.30	0.27	0.31	0.13
Forestry	1.50	1.32	2.04	1.79	2.21	1.64	1.53	1.49	1.46	1.24	1.25
Fishing and trapping	2.70	4.00	1.20	3.40	3.70	4.00	3.60	3.30	2.11	2.00	2.33
Mining[1]	1.92	1.73	1.89	2.33	1.87	1.24	1.13	1.62	1.14	1.42	0.97
Manufacturing	0.19	0.12	0.15	0.15	0.14	0.14	0.14	0.10	0.10	0.12	0.09
Construction	0.56	0.77	0.63	0.70	0.75	0.72	0.66	0.56	0.55	0.59	0.43
Transportation, communication and other utilities	0.37	0.36	0.38	0.42	0.43	0.49	0.41	0.37	0.28	0.31	0.21
Trade	0.06	0.06	0.07	0.07	0.07	0.07	0.05	0.06	0.05	0.06	0.04
Finance, insurance and real estate	0.09	0.05	0.08	0.04	0.08	0.01	0.04	0.01	–	0.01	0.01
Service[2]	0.07	0.06	0.06	0.09	0.07	0.05	0.04	0.04	0.05	0.05	0.04
Total	0.21	0.22	0.22	0.23	0.24	0.23	0.19	0.18	0.16	0.17	0.12

[1] Includes quarrying and oil-well drilling. Cement, lime and clay products manufacturers are included under manufacturing.
[2] Includes public administration.
[p] Preliminary; – Nil.

TABLE 45

Canada–Strikes and Lockouts in Existence, 1969 and 1970p

	1969			1970p		
	Strikes and Lockouts	Workers Involved	Duration in Man-Days	Strikes and Lockouts	Workers involved	Duration in Man-Days
	Number	Number	Number	Number	Number	Number
Forestry	12	2,798	8,100	5	403	2,010
Mines	27	31,511	2,087,490	15	6,876	53,680
Manufacturing	284	88,303	2,690,260	263	92,011	3,630,670
Construction	118	79,748	1,981,300	109	112,533	2,156,890
Transportation and utilities	46	30,312	559,460	48	35,502	379,990
Trade	44	7,052	270,930	42	2,214	46,220
Service	51	58,147	141,250	47	9,458	239,440
Public administration	13	8,928	13,090	13	2,709	30,660
All industries	595	306,799	7,751,880	542	261,706	6,539,560

pPreliminary; – Nil.

TABLE 46

Canada–Ore Mined and Rock Quarried, Mining Industry
1966-1968
(short tons)

	1966	1967	1968
Metallic ores			
Gold-quartz	11,187,827	10,289,826	9,268,857
Copper-gold-silver	23,085,616	31,279,288	34,909,280
Silver-cobalt	270,492	225,898	269,036
Silver-lead-zinc	11,755,330	11,662,803	12,503,061
Nickel-copper	21,792,636	24,795,565	29,650,613
Iron	79,818,862	90,165,071	101,753,446
Miscellaneous metals	14,883,076	18,118,195	17,702,304
Total	162,793,839	186,536,646	206,056,597
Industrial minerals			
Asbestos	60,239,777	77,502,293	78,115,612
Feldspar, nepheline syenite	557,003	588,330	662,046
Quartz (exclusive of sand)	1,509,603	1,264,397	1,101,805
Gypsum	5,857,796	5,302,119	5,914,312
Talc, soapstone	69,817	62,949	87,588
Rock salt	3,077,027	3,625,115	3,865,097
Other nonmetallics	7,223,902	9,221,764	11,598,754
Total	78,534,925	97,566,967	101,345,214
Structural materials			
Stone, all kinds quarried	95,822,054r	84,007,308r	75,939,767
Stone used to make cement	12,104,057	10,797,456r	10,501,240
Stone used to make lime	2,972,618	3,269,092	2,531,850
Total	110,898,729r	98,073,856r	88,972,857
Total ore mined and rock quarried	352,227,493r	382,177,469r	396,374,668

rRevised.

TABLE 47

Canada–Ore Mined and Rock Quarried, Mining Industry,
1935-1968
(million short tons)

	Metal Mines	Industrial Mineral Operations*	Total
1935	20.4	9.6	30.0
1936	22.7	13.0	35.7
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[r]	352.2[r]
1967	186.5	195.7[r]	382.2[r]
1968	206.1	190.3	396.4

*Includes nonmetallic mineral mining and all stone quarried, including stone used to make cement and lime.
[r]Revised.

TABLE 48

Canada–Exploration, Development and Capital Expenditures by Mining Industry*, by Province or Territory, 1968 and 1969

($ million)

		Outside or General Exploration	On-property Exploration	On-property Development	Structure	Machinery and Equipment	Total
Newfoundland	1968	1.5	0.5	2.6	3.6	7.8	16.0
	1969	1.8	0.4	2.3	4.2	5.8	14.5
Prince Edward Island	1968	–	–	–	–	–	–
	1969	–	–	–	–	–	–
Nova Scotia	1968	0.4	0.3	0.8	0.1	4.7	6.3
	1969	0.5	0.1	0.8	1.8	3.5	6.7
New Brunswick	1968	1.8	0.9	4.7	0.7	4.3	12.4
	1969	2.3	2.2	5.0	5.4	9.3	24.2
Quebec	1968	12.2	5.2	15.7	16.1	25.7	74.9
	1969	14.2	12.9	25.5	19.6	25.1	97.3
Ontario	1968	18.0	7.5	44.8	39.7	48.5	158.5
	1969	22.6	9.6	51.1	16.3	50.2	149.8
Manitoba	1968	5.6	2.9	21.3	16.0	10.8	56.6
	1969	7.9	3.5	23.6	17.6	17.9	70.5
Saskatchewan	1968	6.2	1.4	31.4	44.7	88.2	171.9
	1969	8.3	0.2	12.8	24.9	38.5	84.7
Alberta	1968	0.8	1.5	4.3	(2)	2.0	8.6
	1969	0.5	1.7	3.6	19.8	18.0	43.6
British Columbia	1968	19.1	8.4	23.3	54.2	28.2	133.2
	1969	28.4	5.2	32.7	88.7	37.0	192.0
Yukon and Northwest Territories	1968	8.3	3.0	17.8	1.6†	13.4	44.1
	1969	12.3	2.1	7.7	21.9	6.8	50.8
Total Canada	1968	73.9	31.6	166.7†	176.7†	233.6	682.5
	1969	98.8	37.9	165.1	220.2	212.1	734.1

*Includes producers and non-producers in the metallic and nonmetallic sectors of the mining industry. Mining companies in the petroleum and natural gas sectors are not included.
†Expenditures for on-property development and structures are combined for Alberta and Yukon.
– Nil. [r]Revised.

TABLE 49

Canada–Exploration, Development and Capital Expenditures by Mining Industry, by Type of Mining[1], 1968[r] and 1969
($ million)

		Outside or General Exploration	On-property Exploration	On-property Development	Structure	Machinery and Equipment	Total
Metal mining							
Gold	1968	1.1	1.6	7.6	2.1	3.5	15.9
	1969	1.0	2.6	11.1	1.9	4.1	20.7
Copper-gold-silver	1968	2.4	7.1	25.2	43.0	24.9	102.6
	1969	2.0	7.5	37.9	58.8	21.5	127.7
Silver-lead-zinc	1968	1.1	1.7	24.0	1.5	13.8	42.1
	1969	1.5	3.2	12.8	23.3	13.5	54.3
Uranium	1968	0.4	0.2	8.0	8.4	7.1	24.1
	1969	1.3	–	8.9	2.6	1.0	13.8
Iron mines	1968	0.5	0.4	11.9	16.3	17.7	46.8
	1969	1.0	0.3	13.3	12.8	12.3	39.7
Other metals	1968	67.7	15.2	49.3	41.4	38.2	211.8
	1969	90.8	20.0	54.0	24.1	45.8	234.7
Total	1968	73.2	26.2	126.0	112.7	105.2	443.3
	1969	97.6	33.6	138.0	123.5	98.2	490.9
Nonmetal mining							
Asbestos	1968	0.3	0.2	6.5	3.4	15.6	26.0
	1969	0.4	1.3	7.0	4.7	15.8	29.2
Potash and other miscellaneous nonmetals	1968	0.3	1.2	29.5	43.1	91.2	165.3
	1969	0.7	0.1	10.5	23.7	47.2	82.2
Other nonmetal mining[2]	1968	0.1	4.0	4.7	17.5	21.6	47.9
	1969	0.1	2.9	9.6	68.3	50.9	131.8
Total nonmetal mining	1968	0.7	5.4	40.7	64.0	128.4	239.2
	1969	1.2	4.3	27.1	96.7	113.9	243.2
Total mining	1968	73.9	31.6	166.7	176.7	233.6	682.5
	1969	98.8	37.9	165.1	220.2	212.1	734.1

[1]Includes producers and non-producers in the metallic and nonmetallic sectors of the mining industry. Companies in the petroleum and natural gas sectors of the mining industry are not included.
[2]Includes coal, gypsum, salt mines and stone quarries.
– Nil. [r]Revised.

TABLE 50

Canada–All Diamond Drilling on Metal Deposits by Mining Companies with Own Equipment and by Drilling Contractors 1955-1968 (footage)

	Gold-Quartz Deposits	Copper-Gold-Silver and Nickel-Copper Deposits	Silver-Lead Zinc and Silver-Cobalt Depostis	Other Metal Bearing Deposits*	Total Metal Deposits
1955	2,354,572	2,873,826	1,121,578	1,763,820	8,113,796
1956	2,239,502	4,889,428	1,311,282	1,257,977	9,698,189
1957	1,846,621[r]	3,603,971	1,062,020	942,794	7,455,406[r]
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[r]	3,363,019	1,148,886	1,176,768	8,648,938[r]
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

*Includes iron, chromite, titanium, uranium molybdenum deposits.
Note: Non-producing companies are not included since 1964.
[r]Revised.

TABLE 51

Canada–Exploration, Diamond Drilling, Metal Deposits, 1955-1968 (footage)

	By Mining Companies with Own Personnel and Equipment	By Diamond Drill Contractors	Total
1955	1,522,696	5,072,263	6,594,959
1956	1,556,963	5,396,113	6,953,076
1957	1,175,526	4,046,336	5,221,862
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

Note: Non-producing companies are not included since 1964.

TABLE 52

Canada–Diamond Drilling, Other than for Exploration, on Metal Deposits by Companies with Own Equipment and by Drilling Contractors 1955-1968 (footage)

	By Mining Companies with Own Personnel and Equipment	By Diamond Drill Contractors	Total
1955	1,348,177	170,660	1,518,837
1956	2,593,578	151,535	2,745,113
1957	1,721,535	512,009	2,233,544
1958	1,457,926	565,999	2,023,925
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	1,446,095
1966	747,929	629,474	1,377,403
1967	611,755	941,836	1,553,591
1968	403,056	961,004	1,364,060

Note: Non-producing companies are not included since 1964.
The total footage drilled shown in Tables 51 and 52 equals the total footage drilled reported in Table 50.

TABLE 53

Canada–Contract Diamond Drilling Operations*, 1957-1968

	Footage Drilled	Income from Drilling	Average No. of Employees	Total Salaries and Wages
	feet	$ million	number	$ million
1957	6,296,128	21.2	2,951	10.8
1958	4,426,594	14.4	1,717	6.9
1959	5,435,971	17.9	1,902	8.0
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	9,029,625	38.7	2,985	18.8

*Includes contract diamond drilling in mining and in other industries.

TABLE 54

Canada–Contract Drilling for Oil and Gas 1958-1968

	Footage Drilled				Gross Income from Drilling	Average No. of Employees	Total Salaries and Wages
	Rotary	Cable	Diamond	Total	$ million	Number	$ million
1958	12,998,094	446,451	–	13,444,545	69.3	5,261	24.1
1959	13,020,214	317,719	7,567	13,345,500	63.8	4,734	21.4
1960	13,538,783	231,748	–	13,770,531	75.2	4,860	23.2
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	14,783,110	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

– Nil.

TABLE 55

Crude Minerals* Transported by Canadian Railways, 1968 and 1969
(thousands of short tons)

	1968	1969
Coal		
Anthracite	548	540
Bituminous	8,263	7,474
Iron ore	47,203	38,587
Aluminum ores and concentrates	2,815	2,847
Copper ores and concentrates	1,698	1,859
Copper-nickel ores and concentrates	5,416	3,833
Lead ores and concentrates	777	619
Zinc ores and concentrates	2,980	2,712
Ores and concentrates, other	683	779
Barite	54	67
Clay and bentonite	610	657
Sand	1,265	1,509
Sand and gravel	4,326	3,579
Stone, crushed and ground	5,078	5,689
Stone, fluxing and dolomite	243	273
Stone, rough	725	31
Stone, dressed	17	11
Petroleum, crude	367	412
Salt	1,336	1,177
Phosphate rock	1,780	1,603
Sulphur	2,521	2,673
Asbestos	1,216	1,162
Gypsum, crude	4,221	4,432
Products of mines, other	1,527	1,454
Total, crude minerals	95,669	83,979
Total, all revenue freight moved by Canadian railways	215,417	206,864
Crude minerals as a percentage of total revenue freight moved by Canadian railways	44.4	40.6

*Domestic and imported.

TABLE 56

Crude Minerals* Transported by Canadian Railways, 1960-1969
(million short tons)

	Total Revenue Freight	Total Crude Minerals	Crude Minerals as a % of Revenue Freight
1960	157.4	62.9	39.9
1961	153.1	59.6	38.9
1962	160.9	66.5	41.3
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	206.8	83.9	40.6

*Domestic and imported.

TABLE 57

Fabricated Mineral Products* Transported by Canadian Railways, 1968 and 1969
(thousand short tons)

	1968	1969
Aluminum; bar, ingot, pig, shot	725	706
Aluminum metal, other	122	128
Copper; ingot and pig	794	599
Copper, brass and bronze, other	121	178
Lead and zinc; bar, ingot, pig	648	640
Lead and zinc, n.e.s.	8	6
Alloys for manufacture of steel	145	176
Metals and alloys, other	103	100
Iron; pig	216	217
Iron and steel; billet, bloom, ingot	688	926
Iron and steel; bar, rod, slab	721	809
Iron and steel, other	66	80
Matte	331	237
Furnace slag	303	282
Cement, natural and portland	1,904	1,687
Cement, other	58	54
Brick, common	73	70
Brick, other and building tile	101	94
Refractories	278	256
Artificial stone	71	66
Lime	633	732
Plaster; stucco and wall	66	69
Sewer pipe and drain tile	7	10
Broken brick and crockery	10	10
Gasoline	2,865	2,831
Fuel oil and petroleum oil	4,684	4,418
Lubricating oils and greases	408	398
Petroleum products, refined	2,455	2,736
Coke	1,796	1,691
Asphalt	353	313
Total, fabricated mineral products	20,753	20,519
Total, all revenue freight	215,417	206,864
Fabricated minerals as a per cent of total freight	9.6	9.9

*Domestic and imported.

TABLE 58

Crude and Fabricated Minerals* Transported Through Canadian Canals†, 1968 and 1969
(thousand short tons)

	1968[r]	1969
Crude minerals		
Alumina, bauxite ores	343	266
Copper ore, concentrates, matte, precipitate	2	19
Iron ore, crude, concentrated, calcined	36,373	25,199
Manganese ore	271	539
Nickel-copper ore	6	5
Titanium ore	111	87
Zinc ore and concentrates	–	2
Ores and concentrates n.e.s.	69	105
Iron and steel scrap	846	2,797
Nonferrous metal scrap	46	84
Slag, dross and byproducts	44	12
Coal, bituminous, subbituminous and lignite	11,020	11,432
Coal n.e.s.	–	1
Crude petroleum	196	104
Natural gas	7	6
Asbestos	5	6
Bentonite	374	289
China clay	70	83
Dolomite	1,387	1,173
Clay materials n.e.s.	27	114
Sand and gravel	228	388
Limestone	9	11
Crushed stone, including stone refuse, excluding limestone	16	–
Stone, crude n.e.s.	52	173
Fluorspar	366	461
Gypsum	38	94
Phosphate rock	3	23
Salt	1,658	1,226
Sulphur in ores, crude and refined	12	4
Crude nonmetallic minerals n.e.s.	10	22
	53,589	44,725

TABLE 58 (Cont'd)

	1968[r]	1969
Fabricated mineral products		
Gasoline	865	1,244
Fuel oil	4,222	4,337
Lubricating oils and greases	293	339
Coke	598	666
Asphalt and road oils	17	27
Coal tar, pitch	139	169
Petroleum and coal products, n.e.s.	352	595
Ferroalloys	155	104
Pig iron	521	513
Primary iron and steel n.e.s.	99	436
Castings and forgings	112	65
Bars and rods, steel	978	849
Plate, sheet, steel	7,632	5,257
Structural shapes	1,640	1,772
Rails and track material	8	19
Pipe, tube, iron and steel	109	198
Wire	223	253
Aluminum	55	56
Copper and alloys	22	18
Lead and alloys	8	13
Nickel and alloys	10	16
Zinc and alloys	72	55
Nonferrous metals n.e.s.	17	18
Metal fabricated, basic products	193	251
Bricks, tiles, n.e.s.	55	24
Glass basic products	144	165
Asbestos basic products	2	2
Cement	170	191
Cement basic products	2	1
Nonmetallic mineral basic products, n.e.s.	58	88
Total fabricated	18,771	17,741
Total crude and fabricated materials	72,360	62,466
Total all freight transported	108,274	97,358
Per cent crude and fabricated minerals of total freight	66.8	64.2

*Domestic and imported. †Canals and inland waterways include: St. Lawrence, Welland, Sault Ste. Marie, St. Peter's, Canso, Richelieu River, Ottawa River, Murray, Trent and St. Andrews.
n.e.s. Not elsewhere specified; [r]Revised; – Nil.

TABLE 59

Canada–Taxes* Paid to Federal, Provincial and Municipal Governments by Important Divisions of the Mining Industry 1967 and 1968 ($000)

	1967				1968			
	Federal Income Tax	Provincial Tax	Municipal Tax	Total	Federal Income Tax	Provincial Tax	Municipal Tax	Total
Auriferous-quartz mining	2,376	1,570	925	4,871	2,014	1,230	928	4,172
Copper-gold-silver mining, smelting and refining	25,512r	20,737r	3,080r	49,329r	25,827	22,937	3,292	52,056
Silver-lead-zinc mining, smelting and refining	8,440	7,503	2,739	18,682	7,865	4,606	2,999	15,470
Nickel-copper, mining, smelting and refining	26,067	15,914	2,942	44,923	30,789	16,222	3,227	50,238
Iron mining	1,482	7,647	3,891	13,020	2,359	10,361	4,512	17,232
Miscellaneous metal mining	88	1,883	820	2,791	12	645	256	913
Asbestos mining	14,325	10,250	1,629	26,204	9,971	8,051	1,884	19,906
Feldspar, quartz, nepheline syenite mining	34	71	41	146	26	47	31	104
Gypsum mining	694	234	278	1,206	289	258	308	855
Peat mining	34	73	91	198	92	62	104	258
Salt mining	–	1,020	314	1,334	–	1,287	336	1,623
Talc and soapstone mining	1	16	6	23	–	17	5	22
Stone quarries	1,179	713	449	2,341	1,140	470	510	2,120
Sand and gravel pits	729	534	303	1,566	831	616	463	1,910
Miscellaneous nonmetal mining	1,751	2,321	990	5,062	1,421	2,427	1,617	5,465
Total of sectors covered	82,712r	70,486r	18,498r	171,696r	82,636	69,236	20,472	172,344

*These include taxes on non-operating revenue and do not reflect the annual tax assessment, but the taxes paid within a calendar year.
– Nil. r Revised.

TABLE 60

Canada–Taxes* Paid by Six Important Divisions of the Mineral Industry, 1962-1968 ($ million)

	1962	1963	1964	1965	1966	1967	1968
Auriferous quartz mining	6.1	6.5	5.2	4.4	5.2	4.9	4.2
Copper-gold-silver mining	15.2	20.3	26.0	34.9	34.3	49.3	52.1
Silver-lead-zinc mining, smelting and refining	17.7	20.5	26.5	27.9	22.9	18.7	15.5
Nickel-copper mining, smelting and refining	51.6	35.9	47.8	77.7	70.7	44.9	50.2
Iron mining	7.5	11.0	6.1	11.6	15.0	13.0	17.2
Asbestos mining	18.4	18.6	20.3	22.5	26.3	26.2	19.9
Total	116.5	112.8	131.9	179.0	174.4	157.0r	159.1

*These include taxes on non-operating revenue and do not reflect the annual tax assessment, but the taxes paid within a calendar year.
r Revised.

TABLE 61

Canada–Federal Income Taxes of Reporting Companies in the Mining and Mineral Fabricating Industries 1967 and 1968 ($ million)

	1967	1968
Mining		
Metals		
Gold	1.7	2.4
Iron	1.1	7.8
Other metal mines	29.0	25.3
Total	31.8	35.5
Mineral fuels		
Coal	0.1	–
Oil and gas	46.4	32.0
Total	46.5	32.0
Other mining		
Nonmetal mines	11.4	14.5
Quarries	2.6	2.8
Mining services	2.4	5.4
Total	16.4	22.7
Total mining industry	94.7	90.2
Mineral fabricating industries		
Primary metals		
Iron and steel mills	8.6	41.5
Iron foundries	4.4	5.0
Smelting and refining	46.6	69.5
Total	59.6	116.0
Nonmetallic mineral products		
Cement	0.3	6.1
Concrete	4.0	2.4
Ready-mix concrete	3.7	2.9
Clay products	1.8	0.8
Glass and glass products	2.0	2.0
Other nonmetallic products	9.0	11.4
Total	20.8	25.6
Petroleum and coal products		
Petroleum refineries	21.4	31.9
Other petroleum and coal products	0.5	0.6
Total	21.9	32.5
Total mineral manufacturing	102.3	174.1

– Nil.

TABLE 62

Canada–Provincial Income Taxes of Reporting Companies in the Mining and Mineral Fabricating Industries 1967 and 1968 ($ million)

	1967	1968
Mining		
Metals		
Gold	0.4	0.5
Iron	0.3	2.2
Other metal mines	8.2	7.2
Total	8.9	9.9
Mineral fuels		
Coal	–	–
Oil and gas	12.2	7.8
Total	12.2	7.8
Other mining		
Nonmetal mines	3.4	4.1
Quarries	1.1	1.0
Mining services	0.8	1.8
Total	5.3	6.9
Total mining industry	26.4	24.6
Mineral fabricating industries		
Primary metals		
Iron and steel mills	2.6	11.8
Iron foundries	1.1	1.5
Smelting and refining	13.7	19.7
Total	17.4	33.0
Nonmetallic mineral products		
Cement	0.1	1.7
Concrete	1.3	0.9
Ready-mix concrete	1.2	0.9
Clay products	0.6	0.3
Glass and glass products	0.7	0.6
Other nonmetallic products	2.9	3.4
Total	6.8	7.8
Petroleum and coal products		
Petroleum refineries	5.9	8.6
Other petroleum and coal products	0.2	0.2
Total	6.1	8.8
Total mineral fabricating industries	30.3	49.6

– Nil.

TABLE 63

Canada–Capital and Repair Expenditure in the Mining and Mineral Manufacturing Industries, 1969, 1970, 1971
($ million)

	1969			1970p			1971f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
Mining industry									
Metal mines									
Gold	19.4	6.4	25.8	12.6	5.0	17.6	8.6	4.9	13.5
Silver, lead, zinc	53.0	13.2	66.2	22.7	11.8	34.5	25.1	13.0	38.1
Iron	38.8	79.4	118.2	41.3	84.9	126.2	115.3	83.4	198.7
Other metal mines	282.1	97.6	379.7	358.1	139.1	497.2	557.1	145.5	702.6
Total metal mines	393.3	196.6	589.9	434.7	240.8	675.5	706.1	246.8	952.9
Nonmetal mines									
Quarries and sand pits	13.1	16.3	29.4	11.0	16.4	27.4	10.3	16.7	27.0
Other nonmetal mines*	228.9	58.8	287.7	163.9	65.0	228.9	150.6	65.6	216.2
Total nonmetal mines	242.0	75.1	317.1	174.9	81.4	256.3	160.9	82.3	243.2
Mineral fuels									
Petroleum and gas	541.9	92.7	634.6	617.6	107.3	724.9	696.0	112.8	808.8
Total mining industry	1,177.2	364.4	1,541.6	1,227.2	429.5	1,656.7	1,563.0	441.9	2,004.9
Mineral manufacturing									
Primary metal industries									
Iron and steel mills	108.4	141.2	249.6	180.9	172.3	353.2	213.2	185.9	399.1
Steel pipe and tube mills	8.4	10.0	18.4	10.1	11.4	21.5	11.2	11.1	22.3
Iron foundries	6.8	9.4	16.2	12.2	12.1	24.3	12.0	12.8	24.8
Smelting and refining	151.8	116.7	268.5	160.1	139.3	299.4	215.8	150.8	366.6
Aluminum, rolling, casting and extruding	10.9	5.7	16.6	22.7	5.5	28.2	8.2	5.5	13.7
Copper and alloy rolling, casting and extruding	3.2	5.1	8.3	2.0	3.9	5.9	2.2	4.1	6.3
Other primary metal industries	3.4	2.4	5.8	3.6	2.0	5.6	2.6	2.2	4.8
Total primary metal industries	292.9	290.5	583.4	391.6	346.5	738.1	465.2	372.4	837.6
Nonmetallic mineral products									
Cement	17.1	13.9	31.0	17.8	14.0	31.8	14.2	13.8	28.0
Lime	3.4	1.1	4.5	7.4	0.9	8.3	4.6	0.9	5.5
Gypsum products	4.4	1.5	5.9	7.2	1.1	8.3	3.0	2.1	5.1
Concrete products and ready-mix	39.9	35.6	75.5	43.7	38.0	81.7	29.3	38.3	67.6
Clay products	8.0	5.0	13.0	6.4	4.1	10.5	4.6	3.8	8.4
Refractories	1.1	1.3	2.4	1.7	1.3	3.0	2.3	1.3	3.6
Asbestos	2.0	2.6	4.6	1.4	2.4	3.8	2.8	2.4	5.2

TABLE 63 (Cont'd)

	1969			1970p			1971f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
Mineral manufacturing (Cont'd)									
Nonmetallic mineral products (Cont'd)									
Glass and glass products	37.5	8.7	46.2	56.4	13.4	69.8	26.6	11.3	37.9
Abrasives	2.4	5.6	8.0	2.6	5.0	7.6	4.5	5.3	9.8
Other nonmetallic mineral products	5.3	4.0	9.3	3.0	4.1	7.1	2.8	4.8	7.6
Total nonmetallic mineral products	121.1	79.3	200.4	147.6	84.3	231.9	94.7	84.0	178.7
Petroleum and coal products	129.8	58.9	188.7	234.1	60.4	294.5	267.1	66.0	333.1
Total mineral manufacturing industries	543.8	428.7	972.5	773.3	491.2	1,264.5	827.0	522.4	1,349.4
Total mining and mineral manufacturing industries	1,721.0	793.1	2,514.1	2,000.5	920.7	2,921.2	2,390.0	964.3	3,354.3

*Includes coal mines, asbestos, gypsum, salt.
pPreliminary estimates of intentions. fForecast intentions.

TABLE 64

Canada—Capital and Repair Expenditure in the Mining Industry*, 1961-1971
($ million)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970P	1971f
Metal mines											
Capital											
Construction	107.6	137.8	118.3	146.8	121.4	209.8	238.1	264.8	295.1	296.9	495.0
Machinery	42.5	71.2	71.6	92.7	79.2	138.6	131.3	105.2	98.2	137.8	211.1
Total	150.1	209.0	189.9	239.5	200.6	348.4	369.4	370.0	393.3	434.7	706.1
Repair											
Construction	12.8	14.0	15.8	17.8	21.9	25.2	33.4	47.9	35.7	29.3	30.0
Machinery	55.7	64.5	76.3	84.5	100.5	115.9	116.6	152.2	160.9	211.5	216.8
Total	68.5	78.5	92.1	102.3	122.4	141.1	150.0	200.1	196.6	240.8	246.8
Total capital and repair	218.6	287.5	282.0	341.8	323.0	489.5	519.4	570.1	589.9	675.5	952.9
Nonmetal mines†											
Capital											
Construction	15.9	24.7	18.7	36.7	58.1	106.7	121.1	110.2	128.1	63.3	57.9
Machinery	20.8	35.5	40.8	44.9	34.8	68.8	85.4	128.4	113.9	111.6	103.0
Total	36.7	60.2	59.5	81.6	92.9	175.5	206.5	238.6	242.0	174.9	160.9
Repair											
Construction	3.1	3.3	3.6	3.2	3.7	3.5	4.5	4.3	10.4	5.6	5.5
Machinery	28.6	27.6	31.5	37.9	47.2	49.5	57.0	57.5	64.7	75.8	76.8
Total	31.7	30.9	35.1	41.1	50.9	53.0	61.5	61.8	75.1	81.4	82.3
Total capital and repair	68.4	91.1	94.6	122.7	143.8	228.5	268.0	300.4	317.1	256.3	243.2
Mineral fuels											
Capital											
Construction	238.4	176.8	234.3	270.6	419.2	450.0	403.0	407.4	465.3	546.3	606.4
Machinery	23.6	33.7	37.9	40.4	22.1	55.7	71.8	58.0	76.6	71.3	89.6
Total	262.0	210.5	272.2	311.0	441.3	505.7	474.8	465.4	541.9	617.6	696.0
Repair											
Construction	10.2	13.6	15.7	23.6	25.4	28.6	34.2	56.3	73.7	81.6	83.7
Machinery	11.4	12.3	13.9	10.8	24.0	21.3	14.7	19.2	19.0	25.7	29.1
Total	21.6	25.9	29.6	34.4	49.4	49.9	48.9	75.5	92.7	107.3	112.8
Total capital and repair	283.6	236.4	301.8	345.4	490.7	555.6	523.7	540.9	634.6	724.9	808.8

TABLE 64 (Cont'd)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970p	1971f
Total mining											
Capital											
Construction	361.9	339.3	371.3	454.1	598.7	766.5	762.2	782.4	888.5	906.5	1,159.3
Machinery	86.9	140.4	150.3	178.0	136.1	263.1	288.5	291.6	288.7	320.7	403.7
Total	448.8	479.7	521.6	632.1	734.8	1,029.6	1,050.7	1,074.0	1,177.2	1,227.2	1,563.0
Repair											
Construction	26.1	30.9	35.1	44.6	51.0	57.3	72.1	108.5	119.8	116.5	119.2
Machinery	95.7	104.4	121.7	133.2	171.7	186.7	188.3	228.9	244.6	313.0	322.7
Total	121.8	135.3	156.8	177.8	222.7	244.0	260.4	337.4	364.4	429.5	441.9
Total capital and repair	570.6	615.0	678.4	809.9	957.5	1,273.6	1,311.1	1,411.4	1,541.6	1,656.7	2,004.9

*Does not include cement, lime and clay products (domestic clays) manufacturing, and smelting and refining. † Includes coal mines, asbestos, gypsum, salt, miscellaneous nonmetals and quarrying.

pPreliminary estimates of intentions; f Forecast intentions.

TABLE 65

Canada—Capital and Repair Expenditures in the Mineral Manufacturing Industries, 1961-1971
($ million)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970p	1971f
Primary metal industries*											
Capital											
Construction	32.9	58.4	44.4	58.4	61.6	85.2	82.0	77.5	71.5	93.6	3.1
Machinery	93.7	159.1	136.8	214.4	202.9	300.7	202.8	157.9	221.4	298.0	462.1
Total	126.6	217.5	181.2	272.8	264.5	385.9	284.8	235.4	292.9	391.6	465.2
Repair											
Construction	19.0	18.5	16.6	18.0	18.5	21.8	24.9	27.7	22.6	24.9	26.8
Machinery	134.9	151.9	166.1	194.4	215.0	253.4	258.1	281.4	267.9	321.6	345.6
Total	153.9	170.4	182.7	212.4	233.5	275.2	283.0	309.1	290.5	346.5	372.4
Total capital and repair	280.5	387.9	363.9	485.2	498.0	661.1	567.8	544.5	583.4	738.1	837.6
Nonmetallic mineral products†											
Capital											
Construction	11.8	13.7	13.8	20.1	30.0	50.9	39.5	19.6	37.1	44.9	18.2
Machinery	32.8	38.4	38.9	61.9	78.3	108.6	80.3	66.5	84.0	102.7	76.5
Total	44.6	52.1	52.7	82.0	108.3	159.5	119.8	86.1	121.1	147.6	94.7
Repair											
Construction	4.3	5.2	5.5	5.4	6.4	7.2	9.3	7.2	72.2	5.5	6.4
Machinery	41.9	51.3	52.8	58.3	66.1	72.1	63.9	73.8	72.1	78.8	77.6
Total	46.2	56.5	58.3	63.7	72.5	79.3	73.2	81.0	79.3	84.3	84.0
Total capital and repair	90.8	108.6	111.0	145.7	180.8	238.8	193.0	167.1	200.4	231.9	178.7
Petroleum and coal products											
Capital											
Construction	27.7	56.7	38.0	20.4	30.3	55.5	78.8	99.0	116.9	220.6	232.6
Machinery	4.0	8.9	8.6	4.3	10.3	9.6	21.4	28.8	12.9	13.5	34.5
Total	31.7	65.6	46.6	24.7	40.6	65.1	100.2	127.8	129.8	234.1	267.1
Repair											
Construction	26.1	28.1	30.0	32.3	29.5	32.6	36.0	46.6	52.1	53.6	57.9
Machinery	4.4	4.9	5.2	5.9	7.0	9.1	10.2	8.6	6.8	6.8	8.1
Total	30.5	33.0	35.2	38.2	36.5	41.7	46.2	55.2	58.9	60.4	66.0
Total capital and repair	62.2	98.6	81.8	62.9	77.1	106.8	146.4	183.0	188.7	294.5	333.1

TABLE 65 (Cont'd)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970p	1971f
Total mineral manufacturing industries											
Capital											
Construction	72.4	128.8	96.2	98.9	121.9	191.6	200.3	196.1	225.5	359.1	253.9
Machinery	130.5	206.4	184.3	280.6	291.5	418.9	304.5	253.2	318.3	414.2	573.1
Total	202.9	335.2	280.5	379.5	413.4	610.5	504.8	449.3	543.8	773.3	827.0
Repair											
Construction	49.4	51.8	52.1	55.7	54.4	61.6	70.2	81.5	81.9	84.0	91.1
Machinery	181.2	208.1	224.1	258.6	288.1	334.6	332.2	363.8	346.8	407.2	431.3
Total	230.6	259.9	276.2	314.3	342.5	396.2	402.4	445.3	428.7	491.2	522.4
Total capital and repair	433.5	595.1	556.7	693.8	755.9	1,006.7	907.2	894.6	972.5	1,264.5	1,349.4

*Includes smelting and refining. † Includes cement, lime, and clay products manufacturing.
pPreliminary estimates of intentions; fForecast intentions.

TABLE 66

Canada–Capital Expenditures in the Petroleum and Natural Gas and Allied Industries*, 1960-1971
($ million)

	Petroleum and natural gas extraction**	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
1960	209.1	98.9	68.1	62.9	59.2	19.4	517.6
1961	272.0	164.9	56.0	59.3	31.2	76.5	659.9
1962	268.9	72.2	47.7	69.3	64.8	21.9	544.8
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
1970p	419.2	250.9	100.8	98.5	233.4	198.4	1,301.2
1971f	476.4	425.7	104.2	108.4	259.1	219.6	1,593.4

*The petroleum and natural gas industries in this table include all companies engaged, in whole or in part, in oil and gas activities.
**Includes capital expenditures by oil and gas drilling contractors back to 1961. Does not include expenditures for geological and geophysical operations.
pPreliminary. fForecast intentions.

TABLE 67

Canada–Corporations in the Mining Industry by Degree of Non-resident Ownership, 1968

	Corporations[1]		Assets[2]		Equity[3]		Sales[4]		Profits[5]	
	Number	%	$ million	%	$ million	%	$ million	%	$ million	%
Metal mines										
Reporting corporations										
50 per cent and over non-resident	63	20.7	1,984.4	44.2	1,058.4	36.5	843.7	45.0	189.0	38.2
under 50 per cent non-resident	205	67.2	2,430.8	54.1	1,780.4	61.4	1,002.0	53.5	305.8	61.8
Total reporting corporations	268	87.9	4,415.2	98.3	2,838.8	97.9	1,845.7	98.5	494.8	100.0
Other corporations	37	12.1	76.9	1.7	60.3	2.1	27.7	1.5	–0.1	–
Total all corporations	305	100.0	4,492.1	100.0	2,899.1	100.0	1,873.4	100.0	494.7	100.0
Nonmetal mines (including mining services)										
Reporting corporations										
50 per cent and over non-resident	178	6.8	1,307.6	57.1	684.4	50.5	453.2	52.7	85.7	81.8
under 50 per cent non-resident	720	27.5	824.2	36.0	585.1	43.1	324.9	37.8	24.1	23.0
Total reporting corporations	898	34.3	2,131.8	93.1	1,269.5	93.6	778.1	90.5	109.8	104.8
Other corporations	1,722	65.7	157.8	6.9	87.4	6.4	81.8	9.5	–5.0	–4.8
Total all corporations	2,620	100.0	2,289.6	100.0	1,356.9	100.0	859.9	100.0	104.8	100.0
Mineral fuels										
Reporting corporations										
50 per cent and over non-resident	198	26.8	4,066.4	82.3	2,418.9	81.4	1,118.6	87.1	182.2	79.5
under 50 per cent non-resident	169	22.9	845.8	17.2	544.9	18.3	151.4	11.8	48.7	21.3
Total reporting corporations	367	49.7	4,912.2	99.5	2,963.8	99.7	1,270.0	98.9	230.9	100.8
Other corporations	371	50.3	26.1	0.5	7.8	0.3	13.6	1.1	–1.8	–0.8
Total all corporations	738	100.0	4,938.3	100.0	2,971.6	100.0	1,283.6	100.0	229.1	100.0
Total mining										
Reporting corporations										
50 per cent and over non-resident	439	12.0	7,358.4	62.8	4,161.7	57.6	2,415.5	60.1	456.9	55.1
under 50 per cent non-resident	1,094	29.9	4,100.8	35.0	2,910.4	40.3	1,478.3	36.8	378.6	45.7
Total reporting corporations	1,533	41.9	11,459.2	97.8	7,072.1	97.9	3,893.8	96.9	835.5	100.8
Other corporations	2,130	58.1	260.8	2.2	155.5	2.1	123.1	3.1	–6.9	–0.8
Total all corporations	3,663	100.0	11,720.0	100.0	7,227.6	100.0	4,016.9	100.0	828.6	100.0

[1]Corporations include all resident and non-resident dominated corporations in the Canadian corporate community. [2]Assets include cash, receivable, inventories, net fixed assets, investments, etc. [3]Equity represents all issued share capital, retained earnings in the business (or minus any deficit) and other surplus. [4]Sales represent gross revenue derived from the principal source of operations, and from rents, dividends or interest. [5]Profits include operating profits, investment income, capital gains, dividend income etc.

TABLE 68

Canada—Financial Statistics, Mining and Mineral Manufacturing Industries, 1968
($ million)

	Number of Corporations[1]	Assets[2]	Liabilities[3]	Equity[4]	Income[5]	Expense[6]	Net Profit[7]
Mining industry							
Metal mines							
Gold	67	529.8	18.3	511.5	68.2	26.8	43.0
Iron	32	1,463.2	854.2	609.0	298.9	209.9	66.5
Other metal mines	207	2,605.4	729.1	1,876.3	712.1	320.7	305.8
Total	306	4,598.4	1,601.6	2,996.8	1,079.2	557.4	415.3
Nonmetal mines and mining services							
Nonmetal mines	120	1,004.9	378.9	626.0	136.7	55.6	53.6
Quarries	411	136.5	75.5	61.0	53.2	43.3	6.3
Mining services	2,087	1,050.5	408.4	642.2	254.8	225.9	25.9
Total	2,618	2,191.9	862.8	1,329.2	444.7	324.8	85.8
Mineral fuels							
Coal mines	44	130.6	69.2	61.4	13.8	9.5	3.7
Oil and gas wells	694	5,925.5	2,270.4	3,655.1	1,034.2	709.8	277.4
Total	738	6,056.1	2,339.6	3,716.5	1,048.0	719.3	281.1
Total mining industry	3,662	12,846.4	4,804.0	8,042.5	2,571.9	1,601.5	782.2
Mineral manufacturing							
Primary metals							
Iron and steel mills	101	2,369.3	1,024.8	1,344.5	383.4	202.6	136.5
Iron foundries	123	206.2	99.2	107.0	44.2	28.6	8.3
Smelting and refining	161	2,945.7	1,485.6	1,460.2	513.8	192.5	200.3
Total	385	5,521.2	2,609.6	2,911.7	941.4	423.7	345.1
Nonmetallic mineral products							
Cement manufacturing	31	646.8	342.8	304.0	85.0	63.4	8.9
Concrete manufacturing	366	170.0	100.3	69.7	54.7	43.4	7.7
Ready-mix concrete	230	204.7	148.5	56.2	64.6	56.2	5.4
Clay products	77	77.0	38.2	38.8	19.4	13.5	4.6
Glass and glass products	90	175.3	69.0	106.3	35.4	26.4	5.2
Other nonmetallic mineral products	156	254.0	72.8	181.2	83.8	50.8	18.5
Total	950	1,527.8	771.6	756.2	342.9	253.7	50.3

TABLE 68 (Cont'd)

	Number of Corpora-tions[1]	Assets[2]	Liabil-ities[3]	Equity[4]	Income[5]	Expense[6]	Net Profit[7]
Mineral manufacturing (Cont'd)							
Petroleum and coal products							
Petroleum refineries	32	3,052.3	1,228.6	1,823.7	738.4	520.9	165.1
Other petroleum and coal products	23	18.2	2.9	15.3	7.0	4.6	1.9
Total	55	3,070.5	1,231.5	1,839.0	745.4	525.5	167.0
Total mineral manufacturing	1,390	10,119.5	4,612.7	5,506.9	2,029.7	1,202.9	562.4

[1]These corporations do not include certain groups of companies such as tax exempt corporations, co-operatives, credit unions etc. [2]Assets include cash, accounts receivable, inventories, net fixed assets, investments etc. [3]Liabilities include bank and other loans, accounts payable, taxes payable, dividents payable etc. [4]Equity represents all issued share capital, retained earnings in the business (or minus any deficit) and any other surplus. [5]Income refers to all revenues received from sales of products and services, rent and royalties, dividends and interest etc. [6]Expense includes expenditures on buying material and supplies, paying salaries and wages, allowing for depreciation, income taxes etc. [7]Net profit is the amount of income remaining after all expenses and provisions, including income taxes, have been deducted from the total income.

TABLE 69

Canada – Estimated Book Value, Ownership and Control of Capital Employed in the Mineral Industry, 1963-1966

		Foreign Ownership				Foreign Control			
		Investment owned in		Percentage owned in		Investment controlled in		Percentage controlled in	
	Total Capital Employed	United States	Other Foreign Countries	United States	Other Foreign Countries	United States	Other Foreign Countries	United States	Other Foreign Countries
		$ billion		%	%	$ billion		%	%
Petroleum and Natural gas									
1963	7.6	4.0	0.8	53	10	4.6	0.9	61	11
1964	7.9	4.0	0.8	51	11	4.7	1.0	60	12
1965	8.4	4.2	1.0	50	12	4.8	1.3	57	15
1966	9.2	4.7	1.1	50	12	5.4	1.4	53	15
Other mining and smelting									
1963	3.8	2.0	0.3	53	8	2.0	0.3	52	7
1964	4.1	2.1	0.4	51	9	2.1	0.3	51	8
1965	4.4	2.2	0.4	51	8	2.3	0.3	52	8
1966	4.8	2.5	0.4	51	8	2.6	0.4	53	9

Lightweight Aggregates

H. S. WILSON*

For the first time since 1963, the production of lightweight aggregate decreased from the level of the preceding year. The value in 1970 was $7.36 million, 10 per cent lower than in 1969. All the types of lightweight aggregate shared in this loss in business during 1970.

Expanded perlite showed the greatest decrease, 31 per cent in volume and 27 per cent in value. Only two of the nine Canadian plants produced more in 1970 than in 1969. Silbrico Corporation, Hodgkins, Illinois, which uses portable equipment to expand and install cryogenic insulation in Canada produced less than in 1969.

The production of exfoliated vermiculite decreased 11 and 7.5 per cent in volume and value respectively. Two of the producing companies had increased production, whereas four had decreased. In December 1970, the four expanding plants of Grant Industries Division, Eddy Match Company, Limited were purchased by Grace Construction Materials Ltd., Vancouver, British Columbia.

The plants producing expanded clay, shale and slag produced 10 per cent less in volume and 7 per cent less in value in 1970 than in 1969. The plant of Cell-Rock Inc., Laflèche, Quebec, was not in production in 1970. Because National Slag Limited, Hamilton, Ontario, is the sole producer of expanded slag in Canada, its production figures are combined with those of the plants producing expanded clay and shale. Only four of the ten producing plants had increased production during 1970.

The value of pumice used as lightweight aggregate decreased 5 per cent in 1970 compared with 1969.

Table 1 shows the volume and value of the various types of lightweight aggregate produced in Canada in 1969 and 1970. The value of pumice used as lightweight aggregate during the two years is shown.

CONSTRUCTION

The total value of construction in 1970 on a current dollar basis reached a new high of $13.623 billion, an increase of 3.1 per cent above the 1969 value. On a constant 1961 dollar basis, construction decreased 0.7 per cent. Table 2 shows the year-to-year changes in the value of construction from 1961 to 1970 on both a current dollar basis and a constant 1961 dollar basis. Table 3 shows the percentage changes in the different types of construction from 1968 to 1969 and from 1969 to 1970. It also gives the percentage of each type of construction making up the total value for 1968, 1969 and 1970. These figures are all on a current dollar basis.

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*Mineral Processing Division, Mines Branch.

TABLE 1

Production of Lightweight Aggregates 1969-70

	1969 Cubic Yards	1969 $	1970 Cubic Yards	1970 $
From domestic raw materials				
Expanded clay, shale and slag	802,677	3,771,400	725,169	3,512,700
From imported raw materials				
Exfoliated vermiculite	340,400	3,174,600	301,500	2,935,400
Expanded perlite	117,800	1,131,100	73,800	824,200
Pumice		95,000		90,000
Total		8,172,100		7,362,300

Source: Statistics supplied to Mineral Processing Division by producers.

TABLE 2

Annual Value of Construction

Year	Total Value ($ million)	Per Cent Change from Previous Year: Current Dollar Value	Per Cent Change from Previous Year: Constant (1961) Dollar Value
1961	7,086	1.9	3.2
1962	7,343	3.6	2.8
1963	7,715	5.1	2.4
1964	8,662	12.3	9.8
1965	9,929	14.6	7.4
1966	11,235	13.2	6.2
1967	11,620	3.4	2.8
1968	12,214	5.1	2.2
1969	13,207	8.1	2.7
1970p	13,623	3.1	-0.7

Source: Dominion Bureau of Statistics.
p Preliminary.

RAW MATERIAL

The common clays and shales are the most widespread of the raw materials used for the production of lightweight aggregates. All plants obtain such materials locally. All use the rotary-kiln method of production.

Vermiculite is micaceous in appearance, but differs from mica in that it exfoliates or expands in one direction up to 15 times when heated to form a cellular material of low density and high insulating value. The raw vermiculite, sized and concentrated, is imported principally from the United States and in lesser quantities from South Africa.

Perlite is a volcanic rock that expands or 'pops' when heated, to form a white, cellular material of low density and good insulating properties. All the raw material is imported sized from Colorado, New Mexico, and Utah.

Expanded slag is a processed byproduct of the production of pig iron in blast furnaces. It is produced in Canada, in pelletized form, by a patented process that introduces water into the molten slag.

Pumice is a vesicular material of volcanic origin that is used in its natural state as a lightweight

TABLE 3

Construction in Canada 1968-70

Type of Construction	Percentage Change 1968-69	Percentage Change 1969-70	Percentage of Total Value 1968	Percentage of Total Value 1969	Percentage of Total Value 1970
Engineering	+4.0	+8.4	40.6	39.0	41.0
Residential	+17.9	−6.9	29.3	32.0	28.9
Commercial	+0.52	+9.5	9.4	8.7	9.3
Institutional	− 3.3	+0.9	11.3	10.1	9.9
Industrial	+16.8	+14.6	6.1	6.6	7.3
Other building	+17.4	+5.7	3.3	3.6	3.6
Total construction	+8.1	+3.1	100.0	100.0	100.0

aggregate. It is imported into Canada from the western United States and from Greece.

Table 4 lists the lightweight aggregate plants, both producing and non-producing, during 1970.

Tables 5, 6 and 7 give a break down of end-use consumption of expanded clay and shale, exfoliated vermiculite and expanded perlite.

In a departure from previous years, in which over 98 per cent of expanded slag was used in concrete block, in 1970 the quantity used for that purpose decreased to 88 per cent. Structural concrete consumed 11.5 per cent and 0.5 per cent was used as loose insulation.

All pumice imported as lightweight aggregate is used in concrete block.

TABLE 4

Lightweight Aggregate Plants in Canada

Company	Location
Producing Plants	
Expanded clay	
Cindercrete Products Limited	Regina, Sask.
Echo-Lite Aggregate Ltd.	St. Boniface Man.
Edmonton Concrete Block Co. Ltd.	Edmonton, Alta.
Kildonan Concrete Products Ltd.	St. Boniface, Man.
Redi-Mix Concrete Ltd.	Regina, Sask.
Expanded shale	
Avon Aggregates Ltd.	Minto, N.B.
British Columbia Lightweight Aggregates Ltd.	Saturna Island, B.C.
Consolidated Concrete Limited	Calgary, Alta.
Domtar Construction Materials Ltd.	Cooksville, Ont.
Expanded slag	
National Slag Limited	Hamilton, Ont.
Vermiculite	
Eddy Match Company, Limited, Grant Industries Division (Now Grace Construction Materials Ltd.)	Vancouver, B.C. Calgary, Alta. Regina, Sask. Winnipeg, Man.
F. Hyde & Company, Limited	Montreal, Que. St. Thomas, Ont.
Northern Perlite & Vermiculite Products	St. Boniface, Man.
Vermiculite Insulating Limited	Lachine, Que.
Western Gypsum Limited	Vancouver, B.C.
Western Insulation Products Ltd.	Edmonton, Alta.
Perlite	
Canadian Gypsum Company, Limited	Hagersville, Ont.
Domtar Construction Materials Ltd.	Caledonia, Ont. Calgary, Alta.
Holmes Insulations Limited	Sarnia, Ont.
Laurentide Perlite Inc.	Charlesbourg West, Que.
Northern Perlite & Vermiculite Products	St. Boniface, Man.
Perlite Industries Reg'd.	Ville St. Pierre, Que.
Western Gypsum Limited	Vancouver, B.C.
Western Insulation Products Ltd.	Edmonton, Alta.
Pumice	
Miron Company Ltd.	Montreal, Que.
Ocean Cement Limited	Vancouver, B.C.
Non-Producing Plants	
Cell-Rock Inc.	Laflèche, Que.
Sydney Steel Corporation	Sydney, N.S.

TABLE 5

Consumption of Expanded Clay and Shale

	1968	1969	1970
Concrete:			
block	74%	68%	61%
precase structural	2	2	5
cast-in-place structural	22	29	30
Minor uses:			
sand blasting, horticulture, refractories, insulation, brick grog, flexible pavement	2	1	4

TABLE 6

Consumption of Exfoliated Vermiculite

	1968	1969	1970
Loose insulation	75%	71%	63%
Insulating plaster	11	11	14
Insulating concrete	8	7	11
Minor uses:			
fireproofing, agriculture, underground pipe insulation, horticulture, barbecue base	6	11	12

TABLE 7

Consumption of Expanded Perlite

	1968	1969	1970
Insulating plaster	42%	52%	62%
Insulation	25	34	17
	(20)*	(18)*	(2)*
Industrial fillers	10	7	10
Insulating concrete	11	4	7
Minor uses:			
agriculture, horticulture	12	3	4

*Cryogenie insulation produced in Canada by Silbrico Corp.

PRICES

Expanded clay and shale	$4.50 to $7.67/cu yd
Expanded slag	$3.50/ton
Exfoliated vermiculite	$0.30 to 0.42/cu ft
Expanded perlite	$0.30 to 0.40/cu ft

All prices are f.o.b. plant.

Aluminum

D. PEARSON*

World demand for aluminum was strong during the first six months of 1970 but declined during the second half of the year because of a general weakening of manufacturing activity and a strike at General Motors Corporation's automobile plants in the United States and Canada. Demand is expected to pick up in the second or third quarter of 1971 and to be well maintained throughout 1972.

CANADIAN INDUSTRY

Bauxite, the ore from which aluminum is made, has not been found in economic concentrations in Canada. Occurrences, of mineralogical interest only, have been noted at Steep Rock Lake in Ontario and at Sooke, British Columbia. Bauxite was formed under tropical or sub-tropical conditions by the weathering and leaching (laterization) of rocks containing high concentrations of aluminum oxide. Alumina is usually extracted from bauxite in the Bayer process and, after drying, is smelted in reduction cells to aluminum. In round figures 4 tons of bauxite makes 2 tons of alumina which in turn is smelted electrically to produce 1 ton of aluminum. The industry consumes vast amounts of electrical power so that aluminum smelters are generally located near low-cost power. Tidewater port facilities are essential to minimize the cost of transporting raw materials to the smelter and of shipping aluminum to market areas, which are predominantly outside of Canada.

PRODUCTION

Primary aluminum production in Canada was 1,071,718 short tons in 1970, about 7,000 tons less than that produced in 1969. The two primary producers, Aluminum Company of Canada, Limited (Alcan), and Canadian Reynolds Metals Company, Limited, operated at well below full capacity during the year. Detailed production and trace statistics are shown in Table 1.

Alcan's five smelters in Canada produced 903,000 short tons of aluminum compared to 969,000 tons in 1969. There was a 15-week strike at the Kitimat smelter which contributed to this reduction. For the first time in Alcan's history, shipments of semi-fabricated products exceeded 50 per cent of total aluminum product shipments. Almost two-thirds of the company's metal sales in 1970 went to captive outlets. Alcan is a wholly-owned subsidiary of Alcan Aluminium Limited, an international company based in Montreal and one of the leading fully-integrated companies in the world aluminum industry. It has smelters in nine countries (Canada, Australia, Brazil, India, Italy, Japan, Norway, Sweden and Spain). Construction of a new smelter at Lynemouth in England was delayed because of work stoppages among the construction workers during the year.

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*Mineral Resources Branch.

TABLE 1

Canada, Aluminum Production and Trade, 1969-70

	1969		1970p	
	Short Tons	$	Short Tons	$
Production				
Ingot	1,078,647		1,071,718	
Imports				
Bauxite ore				
Guyana	1,797,782	15,844,000	2,280,583	19,343,000
Surinam	532,491	6,641,000	174,418	3,288,000
Malaysia	116,508	602,000	176,234	890,000
Australia	–	–	35,595	535,000
United States	7,339	200,000	5,712	231,000
Other countries	37,039	179,000	111,287	584,000
Total	2,491,159	23,466,000	2,783,829	24,871,000
Alumina				
United States	233,399	17,096,000	385,479	27,385,000
Jamaica	588,052	40,822,000	348,945	24,531,000
Australia	76,782	5,430,000	182,578	12,868,000
Guyana	142,693	9,672,000	89,657	6,096,000
Other countries	22,098	1,486,000	33,166	2,156,000
Total	1,063,024	74,506,000	1,039,825	73,036,000
Aluminum and aluminum alloy scrap	15,579	4,970,000	5,732	1,683,000
Aluminum paste and aluminum powder	941	715,000	1,120	739,000
Aluminum pigs, ingots, shots, slabs, billets, blooms, and extruded wire bars	11,531	2,258,000	13,425	8,612,000
Aluminum castings	1,385	3,470,000	810	2,288,000
Aluminum forgings	1,273	2,642,000	898	2,879,000
Aluminum bars and rods, n.e.s.	1,316	1,427,000	756	908,000
Aluminum plates	13,400	9,517,000	12,306	8,335,000
Aluminum sheet and strip up to .025 inch in thickness	9,653	7,673,000	9,891	7,789,000
Aluminum sheet and strip, over .025 inch up to .051 inch in thickness	3,853	3,717,000	2,875	2,662,000
Aluminum sheet and strip, over .051 inch up to 1.25 inch in thickness	47,678	28,700,000	42,662	24,572,000
Aluminum sheet and strip over .125 inch in thickness	13,167	8,265,000	13,068	7,795,000
Aluminum foil or leaf	527	651,000	733	886,000
Converted aluminum foil	–	1,986,000	–	2,374,000
Structural shapes, aluminum	1,722	3,508,000	2,198	5,372,000
Aluminum pipe and tubing	508	948,000	766	1,347,000
Aluminum wire and cable, excluding insulated	993	1,003,000	1,109	1,147,000
Aluminum and aluminum alloy fabricated materials, n.e.s.	–	5,477,000	–	3,486,000
Exports				
Pigs, ingots, shot, slab, billets, blooms, and extruded wire bars				
United States	408,921	201,486,000	324,799	159,902,000
Britain	128,829	73,192,000	185,292	108,297,000
Japan	130,242	60,738,000	91,166	40,289,000
South Africa	39,546	21,705,000	44,765	25,414,000
West Germany	31,081	14,394,000	33,932	16,221,000
Belgium and Luxembourg	6,613	3,489,000	18,638	10,390,000
Argentina	17,434	9,276,000	17,458	9,473,000

TABLE 1 (Cont'd)

	1969		1970P	
	Short Tons	$	Short Tons	$
Exports (Cont'd)				
Italy	11,694	6,041,000	14,674	7,634,000
New Zealand	9,068	4,838,000	13,099	7,310,000
Pakistan	2,430	1,316,000	10,502	5,852,000
France	2,957	1,624,000	10,015	5,688,000
Spain	19,599	10,235,000	8,519	4,903,000
Netherlands	9,577	5,340,000	7,305	3,855,000
Brazil	18,147	9,451,000	7,221	3,802,000
Yugoslavia	1,101	600,000	6,168	3,256,000
Other countries	49,449	26,430,000	46,045	25,396,000
Total	886,688	450,155,000	839,598	437,682,000
Castings and forgings				
United States	2,484	3,384,000	2,677	4,131,000
Netherlands	35	811,000	7	180,000
Britain	4	11,000	112	72,000
Other countries	22	108,000	7	89,000
Total	2,545	4,314,000	2,803	4,472,000
Bars, rods, plates, sheet, circles, castings and forgings				
United States	7,537	5,965,000	3,241	2,753,000
New Zealand	3,778	2,242,000	2,919	1,747,000
South Africa	1,840	1,035,000	2,113	1,246,000
Jamaica	667	574,000	811	648,000
Algeria	385	240,000	881	558,000
Panama	156	139,000	429	375,000
Portugal	387	206,000	559	321,000
Peru	35	24,000	257	189,000
Colombia	–	–	224	176,000
Other countries	4,159	3,616,000	1,155	1,185,000
Total	18,944	14,041,000	12,589	9,198,000
Foil				
United States	151	213,000	213	251,000
Mexico	15	22,000	22	37,000
Trinidad and Tobago	7	11,000	5	9,000
Ireland	9	7,000	7	6,000
Jamaica	1	3,000	2	3,000
Other countries	37	62,000	9	8,000
Total	220	318,000	258	314,000
Fabricated materials, n.e.s.				
United States	3,841	3,508,000	3,724	3,628,000
Peru	204	143,000	515	385,000
Trinidad and Tobago	209	137,000	533	336,000
Brazil	175	160,000	220	178,000
Panama	565	498,000	157	145,000
Other countries	1,332	1,477,000	2,130	2,299,000
Total	6,326	5,923,000	7,279	6,971,000

TABLE 1 (Cont'd)

	1969		1970P	
	Short Tons	$	Short Tons	$
Exports (Cont'd)				
In ores and concentrates				
United States	13,459	1,421,000	17,195	1,926,000
Spain	1,508	297,000	1,067	182,000
Norway	143	22,000	145	23,000
Venezuela	–	–	54	8,000
Australia	81	24,000	33	6,000
Other countries	5,115	592,000	5,283	654,000
Total	20,306	2,356,000	23,777	2,799,000
Scrap				
United States	35,141	10,580,000	32,974	11,232,000
Italy	11,152	4,535,000	9,180	3,859,000
West Germany	2,841	1,125,000	2,263	873,000
Spain	194	42,000	673	133,000
Britain	132	56,000	304	136,000
Other countries	2,457	942,000	918	336,000
Total	51,917	17,280,000	46,312	16,569,000

Source: Dominion Bureau of Statistics.
PPreliminary; – Nil; n.e.s. Not elsewhere specified.

TABLE 2

Canada, Primary Aluminum Production, Trade and Consumption, 1961-70
(short tons)

	Production	Imports	Exports	Consumption*
1961	663,173	636	487,034	135,575
1962	690,297	3,855	576,206	151,898
1963	719,390	1,954	635,187	161,833
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	862,633	242,390
1969	1,078,647	11,531	886,688	269,027r
1970P	1,071,718	13,425	839,598	275,743

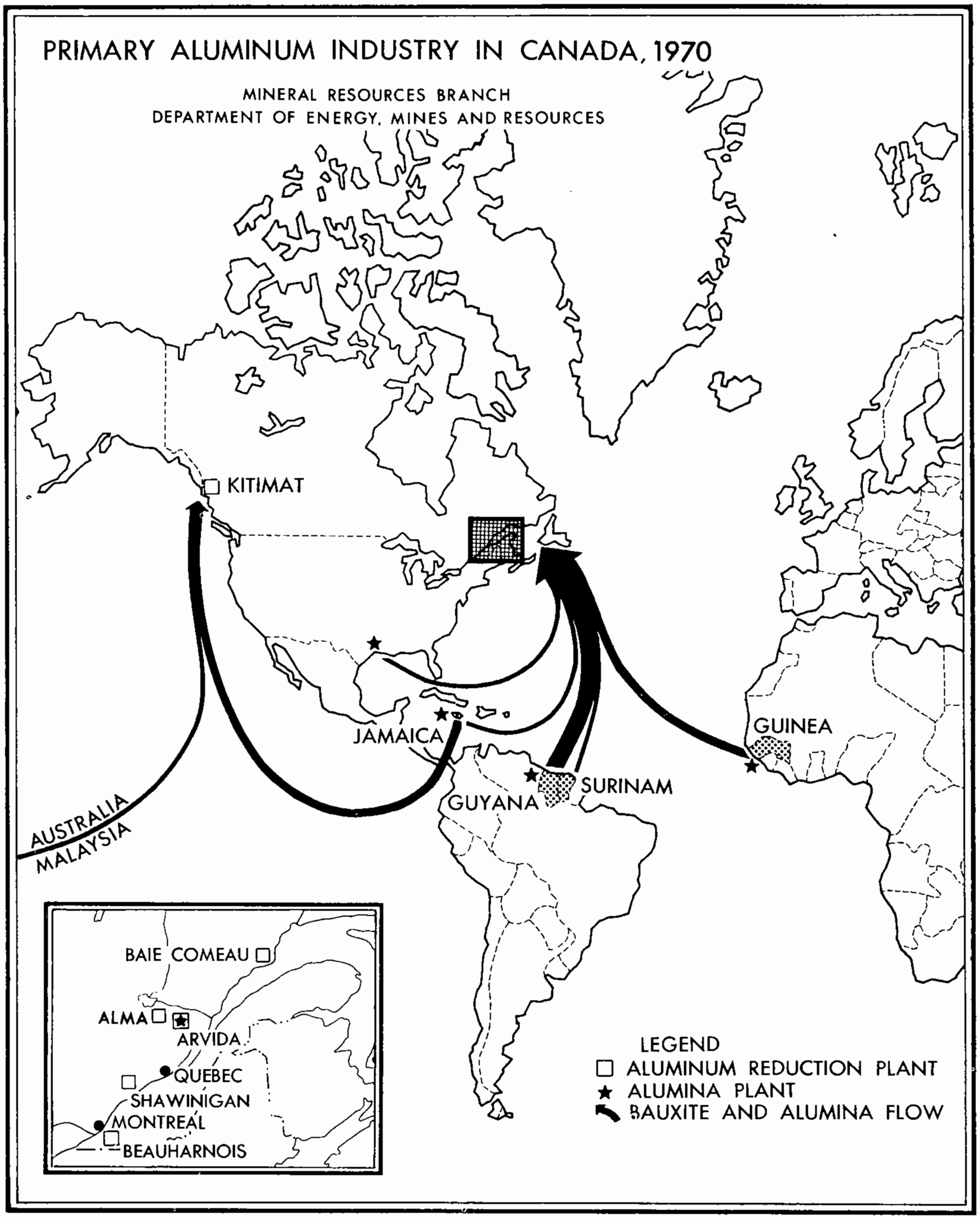
Source: Dominion Bureau of Statistics.

*Including secondary as reported by consumers.
PPreliminary; rRevised.

Canadian British Aluminium Company Limited changed its name to Canadian Reynolds Metals Company, Limited on July 31, 1970. Capacity at the company's smelter at Baie Comeau, Quebec was increased to 175,000 tons a year from 115,000 tons; total output in 1970 was about 169,000 tons. The U.S. based Reynolds group is the second largest aluminum fabricator in Canada after Alcan.

Noranda Aluminum Inc., a wholly-owned subsidiary of Noranda Mines Limited, a Canadian company, is expected to produce its first aluminum early in 1971 from a smelter in New Madrid, Missouri. This 70,000-ton-a-year smelter will use alumina supplied by Kaiser Aluminum & Chemical Corporation. On the same site, a rod, wire and cable mill with an ultimate capacity of 25,000 tons a year has been in operation since late 1969.

The geographic locations of Canadian smelters in relation to ore supply are shown on the accompanying map. Canada's only alumina plant is located at the site of Alcan's Arvida smelter. Alumina from this plant helps supply Alcan's Quebec smelters. Its capacity is some 5 million tons of bauxite a year, or 1.25 million tons of alumina. Bauxite for this plant, for many years, came from Guyana. However, two factors have caused a decline in Alcan's use of this country's ore in favour of other sources: Guyanian ore has become less economic to extract because of a greater weight of overburden, and nationalization of the bauxite deposits has become imminent. The Guyanese government carried out negotiations with Alcan early in 1971 aimed at nationalizing Alcan's holdings, and announced that nationalization would be implemented on


PRIMARY ALUMINUM INDUSTRY IN CANADA, 1970
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
KITIMAT
JAMAICA
GUYANA
SURINAM
GUINEA
AUSTRALIA
MALAYSIA
BAIE COMEAU
ALMA
ARVIDA
QUEBEC
SHAWINIGAN
MONTREAL
BEAUHARNOIS
LEGEND
ALUMINUM REDUCTION PLANT
ALUMINA PLANT
BAUXITE AND ALUMINA FLOW

July 15, 1971. Bauxite from Jamaica, Guinea and Australia has been gradually replacing the Guyana product and was processed at the Arvida plant during 1970. Alumina from Jamaica, Guyana and Australia has supplied Alcan's additional requirements, particularly those of the Kitimat smelter. Alumina for the Canadian Reynolds' plant comes from Guinea and the parent company's Corpus Christi plant in the United States that processes Jamaican ore.

Capacities of the Canadian plants are shown in Table 5.

CONSUMPTION

Consumption of aluminum at the first processing stage in Canada for 1970 and the three preceding years may be seen in Table 3. Total consumption of primary aluminum increased 2.5 per cent over that of 1969 due to a 5.2 per cent increase in wrought products production. The building industry, transportation and packaging markets are mainly responsible for this increase. These areas have shown strength for several years. Secondary aluminum use was down 13.7 per cent in 1970. Producer's domestic shipments of primary aluminum in 1970 totalled 235,300 tons, a slight increase over that of 1969. In the United States there was a decline of 9 per cent whereas in Europe there was an increase of 9 per cent in consumption in 1970. The decline in the United States was due in part to the General Motors strike which also affected Canadian industry.

TABLE 3

Canada, Consumption of Aluminum at First Processing Stage
(short tons)

	1967	1968	1969	1970p
Castings				
Sand	1,685	1,614	1,578	1,596
Permanent-mould	10,686	12,325	12,262	11,574
Die	17,481	19,747	22,670	19,546
Other	62	92	103	73
Total	29,914	33,778	36,613r	32,789
Wrought products				
Extrusions, including tubing	51,721	61,260	69,653	64,145
Sheet, plate, coil and other (including rod, forgings and slugs)	126,589*	135,960	151,508r	168,521
Total	178,310	197,220	221,161r	232,666
Destructive uses				
Non-aluminum-base alloys, powder and paste, deoxidizers and other	9,260	11,392	11,253	10,288
Total consumed	217,484	242,390	269,027r	275,743
Secondary aluminum consumed	34,396	35,265	34,787r	30,035

Receipts and Inventories at Plants	Metal Entering Plants		On Hand Dec. 31	
	1969	1970p	1969	1970p
Primary aluminum ingot and alloys	245,133r	242,930	53,352r	56,211
Secondary aluminum	23,403r	20,613	1,960r	1,834
Scrap originating outside plant	59,697	35,925	14,809	4,950

Source: Dominion Bureau of Statistics.

*Includes reroll stock imported from United States.

pPreliminary; rRevised.

WORLD INDUSTRY AND USES

World production of bauxite in 1970 was 63.7 million tons. The non-communist countries produced 54.4 million tons, compared with the 50.6 million tons mined in 1969. There were 29 producing countries of which Jamaica and Australia were the largest producers with 12 million and 10.3 million tons respectively. Guyana which produced 4.75 million tons was the source of about 30 per cent of Alcan's requirements.

Expansion of bauxite mining continued throughout the world in 1970. The largest expansion has taken place in Australia where various consortiums have developed three bauxite deposits in the north and one in the south of the country. Australia's bauxite reserves are considered the largest in the world. Deposits are also being developed in Ghana, Brazil, the Solomon Islands, the Indonesian island of Bintan, and Haiti.

Metal grade bauxite specifications call for a minimum permissible alumina content of about 40 per cent and a 5 per cent maximum silica content. Iron and titanium oxides and other impurities should be kept to a minimum. The alumina content should preferably be in the form of the mineral gibbsite ($Al_2O_3 . 3H_2O$) which requires less costly treatment to extract the alumina. Boehmite and diaspore are the other low silica minerals of commercial interest, but extraction of the alumina from these ores requires stronger caustic solutions as well as higher temperatures and pressures. The United States National Materials Advisory Board has shown interest in minerals other than bauxite for alumina production. It is known that some Russian producers are using such materials but in addition to alumina, phosphates and other chemicals are extracted which makes the recovery of alumina from these minerals economic.

TABLE 4

World Primary Aluminum Production and Consumption, 1970
(thousand short tons)

	1970	
	Production	Consumption
Canada	1,061	235
United States	3,976	3,735
Europe	2,186	2,868
Japan	808	1,015
Australia	225	131
India	177	182
Africa	177	80
Sub-total (includes countries not listed)	8,822	8,413
Communist countries	2,146	2,041
Total	10,968	10,454

Source: American Bureau of Metal Statistics for 1970.

TABLE 5

Aluminum Smelter Capacity in Canada
Year-end 1970
(thousand short tons)

Company and Plant Location	Capacity
Aluminum Company of Canada, Limited	
Arvida, Quebec	435
Beauharnois, Quebec	45
Ile Maligne, Quebec	130
Shawinigan, Quebec	90
Kitimat, British Columbia	300
Sub-total	1,000
Canadian Reynolds Metals Company, Limited	
Baie Comeau, Quebec	175
Total	1,175

Primary aluminum production throughout the world rose from 10.1 million short tons in 1969 to almost 11 million tons in 1970 or by about 8.6 per cent. Canada, with a production of 1.1 million tons ranked third among world producers after the United States and Russia.

Eight new smelters were under construction or started operations during 1970. Because of reduced demand in the last quarter of the year, brought about by an economic slowdown, producers curtailed production and delayed construction programs in order to balance supply against demand. Aluminum requirements dropped in all fields except the containers and packaging market; in the United States this market was 19 per cent greater than in 1969. By the end of 1970, demand in the construction and transportation industries was strengthening.

Canada and Norway, the world's major exporters of aluminum ingot, suffered a decline in export sales as a result of reduced demands in 1970 for ingot in the United States, Japan and some European countries, such as Spain, the Netherlands and Eire. There are three smelters under construction in Britain which will add about 155,000 short tons to world production in 1971. Japan's annual production in 1970 rose 28.8 per cent to 808,000 tons and that country is moving rapidly toward self sufficiency. Canada supplied 276,458 tons of aluminum to these two countries in 1970. The immediate outlook is for some over-capacity in the world aluminum industry. During the 60's, consumption grew at a rate of 8 per cent annually, and it is expected to continue to grow at a satisfactory rate throughout the 70's.

In 1970 the United States continued to be the largest single market for Canadian aluminum. Canadian exports to this market totalled 367,628 tons or about 80 per cent of the amount exported in 1969. Eighty-nine per cent of Canadian exports to the United States in both 1969 and 1970 was in the form of ingot or pig.

USES

The intrinsic characteristics of aluminum such as lightness combined with strength, corrosion resistance, conductivity and heat reflectivity make it an ideal metal for use where these and other characteristics are desired. It may be cast, rolled, extruded and forged with comparative ease for applications ranging from electric irons for the home to decorative curtain walls on buildings and automobile trim. It finds uses as an alloying material with other metals, as a deoxidizer in the steel industry and as powder in the manufacture of paint. It is estimated that in the United States in 1970, 22 per cent was used for building and construction, 15 per cent for transportation, 15 per cent for containers and packaging, 13 per cent in the electrical industry, 9 per cent for consumer durables, 6 per cent for machinery and equipment, and 8 per cent for miscellaneous uses. Twelve per cent was exported. Containers and packaging continued to be the fastest growing segment of the market. A greater share of the market for transportation equipment is being actively pursued by all producers. The 1971 Chevrolet's Vega engine block is all aluminum weighing 36 pounds.

PRICES

On April 14 United States producers raised the price of 99.5 per cent aluminum ingot from 28 cents a pound, the price which had been in effect since October 13, 1969, to 29 cents a pound. In Canada, the base price for the same grade of aluminum ingot was 29.5 cents per pound throughout the year.

TARIFFS

CANADA Item No.		British Preferential	Most Favoured Nation	General
32910-1	Bauxite	free	free	free
35-301-1	Aluminum, pigs, ingots, blocks, notch bars, slabs, billets, blooms, and wire bars – per lb (effective Jan. 1, 1968)	free	1¢	5¢
35302-1	Aluminum, bars, rods, plates, sheets, strips, circles, squares, discs and rectangles – per lb (effective June 4, 1969)	free	2¢	7.5¢
35-303-1	Aluminum, channels, beams, ties and other rolled, drawn or extruded sections and shapes (effective June 4, 1969)	free	12½¢	30%
35305-1	Aluminum pipes and tubes (effective June 4, 1969)	free	12½¢	30%
	Various tariffs are in effect on more advanced forms of aluminum			

UNITED STATES		
601.06	Bauxite	
	On and after Jan. 1, 1970	20¢ per lt
	On and after Jan. 1, 1971	10¢ per lt
	On and after Jan. 1, 1972	free
	(Duty suspended until July 15, 1971)	
618.01	Unwrought aluminum, in coils, uniform cross-section not greater than 0.375 inch	
	On and after Jan. 1, 1970	1.7¢ per lb
	On and after Jan. 1, 1971	1.5¢ per lb
	On and after Jan. 1, 1972	1.2¢ per lb

TARIFFS (Cont'd)

618.2	Unwrought aluminum, other, excluding alloys	
	On and after Jan. 1, 1970	1¢ per lb
	On and after Jan. 1, 1971	1¢ per lb
	On and after Jan. 1, 1972	1¢ per lb
618.04 and 618.06	Unwrought aluminum alloy, aluminum silicon, and other aluminum alloys	
	On and after Jan. 1, 1970	1¢ per lb
	On and after Jan. 1, 1971	1¢ per lb
	On and after Jan. 1, 1972	1¢ per lb
618.10	Aluminum scrap	
	On and after Jan. 1, 1970	1¢ per lb
	On and after Jan. 1, 1971	0.9¢ per lb
	On and after Jan. 1, 1972	0.7¢ per lb
	(Duty suspended until 30 June, 1971)	
	Various tariffs are in effect on the more advanced fabricated forms of aluminum	

Sources: **Canada**
The Customs Tariff and Amendments, Department of National Revenue, Custom and Excise Division

United States
Tariff Schedules of the United States, Annotated (1971)
TC Publication 344

Antimony

J.G. GEORGE*

Canada's production of antimony is derived as a byproduct of lead smelting operations, principally in the form of antimonial lead, but also as antimonial dross. There has been no production of antimony metal or regulus in Canada since 1944. The antimony content of primary antimonial lead produced in 1970 was 0.72 million pounds compared with 0.82 million pounds in 1969.

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 Mainland 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 1970 totalled 844,500 pounds of which almost 87 per cent came from Britain and the remainder from the United States. Statistics on exports of antimonial lead are not available.

Cominco Ltd., which operates a lead smelter and refinery and an electrolytic zinc plant 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 East Coast Smelting and Chemical Company Limited, a subsidiary of Brunswick Mining and Smelting Corporation Limited, which operates an Imperial Smelting Furnace (ISF) lead-zinc plant at Belledune, New Brunswick. Secondary smelters recovered antimonial lead from scrap metal but no recent information is available concerning this production.

DOMESTIC SOURCES AND OCCURRENCES

The source of most of the antimonial lead produced at Trail is 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 electrolytic refining of the 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 East Coast plant produced 14 short tons** of antimonial dross in 1970, compared with 499 tons in 1969, together with an unspecified quantity of antimonial lead alloy.

Several Canadian occurrences or deposits of the principal antimony mineral, stibnite (Sb_2S_3), have been explored and partially developed, but results generally have not been encouraging. The better known occurrences are in the Atlantic Provinces, Quebec, British Columbia and the Yukon Territory. Proven and probable reserves of Yukon Antimony Corporation Ltd. were reported in 1965 to be 100,000 and 250,000 tons, respectively, averaging 5 per cent antimony. These deposits are on Carbon and Chieftain Hills in the Wheaton River district of the Yukon Territory, about 55 miles southwest of Whitehorse. Late in 1970, Consolidated Durham Mines & Resources Limited announced that it would bring into

*Mineral Resources Branch.

**The short ton (2,000 pounds avoirdupois) is used throughout this review, unless otherwise specified.

production its Lake George area antimony property about 25 miles west of Fredericton, New Brunswick. Extensive diamond drilling of this old deposit in 1970 reportedly indicated more than 100,000 tons averaging 7 per cent antimony in a section of one of the known veins. Construction of a concentrator with a capacity of 400 tons of ore a day was also under consideration, and the company hoped to have the mine in operation by late 1971.

TABLE 1

Antimony–Canadian Production, Imports and Consumption, 1969-70

	1969		1970P	
	Pounds	$	Pounds	$
Production				
Antimony content of				
antimonial lead alloys	820,122	508,476	716,000	1,131,300
Imports				
Antimony oxide				
Britain	579,600	270,000	731,500	734,000
United States	143,400	63,000	113,000	104,000
Mainland China	66,400	25,000	–	–
Total	789,400	358,000	844,500	838,000
Comsumption				
Antimony regulus (metal)				
in production of:				
Antimonial lead alloys	803,454		..	
Babbitt	145,779		..	
Solder	22,127		..	
Type metal	188,800		..	
Other commodities*	145,582		..	
Total	1,305,742		..	

Source: Dominion Bureau of Statistics.
* Includes foil, bronze, lead-base alloys, drop shot and other minor commodities.
PPreliminary; – Nil; .. Not available.

WORLD REVIEW

World mine production of antimony in 1970, as estimated by the United States Bureau of Mines, totalled 77,600 short tons, 5,600 tons more than in 1969. Antimony is produced from ores and as a smelter byproduct in several countries with the major sources being the Republic of South Africa, Mainland China, Bolivia, USSR, Mexico, Turkey and Yugoslavia. National Lead Company 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 antimony ores. Recovery of antimony in the treatment of antimonial lead scrap is a major source of supply. This secondary supply represents a substantial portion of total antimony supply in the United States and other highly industrialized countries of the world.

The spectacular rise in antimony ore, metal and oxide prices that began in 1969 continued until the first quarter of 1970, when they reached alltime record highs. Subsequently, they levelled off and later began to decline. The decrease resulted mainly from considerably reduced consumption, for which there were two main causes. First, when prices began to rise in 1969, many lead-acid battery manufacturers began to reduce the percentage of antimony contained in battery lead alloys; in the latter part of 1970 the antimony content of battery alloys was not much more than 4 per cent, as against antimony content as high as 11 per cent in the recent past. Secondly, whilst the battery market for antimony was to some extent adversely affected by the General Motors strike and the recession in the economy of the United States and other countries, demand for many of the other important antimony metal and oxide products was considerably reduced as a result of the slower pace of business in 1970.

TABLE 2

Antimony–Canadian Production, Imports and Consumption, 1961-70
(pounds)

	Production* (all forms)	Imports (regulus)	Consumption** (regulus)
1961	1,331,297	832,547	1,029,000
1962	1,931,397	1,275,917	1,211,000
1963	1,601,253	1,036,235	976,000
1964	1,591,523	..	558,000
1965	1,301,787	..	660,000
1966	1,405,681	..	1,098,000
1967	1,267,686	..	1,190,000
1968	1,159,960	..	1,169,000
1969	820,122	..	1,306,000
1970p	716,000	..	..

Source: Dominion Bureau of Statistics.
*Antimony content of antimonial lead alloy shipped.
**Consumption of antimony regulus (metal) as reported by consumers. Does not include antimony in antimonial lead produced by Cominco Ltd.
pPreliminary; . .Not available.

The substantial rise in mine output of antimony in 1970 also was a significant factor in the price decline during the year. All of the major and many of the minor producing countries registered gains in output. In addition to the expansions, the high ore prices enhanced interest in low-grade antimony occurrences throughout the world in 1969-70. A number of deposits were high-graded for saleable antimony ores and at other properties plans were made to develop previously uneconomic antimony deposits. However, with the recent attrition in antimony prices, it is now uncertain just what percentage of such new production will eventually find its way to the market. As a result of the much stronger demand and higher prices that prevailed in 1969 and the first half of 1970, existing facilities for producing antimony metal and oxide were expanding in some countries including the United States. In Malaysia, a new $3 million antimony smelter was under construction at Buso, about 22 miles from Sarawak. It was scheduled to begin operations about mid-July 1971 with a capacity of some 12,000 metric tons of ore monthly. Output from these various new sources was, however, offset to some extent by the suspension of operations by a leading Japanese antimony refinery. The plant, owned by Hibino Metal Industry Company, suspended production late in August 1970 following complaints that its operation was causing air and water pollution. The plant produced some 300 metric tons of antimony per month and accounted for about 60 per cent of Japan's output.

Supplies from Mainland China continued to be an important question mark in the antimony market. Only small quantities were available from China in 1970, and at high prices. If there ever was a real motive for Chinese sales it certainly was the much higher prices that obtained in much of 1969 and 1970.

The United States in 1970 was again the non-communist world's largest consumer of antimony and continued to depend on foreign supplies for a large portion of its requirements. Its consumer requirements have been said to be about 40 per cent of the world supply, in addition to what it can secure from its scrap reclamation. However, as a result of the much higher prices, extensive substitution of other materials was indicated for some of antimony's uses, mainly in the pigments, plastics and rubber manufacture. Antimony metal contained in the United States Government stockpile, for convential war requirements, totalled 46,746 tons as at December 31, 1970, unchanged from that at the beginning of the same year. Because of the severe shortage of antimony that existed early in 1970, the United States Office of Emergency Preparedness (OEP) early in April of that year reduced the stockpile objective, for non-nuclear requirements, from 50,500 to 40,700 tons. This revision resulted in a stockpile surplus of some 6,000 tons for which General Services Administration (GSA) proposed legislative disposal authorization. However, no definite action was taken by Congress and, accordingly, no stockpile sales occurred in 1970. The OEP announcement also exerted a downward pressure on antimony prices.

OUTLOOK

The world outlook for antimony appears to be favourable, with a steady demand expected to prevail during the next few years. The growing requirements as a flame retardant and the continuing use for antimonial-lead alloys should offset any decline in some of the metal's historical uses.

For the near term, the market should be more stable than in 1969-70. Prices are not expected to return to the high levels of late 1969 and early 1970, but inflation and greater exploration and mining costs should prevent them from falling back to the levels of two years ago. What quantity, if any, of antimony will be made available by Mainland China could affect the overall market behaviour. Another unsettling factor is the 6,000 tons of surplus antimony, in the United States government stockpile, which overhangs the market.

TABLE 3

Canadian Consumption of Antimonial Lead Alloy*, 1968-70
(pounds)

	1968	1969	1970^p
Storage batteries	1,975,184	2,155,677	..
Other uses, including babbitt, solder, type metal	149,719	166,093	..
Total	2,124,903	2,321,770	..

Source: Dominion Bureau of Statistics.
*Antimony content of primary and secondary antimonial lead alloys.
pPreliminary; . .Not available.

TABLE 4

Canadian Consumption of Antimonial Lead Alloy*, 1961-70
(pounds)

1961	2,494,220
1962	2,662,400
1963	2,688,157
1964	2,506,454
1965	2,775,241
1966	2,593,733
1967	2,496,032
1968	2,124,903
1969	2,321,770
1970^p	..

Source: Dominion Bureau of Statistics.
*Antimony content of primary and secondary antimonial lead alloys.
pPreliminary; . .Not available.

USES

The principal use of antimony is as an ingredient in many lead alloys in which it hardens and strengthens lead and inhibits chemical corrosion. It is also used in the form of oxides and salts. Antimonial lead containing from 3 to 12 per cent antimony is used in the manufacture of lead storage batteries. Although this use remained a major outlet for antimony metal, the quantities required continued the downward trend of recent years mainly because of the continued reduction in the antimony content of the antimonial lead consumed. Antimonial lead alloys are also used for sheathing electric cables and in pipe and sheet. Various other alloys containing antimony, lead and other metals are used in the production of type metal, anti-friction bearing metal and solder.

TABLE 5

World Mine Production of Antimony, 1968-70
(short tons)

	1968	1969^p	1970^p
Republic of South Africa	18,514	20,080	22,000
Bolivia	12,276	14,484	16,000
Mainland China^e	13,200	13,200	*
USSR^e	7,200	7,300	*
Mexico	3,819	3,471	4,000
Turkey	3,446	2,811	*
Yugoslavia	1,935	2,246	2,300
Morocco	1,336	1,551	*
Italy	865	1,272	*
Peru	900	944	*
United States	856	938	1,300
Australia	931	933	*
Canada	580	410	358
Other countries	1,879	2,406	31,642
Total	67,737	72,046	77,600

Sources: Dominion Bureau of Statistics for Canada for all three years; Minerals Yearbook 1969, United States Department of the Interior, for other 1968 and 1969 figures; and Commodity Data Summaries, January 1971, Bureau of Mines, United States Department of the Interior, for other 1970 figures.
*Included in "Other countries".
pPreliminary; eEstimated.

Antimony oxide. Sb_2O_3, usually produced directly from high-grade sulphide ore (containing 60 per cent or more antimony), is used extensively as a flameproofing additive in paints, plastics and fabrics. The trioxide is also used in metalware and ceramic enamels, and as a white pigment in paints. In the ceramic field, antimony adds hardness and acid resistance to enamel coverings for such products as bathtubs, sinks, and refrigerators. The pentasulphide of antimony is employed as a vulcanizing agent by the rubber industry.

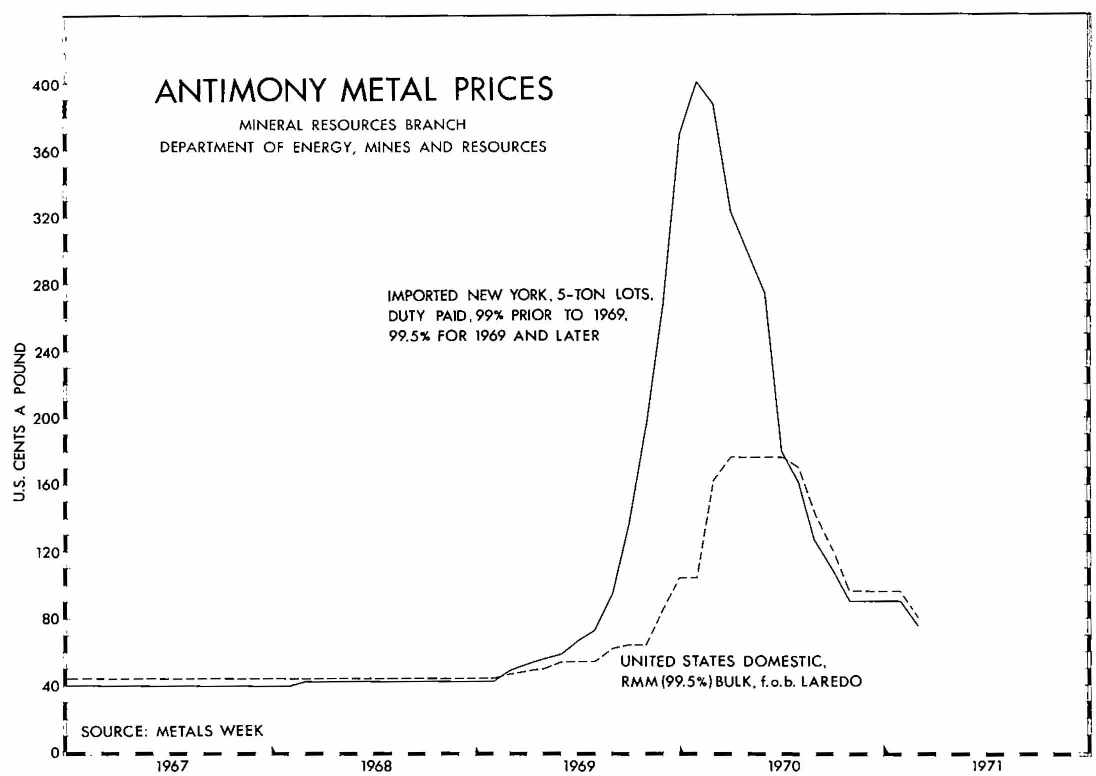
TABLE 6

Industrial Consumption of Primary Antimony in the United States, by class of Material Produced
(short tons, antimony content)

Product	1968	1969
Metal products:		
Ammunition	156	115
Antimonial lead	6,817	6,723
Bearing metal and bearings	755	758
Cable covering	178	55
Castings	46	33
Collapsible tubes and foil	50	56
Sheet and pipe	105	105
Solder	255	242
Type metal	423	541
Other	258	137
Total	9,043	8,765
Nonmetal products:		
Ammunition primers	33	37
Fireworks	37	30
Flameproofing chemicals and compounds	2,774	2,096
Ceramics and glass	2,037	2,108
Matches	*	*
Pigments	859	722
Plastics	2,318	2,558
Rubber products	440	433
Other	979	1,094
Total	9,477	9,078
Grand total	18,520	17,843

Source: United States Bureau of Mines Minerals Yearbook 1969.

*Included with "other" to avoid disclosing individual company confidential data.



High-purity antimony metal is used by manufacturers of intermetallic compounds for semiconductor use. An aluminium-antimony alloy is widely used as a semi-conductor in transistors and rectifiers. Also employed by the electronics industry are alloys of antimony which exhibit thermo-electric properties.

A large portion of the antimony requirements of the United States is derived from secondary sources. Secondary production was 23,699 tons in 1968 and 23,840 tons in 1969. These tonnages, added to the amounts of primary antimony consumption shown in Table 6, give a total use in the United States of about 42,219 tons in 1968 and 41,683 tons in 1969.

PRICES

Antimony prices throughout the world continued, until late in the first quarter of 1970, the spectacular rise that began in mid-March 1969. Thereafter prices levelled off and later began to decline. The United States domestic price of antimony metal, as quoted in *Metals Week*, in bulk, 99.5 per cent, f.o.b. Laredo, Texas, was $1.04 a pound from January 1 until about mid-March 1970 when it was raised to $1.76; the latter price remained in effect until mid-August when it was lowered to $1.68. There were two later decreases to $1.50 and $1.30 in September. The final reduction in this United States price to 96 cents occurred early in November, and this quotation was still in effect at year-end.

The United States price of imported antimony metal, as quoted in *Metals Week*, in 5-ton lots, 99.5-99.6 per cent, f.o.b. New York, 1.5 cents a pound duty paid, was $3 a pound at the beginning of 1970 and, in three successive steps, rose to $4 a pound early in February. This price prevailed until about mid-April when a steady decline set in with the price closing the year at 90-95 cents a pound.

TARIFFS

		Most Favoured Nation
CANADA		
Item No.		
33000-1	Antimony, or regulus of, not ground, pulverized or otherwise manufactured	free
33502-1	Antimony oxides	12½% ad val
UNITED STATES		
Item No.		
601.03	Antimony ore	free
632.02	Antimony metal, unwrought	1.2¢ per lb*

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
Tariff Schedules of the United States Annotated (1970), TC Publication 304.

*On and after January 1, 1971.

Asbestos

A. F. KILLIN*

World demand for asbestos continued strong in 1970 and Canada maintained its position as the major supplier of fibre to world markets. Production of asbestos in Canada in 1970 was 1,654,000 tons valued at $215,270,000, an increase of 42,832 tons and $20,058,899 from 1969. Quebec produced about 82 per cent (84), of total 1970 output; Yukon Territory 6.5 per cent (5.4); British Columbia 5.4 per cent (5.0); Newfoundland 4.0 per cent (3.6); and Ontario 2.1 per cent (2.0). Figures in brackets represent percentage in 1969. Exports of crude and milled fibres at 1,562,432 tons were roughly equivalent to exports in 1969. United States continued as the largest market for Canadian fibre, absorbing 40 per cent of these exports valued at $72 million. Exports of asbestos manufactured products increased 58.5 per cent from 1969, amounting to $6.44 million in 1970; the major increase was in asbestos cement products exported to the United States.

Asbestos is a commercial term applied to fibrous varieties of several specific minerals, the fibres being diverse in length, strength, flexibility and other factors that lead to variable degrees of usefulness and thus of value. The varieties of asbestos produced commercially are chrysotile, crocidolite (blue asbestos), amosite and anthophylite. Chrysotile asbestos makes up 90 per cent of world production and trade and this is the only variety that is mined in Canada. Although asbestos is found in practically all countries, its occurrence in economic quantities of satisfactory quality is not common.

The main criterion for assessing different fibre grades is on the basis of length although a combination of tests defining other qualities is becoming increasingly important. The major standard on a length basis is that developed by the industry in Quebec, where asbestos is described and priced by categories from the longest, crudes Nos. 1 and 2 through Group 3, down to the shortest Group 8.

Approximately 90 per cent of total world output comes from Canada, USSR and southern Africa. Canada accounts for about 35 per cent of the world's asbestos production and some 70 to 75 per cent of world exports of fibre.

*Mineral Resource Branch.

TABLE 1

Canada, Asbestos Production and Trade, 1969-70

	1969		1970[p]	
	Short Tons	$	Short Tons	$
Production (shipments)				
By type				
Crude (groups 1 and 2 and other)	7,017	3,665,018		
Milled fibres (groups 3,4,5)	687,924	129,576,802		
Shorts (groups 6,7,8)	916,227	61,969,281		
Total	1,611,168	195,211,101*	1,654,000	215,270,000*
By Province				
Quebec	1,348,762	153,450,891	1,353,000	165,454,000
Yukon	87,437	11,924,526	108,000	15,173,000
British Columbia	80,388	14,871,334	89,000	17,309,000
Newfoundland	58,513	10,588,875	66,000	12,373,000
Ontario	36,068	4,375,475	38,000	4,961,000
Total	1,611,168	195,211,101	1,654,000	215,270,000
Exports				
Crude				
Japan	69	52,000	73	58,000
West Germany	20	23,000	12	13,000
United States	22	19,000	6	3,000
Other countries	24	10,000	10	17,000
Total	135	104,000	101	91,000
Milled fibre (groups 3, 4 and 5)				
United States	213,881	45,570,000	206,706	44,587,000
Britain	61,230	14,019,000	60,405	14,393,000
West Germany	60,284	12,981,000	60,164	13,023,000
France	46,182	9,453,000	49,622	10,565,000
Japan	46,564	8,064,000	55,336	9,352,000
Australia	37,848	7,061,000	46,865	8,875,000
Belgium and Luxembourg	32,573	6,822,000	26,236	5,738,000
Mexico	23,775	4,788,000	25,628	5,629,000
Spain	32,051	6,416,000	25,128	5,096,000
India	14,622	3,284,000	21,756	4,732,000
Netherlands	16,936	3,551,000	21,386	4,578,000
Other countries	192,695	38,095,000	225,092	45,282,000
Total	778,641	160,104,000	824,324	171,850,000
Shorts (groups 6,7,8 and 9)				
United States	429,107	26,984,000	407,585	27,379,000
Japan	109,548	10,026,000	110,390	10,363,000
Britain	39,672	2,532,000	39,727	2,498,000
West Germany	50,184	3,421,000	28,754	2,293,000
Korea, South	16,873	1,818,000	13,470	1,486,000
France	28,380	1,793,000	21,793	1,481,000
Belgium and Luxembourg	19,687	1,659,000	14,191	1,232,000
Australia	10,196	796,000	15,672	1,076,000
Spain	13,658	1,351,000	8,617	829,000
Mexico	5,431	471,000	6,634	636,000
Netherlands	10,374	714,000	10,813	610,000
Argentina	4,959	354,000	6,925	524,000
Other countries	47,917	4,148,000	53,436	4,900,000
Total	785,986	56,067,000	738,007	55,307,000
Grand total, crude, milled fibres and shorts	1,564,762	216,275,000	1,562,432	227,248,000

TABLE 1 (Cont'd)

	1969		1970p	
	Short Tons	$	Short Tons	$
Manufactured products				
Brake linings and clutch facings				
United States		554,000		798,000
Cuba		419,000		576,000
Ecuador		38,000		109,000
Guatemala		22,000		65,000
Lebanon		61,000		57,000
Britain		4,000		21,000
El Salvador		5,000		21,000
Other countries		143,000		144,000
Total		1,246,000		1,791,000
Asbestos and asbestos cement building materials				
United States		929,000		2,236,000
Cameroon		–		216,000
Australia		181,000		125,000
Algeria		–		121,000
Japan		138,000		98,000
Mexico		–		73,000
Netherlands		95,000		56,000
Other countries		221,000		292,000
Total		1,564,000		3,217,000
Asbestos and asbestos cement basic products, n.e.s.				
United States		1,061,000		1,130,000
Netherlands		–		45,000
Japan		12,000		32,000
Brazil		2,000		27,000
Switzerland		53,000		25,000
Iran		2,000		18,000
Other countries		121,000		151,000
Total		1,251,000		1,428,000
Total exports, asbestos manufactured products		4,061,000		6,436,000
Imports				
Asbestos, unmanufactured	7,449	1,425,000	5,833	1,081,000
Asbestos, manufactured, cloth, dryer felts, sheets woven or fitted		1,205,000		1,161,000
packing		995,000		1,087,000
brake linings		4,191,000		3,365,000
clutch facings		946,000		434,000
Asbestos-cement, shingles and siding		274,000		233,000
board and sheets		1,137,000		827,000
Asbestos and asbestos-cement building materials, n.e.s.		944,000		1,575,000
Asbestos and asbestos-cement basic products, n.e.s.		2,002,000		1,597,000
Total asbestos, manufactured		11,694,000		10,279,000
Total asbestos, unmanufactured and manufactured		13,119,000		11,360,000

Source: Dominion Bureau of Statistics.
*Does not include value of containers.
p Preliminary; – Nil; n.e.s. Not elsewhere specified.

CANADIAN INDUSTRY AND DEVELOPMENTS

A chief source of the world's asbestos supply is the 55-mile-long belt of ultrabasic rocks that stretches through the Eastern Townships of Quebec where asbestos has been mined continuously since 1878. There are nine mines, one underground, one combined underground-open pit, and seven open pits, operated by seven companies. By far the largest mine is Canadian Johns-Manville Company, Limited's Jeffrey open pit at Asbestos, where the concentrating mill can process 32,000 tons of ore a day and in 1970 produced approximately 45 per cent of all asbestos in Canada. The second largest producer is Asbestos Corporation Limited at Thetford Mines with three mines and four milling plants that have a combined capacity of about 25,000 tons of ore a day.

Canadian Johns-Manville Company, Limited continued expansion of its facilities at its Jeffrey open-pit mine at Asbestos. The expansion of mine and mill will provide capacity to produce an additional 100,000 tons of fibre a year. Approximately one-third of this fibre will be recovered as short fibre from pre-1930 tailings. Expansion of the open pit will allow an increase in total ore and waste production from 30 to 40 million tons a year by 1974.

In Quebec, Asbestos Corporation Limited operated the King-Beaver mine and mill at Thetford Mines, and the British Canadian and Normandie mines and mills at Black Lake. Expansion plans at the King-Beaver call for a 50 per cent increase in mining and milling capacity to 12,000 tons of ore a day. Originally scheduled for late 1970, the expansion has been delayed by non-delivery of equipment. Three miles southwest of Thetford Mines the company is developing the Penhale orebody for underground production. Sinking of the development shaft was completed and level development started. A decision was reached to put the Asbestos Hill mine, on the Ungava Peninsula, into production by 1972. The mine and a primary crushing plant will operate seven months of the year. The concentrate produced will be shipped in bulk to a finishing plant in Nordenham, Germany, for fibre classification, bagging and sale. Proposed production will be 10,000 tons of asbestos fibre a year from 300,000 tons of concentrate.

At Thetford Mines, Bell Asbestos Mines, Ltd. completed sinking a new shaft and started underground development of new ore.

In British Columbia, Cassiar Asbestos Corporation Limited continued the $4.3 million expansion of its mine and mill that will increase production capacity from 75,000 tons of fibre a year to 100,000 tons. Included in the new production will be 10,000 tons a year of short fibre, grade AZ.

Cassiar Asbestos was also continuing with expansion of capacity at its Clinton Creek mine in the Yukon Territory. Production at Clinton Creek will be raised from 90,000 tons of fibre a year to 100,000 tons a year.

Asbestos deposits were being explored for in many parts of Canada. Two deposits in Quebec, the properties of McAdam Mining Corporation Limited at Chibougamau, and Abitibi Asbestos Mining Company Limited north of Amos, were being evaluated by diamond drilling, sampling, fibre testing, etc. in 1970; feasibility studies on these properties are scheduled. Cassiar Asbestos was re-evaluating its Kutcho Creek property 60 miles southeast of Dease Lake, British Columbia.

TABLE 2
Canada – Asbestos Production and Exports, 1961-70
(short tons)

Production*	Crude	Milled	Shorts	Total
1961	163	548,230	625,302	1,173,695
1962	205	547,447	668,162	1,215,814
1963	217	579,085	696,228	1,275,530
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
1970p	..	..	..	1,654,000
Exports				
1961	176	527,324	589,380	1,116,880
1962	182	532,020	632,468	1,164,670
1963	195	555,419	650,811	1,206,425
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
1970p	101	824,324	738,007	1,562,432

Source: Dominion Bureau of Statistics.
*Producers' shipments.
pPreliminary; .. Not available.

WORLD REVIEW

Approximately 90 per cent of total world asbestos output of over 4 million tons comes from Canada, USSR, and Republic of South Africa. New production facilities have been established in Australia, Greece and Rhodesia, in 1970. Production from these sources will not be large enough in 1971 to affect the proportion of world markets held by the three major producing countries.

TABLE 3

Canadian Asbestos Producers, 1970

Company	Location	Mill Capacity Short Tons ore/day	Remarks
Canadian Johns-Manville Company, Limited Jeffrey mine	Asbestos, Que.	32,000	Open pit, Expansion of mill for further 100,000 tons of fibre a year was scheduled for completion in 1970. Pit expansion started.
Asbestos Corporation Limited,			
British Canadian Mine	Black Lake, Que.	11,200	Open pit. Two milling plants.
King-Beaver mine	Thetford Mines, Que.	8,000	Underground and open pit. Completion of new processing plant delayed.
Normandie mine	Black Lake, Que.	6,000	Open pit.
Bell Asbestos Mines, Ltd.	Thetford Mines, Que.	3,000	Underground.
Lake Asbestos of Quebec, Ltd.	Black Lake, Que.	6,000	Open pit.
Flintkote Mines Limited	Thetford Mines, Que.	2,000	Open pit.
Carey-Canadian Mines Ltd.	East Broughton, Que.	4,000	Open pit.
Advocate Mines Limited	Baie Verte, Newfoundland	6,000	Open pit. Mill expansion and production of new fibre grade started.
Cassiar Asbestos Corporation Limited			
Cassiar mine	Cassiar, British Columbia	2,400	Open pit. Mill expansion to 100,000 tons of fibre a year underway.
Clinton Creek mine	Clinton Creek, Yukon Territory	3,000	Open pit. Mill expansion to 100,000 tons of fibre a year underway.
Johns-Manville Mining and Trading Limited			
Reeves mine	Timmins, Ont.	5,000	Open pit.
Hedman Mines Limited	Matheson, Ont.	300	Open pit.

In response to strong world demand in 1970, most asbestos producing plants operated at or near capacity in the year. USSR is the world's largest asbestos producer with output close to 2 million tons a year. Most of the asbestos mines are in the region centred on Asbest, about 40 miles east of Sverdlovsk in the central Ural Mountains. Most of the USSR's asbestos output is consumed within the country, a large part being used in asbestos-cement construction materials. Exports from the USSR, amounting to about 15 per cent of production, have gone principally to east European countries, France and Japan.

The Republic of South Africa is the world's largest producer of crocidolite or blue asbestos. Chrysotile and amosite asbestos are also produced in South Africa. Modernization at the Msauli asbestos facility near Barberton, eastern Transvaal, was completed in 1969 and a full year's production from this plant helped increase South African production to 290,000 tons of fibre in 1970. Rhodesia also produces asbestos and almost the entire output from Rhodesia and South Africa moves to world markets.

In Australia, Woodsreef Mines Ltd. near Barraba, New South Wales, started production of chrysotile asbestos fibre for export to Japan. Production capacity is scheduled at 70,000 tons of fibre a year. Other world developments include: production from the Zidani Kozani deposit in Greece; a proposed new mine near Havelock in Swaziland; and proposed asbestos developments in Bolivia, Colombia and Venezuela. Freemex S.A., a wholly-owned subsidiary of Freeport Sulphur Company, and its Mexican partner Industrias Penoles, S.A. have discovered an estimated 25 million tons of asbestos-bearing rock in southern Mexico. Production from this deposit, if realized, could challenge Canadian companies for a part of the United States market.

MARKETS AND TRADE

Asbestos is of use in industry because of its shape as a slender fibre and other physical characteristics, and its chemical stability. Asbestos has durability and resists fungi-growth weather, corrosion, heat, acids, and vermin; it insulates against heat, vibration, electricity and sound; its fibrous form helps to bind fillers, rubber, asphalt and cement, the latter being a most important material in that more than 50 per cent of the world's asbestos production is used in asbestos-cement products. Asbestos fibre is used for filtration of acids, alkalies and a great variety of liquids; it can be sprayed, moulded with plastics or glass, and dispersed in fluids, greases, adhesives and sealing compounds.

TABLE 4
World Production of Asbestos, 1969-70
(short tons)

	1969p	1970e
Canada	1,611,168	1,654,000p
USSR	1,102,310	. .
Republic of South Africa	281,089	290,000
China	176,000	. .
United States	125,936	130,000
Italy	111,333	. .
Cyprus	21,385	. .
Other countries	61,483	2,250,000
Total	3,490,704	4,324,000

Sources: Canadian figures, Dominion Bureau of Statistics, other countries, U.S. Bureau of Mines, Minerals Yearbook, Preprint 1969, and U.S. Bureau of Mines, Commodity Data Summaries, January 1971.
pPreliminary; e Estimated except where indicated; . . Not available.

The fibre is prepared from the ore by a dry milling process consisting of crushing, impact milling, fiberization and separation into different grades or groups of fibre largely based on length. The major uses of these asbestos grades by their groups are:

Crudes No. 1 and 2 (+¾ inch and 3/8 to ¾ inch): long spinning fibre for textiles, electrical industry, felted laminates in moulded resin panels.

Group 3 milled fibre: textiles, papers, packings, brake linings, clutch facings, pipe coverings, insulating blocks.

Group 4 and 5 milled fibres: papers, pipe coverings, packing, gaskets, millboards, roof coatings, plastics, and shingles, flat and corrugated sheets and pipe made of asbestos cement.

Group 6 shorts: asbestos-cement products, papers, brake linings, coatings, putties and plastics.

Group 7 and 8 shorts: insulating cement, coatings, putties, paints, welding rods, floor tile, acoustical plaster, greases, oil well muds, mineral fillers.

Consumers and producers are improving quality control in order to define asbestos quality by features other than length of fibre. The physical characteristics include bulk (determined by volume and density measurements), oil and water absorption, surface area (termed openness), fibre separation (termed crudiness), colour, and strength for asbestos-cement products. Other special tests involve air classification, and the measurement of dust and grit content viscosity, moisture, sag, plastic index, penetration and magnetic rating. These tests combined with group standards based on length and strict consumer specifications have led to the development of over 100 grades of asbestos.

Asbestos products and, in particular, asbestos-cement products used in home and industrial construction remain in high demand. Being fireproof and resistant to corrosion and humidity, asbestos-cement products are especially suitable for use in tropical areas. Domestic manufacture of these building products in the developing countries utilizes the local cement industry and local labour with relatively low bulk amounts of raw material being imported. Markets for Canadian fibres in the developing nations are estimated to have a potential growth rate as high as 10 per cent annually.

Consumption of asbestos in Canada was less than 5 per cent of production. Exports of fibre were made to over 80 countries of which the United States absorbed 40 per cent. Exports to the United States, responding to a drop in construction activity in that country, decreased slightly in 1970 to 614,297 tons from the 643,010 tons in 1969. Exports of fibre to Britain in 1970 totalled 100,132 tons and to the European Economic Community countries 232,959 tons. Sales to Japan in 1970 totalled 165,799 tons an increase of 9,618 tons over 1969.

OUTLOOK

Anticipated demand for asbestos should remain strong in 1971. In the longer term, to 1975, the outlook is for continued growth in consumption provided there is no prolonged downturn in world industrial activity. Industry estimates indicate a virtual balance in supply and demand in 1975. Exports of Canadian fibre are sensitive to demand in the United States markets, in particular to demand for asbestos-cement products for construction. Given a healthy industrial economy in most areas of the world, consumption of asbestos should increase at an average annual rate of 4 per cent. Any surge in construction demands could bring about a tightness of supply over short periods but expansion plans presently announced should allow production to remain in balance with consumption in the near term.

Changes in production schedules and in domestic consumption patterns could release larger amounts of USSR asbestos for export to western markets, in which case, they could materially affect the patterns of world trade; however, there remains no indication of any significant changes.

PRICES

Canadian asbestos prices quoted in *Asbestos* in 1970 were as follows:

	Jan. 1, 1970	Jan. 1, 1971
f.o.b. mines, Quebec, per short ton		
Crude No. 1	$1,525.00	$1,615.00
Crude No. 2	825.00	875.00
Group No. 3 (spinning fibre)	397.00 to 650.00	412.00 to 675.00
Group No. 4 (asbestos-cement fibre)	218.00 to 369.00	227.00 to 383.00
Group No. 5 (paper fibre)	157.00 to 184.00	164.00 to 195.00
Group No. 6 (waste, stucco, plaster)	114.00	120.00
Group No. 7 (refuse, shorts)	48.00 to 95.00	55.00 to 100.00

	Jan. 1, 1969	Jan. 1, 1971
Cassiar, f.o.b. North Vancouver, B.C., per short ton		
Canadian Group No. 3		
AAA grade (nonferrous spinning fibre)	845.00	877.00
AA grade (nonferrous spinning fibre)	673.00	697.00
A grade (nonferrous spinning fibre)	508.00	529.00
Canadian Group No. 4 AC grade (asbestos cement)	363.00	380.00
Canadian Group No. 4 AK grade (shingle fibre)	249.00	263.00
Canadian Group No. 4 CP grade (shingle fibre)	234.00	248.00
Canadian Group No. 4 AS grade (shingle fibre)	217.00	228.00
Canadian Group No. 4 CT grade (shingle fibre)	211.00	223.00
Canadian Group No. 5 AX grade (shingle fibre)	193.00	208.00
Canadian Group No. 5 CY grade (shingle fibre)	136.00	147.00
Canadian Group No. 5 AY grade (shingle fibre)	136.00	147.00

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	7½%	7½%	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, n.o.p.	12½%	12½%	25%
31205-1	Asbestos in any form other than crude, and all manufactures thereof, when made from crude asbestos of British Commonwealth origin, n.o.p.	free	12½%	25%
31220-1	Woven fabric, wholly or in part of asbestos for use in manufacture of clutch facings and brake linings	12½%	12½%	30%

TARIFFS (Cont'd)

UNITED STATES

518.11	Asbestos, not manufactured, crudes, fibres, stucco, sand and refuse containing not more than 15 per cent by weight of foreign matter	free
518.21	Asbestos, yarn, slivers, ravings, wick, rope cord, cloth, tape and tubing	
	On and after Jan. 1, 1970	5.5%
	" " " Jan. 1, 1971	4.5%
	" " " Jan. 1, 1972	4%
	Articles in part of asbestos and hydraulic cement	
518.41	Pipe and tubes, and fittings thereof	
	On and after Jan. 1, 1970	0.2¢ per lb
	" " " Jan. 1, 1971	0.18¢ per lb
	" " " Jan. 1, 1972	0.15¢ per lb
518.44	Other	
	On and after Jan. 1, 1970	0.15¢ per lb
	" " " Jan. 1, 1971	0.1¢ per lb
	" " " Jan. 1, 1972	0.1¢ per lb
518.51	Asbestos articles not specifically provided for	
	On and after Jan. 1, 1970	6%
	" " " Jan. 1, 1971	5%
	" " " Jan. 1, 1972	4.5%

Barite

A.F. KILLIN*

There was a decline in the output of barite in both of Canada's producing areas. In 1970 production was 131,317 tons, 11,913 tons less than in 1969.

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 drilling muds when drilling oil and gas wells. The weight factor in the drilling mud is required to counteract high oil and gas pressures.

Barite deposits are widespread throughout the world and it is mined in many countries, principally United States, followed by West Germany, USSR and Mexico. Canada is eighth in world production and about 90 per cent of the 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 sediments. Pure barite is white and is most common in veins; impure barite may be near-white, grey, brown or reddish in colour. Barite was produced only in Nova Scotia and British Columbia in 1970.

Dresser Minerals Division of Dresser Industries, Inc., the main Canadian barite producer, operates a mine at Walton, Nova Scotia. Barite ore is mined from a large replacement deposit by a block caving method and hoisted through the same shaft as lead-zinc-silver-sulphide ore mined in conjunction with the barite. The main product is crude, lump barite that is washed and crushed to minus 2 inches, trucked 3 miles to Walton harbour and shipped in bulk to the company's grinding plants in Louisiana and Texas. A small proportion of the barite is crushed, ground, classified, pulverized and bagged for sale either in domestic or foreign markets. Some barite is recovered in the flotation processing of the argentiferous sulphides.

There were two barite producers in British Columbia in 1970, 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, the operations of Extender Minerals of Canada Limited, a subsidiary of L.V. Lomas Limited, were hampered by a fire that destroyed the partly rehabilitated mill purchased from Geo-Pax Mines Limited. Extender plans to mine barite from veins on the shore of Mistinikon Lake, 6 miles southwest of Matachewan.

There are many occurrences of barite across Canada. Of note are occurrences in Newfoundland, at Buchans; 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.

*Mineral Resources Branch.

TABLE 1

Canada, Barite Production, Trade and Consumption, 1969-70

	1969		1970^p	
	Short Tons	$	Short Tons	$
Production (mine shipments)	143,230	1,379,752	131,317	1,465,000
Imports				
United States	6,176	337,000	7,449	346,000
West Germany	67	3,000	77	6,000
Total	6,243	340,000	7,526	352,000
Exports				
United States	108,610	1,064,000	94,036	900,000
Venezuela	–	–	5,508	49,000
Total	108,610	1,064,000	99,544	949,000
	1968		1969	
Consumption[1]				
Well drilling	17,000^{er}		18,000^e	
Paints and varnish	2,094		2,299	
Glass and glass products[2]	2,717		3,183	
Rubber goods	287		308	
Other[3]	305		361	
Total	22,403		24,151	

Source: Dominion Bureau of Statistics.

[1]Available data reported by consumers, breakdown by Mineral Resources Branch. [2]Includes miscellaneous chemicals, cleaners, detergents and miscellaneous products. [3]Includes glass fibre and glass wool.

^{p}Preliminary; – Nil; ^{e}Estimated; ^{r}Revised.

USES, CONSUMPTION AND TRADE

The dominant use for barite is as a weighting agent in oil and gas well drilling muds where its high specific gravity assists in counteracting high oil and gas pressures. 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.

Available data reported by consumers indicated that 24,151 tons of barite were consumed in Canada in 1970, of which about 18,000 tons, or 74.5 per cent, was consumed in drilling muds. The next three most important uses are in the paint industry, glass industry and in rubber goods.

Barite is used in paint as a special filler or "extender pigment". This is a vital constituent that provides bulk, improves consistency of texture, surface character 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.

TABLE 2

Canada, Barite Production, Trade and Consumption, 1961-70
(short tons)

	Production[1]	Imports	Exports	Consumption[2]
1961	191,404	1,889	171,696	18,723
1962	226,600	2,427	230,903	11,249
1963	173,503	3,830	159,892	11,343
1964	169,149	3,206	156,527	13,537
1965	203,025	3,686	185,032	12,625
1966	221,376	4,165	199,054	15,184
1967	172,270	5,924	146,103	19,124
1968	138,059	7,901	116,491	21,403
1969	143,320	6,243	108,610	22,403^r
1970^p	131,317	7,526	99,544	24,151

Source: Dominion Bureau of Statistics.

[1]Mine shipments. [2]Totals partially estimated by Statistics Section, Mineral Resources Branch.

^{p}Preliminary; . . Not available; ^{r}Revised.

TABLE 3

Canada–Barium Compounds, Imports, 1968-70

	1968		1969		1970	
	Short Tons	$	Short Tons	$	Short Tons	$
Imports						
Lithopone (70% $BaSO_4$)	404	53,000	*	*	*	*
Barium carbonate	3,495	304,000	4,005	386,000	3,598	357,000

Source: Dominion Bureau of Statistics.
*Effective 1969, lithopone ceased to be a separate import class.

Consumption in this industry in Canada in 1969 was 9.5 per cent of total consumption, a figure of 2,299 tons.

The glass industry uses barite to increase the workabilitv. act as a flux, assist decoloration and increase the brilliance or lustre of the 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 in 1969 included glass fibre and glass wool and amounted to 3,183 tons or 13.2 per cent of total consumption. In 1967 it was 5 per cent of total Canadian consumption.

Where used as a filler in rubber goods the specifications for natural barite vary but the main factors would be whiteness and particle size range. Some requirements, perhaps where weight is most desired, would allow use of off-white material. In 1969 approximately 1.3 per cent of Canada consumption, 308 tons, was reported consumed as a filler in rubber goods.

The balance of Canada's barite consumption, approximately 361 tons or 1.5 per cent of total consumption was used in such diverse uses as the manufacture of ceramic products, soaps and detergents.

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 substituted 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.

Canada exports about 76 per cent of its barite production, almost wholly to United States. In 1970 exports were down to 99,544 tons from 108,610 in 1969. Imports at 7,526 tons were slightly more than in 1969 and consisted mainly of ground high-quality barite.

WORLD REVIEW

There is world wide production and considerable international trade in barite even though transportation costs in some cases may be almost as great as the cost of the lump material. World production of barite in 1969 was estimated at 4.19 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 also geographically. On the other hand, oil and gas exploration is scattered throughout the world and on balance there is a consistent world demand that is most economically served by production from many countries. Viability of any deposit is dominantly controlled by transportation costs to market.

TABLE 4

World Production of Barite, 1969-70
(short tons)

	1969^p	1970^e
United States	1,077,208	942,000
West Germany	521,600	525,000
USSR	308,646	..
Italy	266,658	300,000
Greece	209,400	210,000
Mexico	195,022	225,000
Ireland	176,960	175,000
China	154,323	..
Canada	143,230	131,000
North Korea	121,254	..
France	110,000	110,000
Morocco	95,835	100,000
Other countries	809,705	1,525,000
Total	4,189,841	4,243,000

Source: U.S. Bureau of Mines Minerals Yearbook, Preprint 1969, and U.S. Bureau of Mines Commodity Data Summaries, January 1971. Canada totals from Dominion Bureau of Statistics.
^{p} Preliminary; ^{e} Estimated; .. Not available.

In the United States, production of almost 1 million tons annually is derived mostly from Missouri, Arkansas, and Nevada with smaller amounts from nine other states. The country imports about half a million 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.

OUTLOOK

Canadian barite output in 1971 is expected to remain at about the level of 1970. Oil exploration in the Canadian north should provide a strong base for marketing the relatively small production of barite from western Canada. World production will depend on the strength of petroleum exploration and development.

PRICES

According to *Engineering and Mining Journal* of December 1970, prices in the United States were:

Chemical grade		
Hand picked; 95% $BaSO_4$		
1% Fe	per st	\$22.50 - 23.50
Add \$3 for 100 lb bags		
Water ground; 99½% $BaSO_4$		
325 mesh, 50-lb bags	per st	\$55-78
Drilling mud grade, 83-93% $BaSO_4$		
3-12% Fe, specific gravity 4.20 - 4.30		
Ground	per st	\$31-36
Imported, 4.20-4.30 specific gravity, crude		
bulk, c.i.f. Gulf ports	per lt	\$17-20
from Canada, bulk, crude	per lt	\$14
Ground, 100-lb bags	per st	\$20

TARIFFS

		Most Favoured Nation	
CANADA Item No.		Jan. 1 1970	Jan. 1 1971
49205-1	Drilling mud and additives	free	free
68300-1	Barites	14%	12%
92842-1	Barium carbonate	15%	15%
93207-5	Lithopone	12½%	12½%
UNITED STATES Item No.		Jan. 1 1970	Jan. 1 1971
472.02	Barium carbonate, natural crude	free	free
472.04	Barium carbonate, natural, ground	8.5%	7%
472.10	Barium sulphate, natural crude – per lt	\$1.78	\$1.53
472.12	Barium sulphate, natural ground – per lt	\$4.55	\$3.90

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 (1970) T.C. Publication 304.

Celestite

Celestite ($SrSO_4$) is the main source of strontium and there was increased interest in celestite in 1970. Strontium compounds, mainly strontium carbonate, are in demand for use in glass faceplates in colour television sets where strontium carbonate improves the absorption of x-rays emitted by picture tubes operated at high voltages. Another new and developing use is in the manufacture of ferrites, a material required to make ceramic permanent magnets, which are being increasingly used in small motors.

In late 1969, Kaiser Aluminum & Chemical Corporation acquired a celestite deposit near Loch Lomond on Cape Breton Island, Nova Scotia, from Cape Chemical Corporation Limited. Kaiser is proceeding with construction of mining facilities and also an \$11-million plant to produce strontium carbonate and nitrate at Point Edward, near Sydney. Two new operating companies have been formed, Kaiser Celestite Mining Limited and Kaiser Strontium Products Limited. Open-pit mining started in 1970 and the concentrator was scheduled to be in operation in early 1971. Proposed production rates are 225 tons a day of $SrSO_4$ concentrate and 90 tons a day of $SrCO_3$ from the processing plant. There will be a maximum of 100 tons a day of sodium sulphate produced from the plant as a byproduct.

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

Bentonite

A.F. KILLIN*

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 upon the proportion of sodium or calcium. The sodium bentonites have a great physical avidity for water which provides bentonite with its 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 non-swelling 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 non-swelling bentonite. These clays have natural bleaching and absorbent properties and were originally used by fullers to remove dirt and oil from wool. 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 occurs in 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 to each other. 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

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 an oil well drilling mud additive but some is used as a binder in foundry sands and in feed pelletizing, as a fire-retardant additive to water and as a sealer for farm reservoirs.

In Manitoba, Pembina Mountain Clays Ltd. mines non-swelling 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

*Mineral Resources Branch.

TABLE 1

Canada, Bentonite Imports and Consumption, 1969-70

	1969		1970p	
	Short Tons	$	Short Tons	$
Imports				
Bentonite				
United States	246,153	2,545,000	291,210	2,678,000
Greece	47,818	564,000	52,944	598,000
Total	293,971	3,109,000	344,154	3,276,000
Activated clays and earths				
Greece	–	–	20,944	236,000
United States	7,490	1,197,000	10,332	1,723,000
France	109	37,000	121	40,000
West Germany	10	3,000	–	–
Total	7,609	1,237,000	31,397	1,999,000
Fuller's earth				
United States	9,745	291,000	11,431	315,000
Britain	2	1,000	2	...
Total	9,747	292,000	11,433	315,000
Consumption[1] (available data)				
Pelletizing iron ore	211,209			
Well drilling	18,327			
Foundries	43,024			
Chemicals	2,316			
Fertilizers, stock and poultry feed	225			
Paint and varnish	175			
Pulp and paper	198			
Other products[2]	2,986			
Total	278,460			

Source: Dominion Bureau of Statistics.
[1]Includes fuller's earth. Breakdown by Mineral Resources Branch; [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.
pPreliminary; –Nil; . . .Less than one thousand dollars.

and bagged. The main use is for decolorizing and purifying mineral vegetable oils, animal fats and tallows.

Bentonite is generally accepted as originating from deposits of volcanic ash that have been altered by induration and weathering. In North America, the chief source is clay of Cretaceous age with other occurrences in younger Tertiary rocks. Although clay beds occur in rocks older than Cretaceous, none in Canada have been identified as bentonite; Canadian bentonite occurrences are confined to Cretaceous and Tertiary rocks at many localities in the Provinces of Manitoba, Saskatchewan, Alberta and British Columbia.

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 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

TABLE 2

Canada, Bentonite Imports and Consumption, 1961-70

	Imports[1]		Consumption[2]
	Short Tons	$	Short Tons
1961	. .	1,528,170	63,268
1962	. .	1,524,080	57,237
1963	. .	2,005,337	93,512
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
1970P	386,984	5,590,000	. .

Source: Dominion Bureau of Statistics.
[1] Includes fuller's earth and activated clays and earths; [2] Includes fuller's earth.
PPreliminary; . . Not available.

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. Non-swelling 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 non-swelling bentonite is used in pelletizing stock feed, as a carrier for pesticides, and as a cleaning powder for animals.

Activated bentonite is used in decolorizing 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). This has been largely due to 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 30,000 tons are used annually in Canada.

Imports of bentonite from the United States increased in 1970. Further shipments from Greek deposits were imported as the assessment of this material continues by pelletizing companies. Small 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. The high standards of Wyoming bentonite are not common and this material is transported over distances such that transportation costs commonly exceed its value at the mine, in some cases by several times. Canada is the main importer from the United States but some bentonite moves to Australia and western Europe. Non-swelling bentonite, fuller's earth and bleaching clays are produced in numerous states, the major ones being Florida, Georgia, Mississippi and Texas.

OUTLOOK

The bulk of Canada's bentonite consumption is used in pelletizing iron ore concentrates. The most suitable material for this purpose is imported from the United States. Imports levelled off in 1970 with the slowdown in pellet plant construction, but a change-over from natural pellets to the addition of bentonite at one Canadian plant in late 1970 and the announcement of plans to construct a 6-million-ton-a-year iron ore pellet plant at Sept Îles, Quebec, by 1973 will require an increase in bentonite imports in the near future. No major changes in production and consumption in industries other than in ore pelletizing are foreseen.

PRICES

United States bentonite prices quoted in *Oil, Paint and Drug Reporter*, December 28, 1970, were as follows:

Bentonite, domestic, 200 mesh,
bags, car lots, f.o.b. mines – per ton – $14.00–$14.40

Bentonite, imported Italian, white,
high gel, bags, 5-ton lots, ex-warehouse – per ton – $116.60

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

Source: The Custom Tariff and Amendments, Department of National Revenue, Custom and Excise Division, Ottawa.

UNITED STATES

Item No.		
521.61	Bentonite	
	On and after Jan. 1, 1970	56¢ per long ton
	On and after Jan. 1, 1971	48¢ per long ton
	On and after Jan. 1, 1972	40¢ per long ton
	Fuller's earth	
521.51	Not beneficiated	
	On and after Jan. 1, 1970	35¢ per long ton
	On and after Jan. 1, 1971	30¢ per long ton
	On and after Jan. 1, 1972	25¢ per long ton
521.54	Wholly or partly beneficiated	
	On and after Jan. 1, 1970	70¢ per long ton
	On and after Jan. 1, 1971	60¢ per long ton
	On and after Jan. 1, 1972	50¢ per long ton
521.87	Clays, artificially activated with acid or other material	
	On and after Jan. 1, 1970	.07¢ per lb + 8.5% ad val
	On and after Jan. 1, 1971	.06¢ per lb + 7% ad val
	On and after Jan. 1, 1972	.05¢ per lb + 6% ad val

Bismuth

J. G. GEORGE*

Bismuth is obtained in Canada as a byproduct in the processing of certain lead-zinc, lead-zinc-copper, molybdenum and copper ores. The more important sources are molybdenum ores mined in the Malartic district of western Quebec, lead-zinc ores produced in southeastern British Columbia, and copper ores mined near Gaspé in eastern Quebec. Minor amounts are recovered from lead-zinc-copper ores mined in northeastern New Brunswick and from silver-cobalt ores produced in the Cobalt-Gowganda area of northern Ontario.

Based on preliminary figures, bismuth production in Canada in 1970 totalled 571,000 pounds valued at $3,252,600 compared with 579,059 pounds valued at $2,530,600 in 1969.

In 1969, world production of bismuth, according to an estimate prepared by the United States Bureau of Mines, was some 8.5 million pounds. Japan became the leading producer with output of 1.6 million pounds. Other substantial producers in declining order of output were Peru, Bolivia, Mexico and Mainland China. The United States, although a producer, does not publish its production statistics.

World demand for bismuth slightly exceeded primary supply during 1970, but demand in the United States was somewhat lower than in 1969. Although the United States producer price remained pegged at $6 a pound throughout 1970, in overseas markets bismuth metal was sold at a premium for a good part of the year. Substantial sales of surplus bismuth from the United States government's strategic stockpile again had a stabilizing influence on the market.

Bolivia, traditionally a major supplier of bismuth ore, continued construction of its first bismuth smelter and refinery for the production of bismuth metal. The plant, with an annual capacity reported to be 1.85 million pounds of bismuth metal, was scheduled to begin operations in 1971. It is being built at Telemayu in Potosi Department. Feed for the smelter is expected to consist mainly of local ores mined primarily for their bismuth content, as opposed to the more usual practice of recovering bismuth as a byproduct in the smelting of lead ores and concentrates.

By 1972-73, Australia is expected to become the western world's largest bismuth producer. This will follow construction of a copper smelter and bismuth recovery plant by Peko-Wallsend Ltd. at Tennant Creek, about 600 miles south of Darwin in the Northern Territory. Peko will use the plant to treat copper concentrates, containing an appreciable amount of bismuth, from some of its mines in the Northern Territory. It is expected that the new plant will have an annual bismuth output of up to 2 million pounds by 1972-73.

Authorized sales of bismuth from the United States government stockpile totalled 553,652 pounds in 1970. Some 300,000 pounds of bismuth were authorized for sale by Public Law 90-153 signed by President Nixon July 10, 1970. As at December 31, 1970, approximately 251,000 pounds of this current disposal authorization remained unsold. Stockpiled bismuth at the end of 1970 amounted to 2,350,954 pounds and the stockpile objective at that same time was 2,100,000 pounds, leaving a surplus of 250,954 pounds.

OUTLOOK

The world outlook for bismuth is favourable and, barring any sharp break in the general economic picture, a good demand is expected to prevail for the metal during 1971. World supply could increase with new production from Australia, but possible reduction of lead output could curb byproduct bismuth output.

*Mineral Resources Branch.

TABLE 1

Bismuth–Canadian Production and Consumption, 1969-70

	1969		1970p	
	Pounds	$	Pounds	$
Production all forms*				
Quebec	457,351	1,949,947	384,000	2,080,000
British Columbia	62,488	288,070	137,600	862,800
New Brunswick	56,951	281,338	38,800	243,300
Ontario	2,269	11,209	10,600	66,500
Total	579,059	2,530,564	571,000	3,252,600
Consumption, refined metal				
Fusible alloys and solders	5,160		..	
Other uses**	28,640		..	
Total	33,800		..	

Source: Dominion Bureau of Statistics.

*Refined bismuth metal from Canadian ores plus recoverable bismuth content of bullion and concentrates exported.

**Includes bismuth metal used in manufacture of pharmaceuticals and fine chemicals, other alloys and malleable iron.

pPreliminary; .. Not available.

DOMESTIC SOURCES

BRITISH COLUMBIA

Cominco Ltd. remained the only producer of bismuth metal in British Columbia, deriving most of its output from lead concentrate produced at its Sullivan lead-zinc mine at Kimberley. Other sources included lead concentrates from other company mines and from 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 pure metal from the treatment of residues resulting from the electrolytic refining of the lead bullion. For use in research and in the electronics industry this bismuth is further processed to give it a purity of up to 99.9999 per cent.

QUEBEC

Molybdenite Corporation of Canada Limited in its fiscal year ended September 30, 1970, treated 277,001 short tons* of ore and recovered 158,900 pounds of bismuth in impure metal ingots from its operations in Lacorne Township 12 miles northeast of Malartic. Three principal steps are involved in the process. A bulk concentrate containing about 8 per cent bismuth is produced by flotation. By leaching this concentrate with hydrochloric acid the bismuth is

TABLE 2

Bismuth–Canadian Production, Exports and Consumption, 1961-70 (pounds)

	Production (all forms)[1]	Exports[2]	Consumption[3]
1961	478,118	389,500	42,600
1962	425,102	382,182	37,200
1963	359,125	399,772	47,800
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
1970p	571,000	..	..

Source: Dominion Bureau of Statistics.

[1]Refined bismuth metal from Canadian ores plus recoverable bismuth content of bullion and concentrates exported. [2]Refined and semi-refined bismuth metal. [3]Refined bismuth metal reported by consumers. pPreliminary; .. Not available.

*The short ton (2,000 pounds avoirdupois) is used throughout this review, unless otherwise specified.

TABLE 3

Estimated World Production of Bismuth, 1969p
(pounds)

Japan (metal)	1,642,000
Peru	1,518,000
Bolivia	1,476,000
Mexico	1,336,000
Canada (metal)	579,000
Mainland China (in ore)	551,000e
Australia (in concentrates)	448,000
South Korea (metal)	247,000
Yugoslavia (metal)	227,000
Other countries	299,000
Total	8,323,000*

Source: Dominion Bureau of Statistics for Canada, Minerals Yearbook 1969, United States Department of the Interior, for all other figures.
*Total is of listed figures only; it excludes United States production, which is not available for publication, as well as that of some other smaller producing countries.
pPreliminary; eEstimated.

TABLE 4

United States Consumption of Bismuth, by Principal Uses
(pounds)

	1969	1970p
Fusible alloys	748,393	624,567
Other alloys	14,123	16,370
Pharmaceuticals*	1,250,539	1,183,008
Experimental uses	252	–
Metallurgical additives	509,587	408,990
Other uses	9,065	6,000e
Total	2,531,959	2,238,935

Source: Mineral Industry Surveys, United States Department of the Interior, Bureau of Mines, Bismuth in the fourth quarter 1970.
*Includes industrial and laboratory chemicals.
pPreliminary; eEstimated; – Nil.

separated as bismuth oxychloride which is then smelted in electric-arc furnaces. The resulting bullion is cast into ingots containing about 95 per cent bismuth, minor amounts of lead and silver and traces of copper, iron and antimony.

About mid-1970, operations were suspended at the molybdenum-bismuth property of Cadillac Moly Mines Limited in the Township of Preissac, 16 miles northwest of Malartic. Production statistics have not yet been reported for 1970, but in 1969 the company processed 369,903 tons of ore and recovered 209,964 pounds of bismuth in ingots of about 96 per cent purity. Mining and milling operations continued at Preissac Molybdenite Mines Limited. This molybdenum-bismuth property is in Preissac Township about 17 miles northwest of Malartic; the company produces metallic bismuth of about 95 per cent purity.

Gaspé Copper Mines, Limited recovered bismuth in metal ingots from the treatment of flue dust derived from copper-smelting operations at Murdochville, on the Gaspé Peninsula. Production statistics are not available for 1970 or 1969 but in 1968 the company recovered 19,635 pounds of byproduct bismuth.

NEW BRUNSWICK

In 1970, East Coast Smelting and Chemical Company Limited began production of bismuth metal at its plant at Belledune. The output was derived as a byproduct from the processing of lead and lead-zinc concentrates produced by Brunswick Mining and Smelting Corporation Limited at its mines near Bathurst, New Brunswick. Production in 1970 amounted to 7,960 pounds of refined bismuth grading 99.9 per cent or better. 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.

Substantial amounts of bismuth are contained in the lead concentrates produced at the lead-zinc-copper-silver property of Nigadoo River Mines Limited in the Bathurst area. The byproduct bismuth is recovered by the custom lead smelter to which the concentrates are sold.

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. Another important outlet for the metal is in fusible or low-melting-point alloys for fire-protection devices, electrical fuses and solders. Many of these alloys contain 50 per cent or more bismuth with the chief additive metals being cadmium, lead and tin. The manufacture of jet engines accounts for substantial quantities of these alloys. In 1970, no bismuth was used as a catalyst in the United States. Until 1969, bismuth-molybdate catalysts had been used in the production of acrylic plastics, but in 1970 a non-bismuth substitute catalyst took over the market in the United States. A bismuth catalyst has, however, continued in use in Europe, and in 1970 about

300,000 pounds of bismuth were consumed for this purpose.

Type metal contains bismuth because the latter expands on solidification and imparts expansion to its alloys. Bismuth is also used as an important additive to improve the machinability of aluminum alloys, malleable irons and steel alloys, and for holding lenses and positioning parts in aerospace work. 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, was $6.00 a pound in lots of one ton or more from January 1 to May 13, 1970. Between May 14 and June 19, Cominco's price was $5.70, and from June 20 to year-end it was $6.00. The United States price, as published by Metals Week and expressed in United States currency, remained unchanged throughout 1970 at $6.00 a pound in ton lots, c.i.f. U. S. ports.

TARIFFS

		British Preferential	Most Favoured Nation	General
CANADA				
Item No.				
35106-1	Bismuth metal, not including alloys, in lumps, powders, ingots or blocks	free	free	25% ad val
UNITED STATES*				
Item No.				
632.10	Bismuth metal, unwrought; waste and scrap			free
	Alloys of bismuth:			
632.64	Containing by weight not less than 30 per cent of lead			free
632.66	Other			10.5% ad val
633.00	Bismuth metal, wrought			10.5% ad val

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annoted (1970) TC Publication 304.

*On and after January 1, 1971.

Cadmium

D. B. FRASER*

Cadmium is a minor constituent of most zinc-bearing ores, occurring as a sulphide associated with sphalerite, the common zinc mineral. It follows zinc through the milling process, and is recovered as a byproduct of zinc refining. Canadian zinc ores contain from 0.001 per cent to 0.067 per cent of recoverable cadmium, and zinc concentrates contain up to 0.7 per cent cadmium.

Production in 1970 as reported by the Dominion Bureau of Statistics was 4,246,200 pounds. This figure represents the amount of metallic cadmium recovered at domestic smelters from Canadian ores, plus the recoverable content that was paid for by foreign smelters that treated Canadian zinc concentrates.

Cadmium is recovered at electrolytic zinc plants as a precipitate, or oxide sponge, produced during the purification of zinc electrolyte. The sponge is redissolved, and metallic cadmium is plated out in electrolytic cells, melted, 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 re-distillation.

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; and Canadian Electrolytic Zinc Limited at Valleyfield, Quebec. Total output of refined cadmium in 1970 was 1,844,706 pounds. East Coast Smelting and Chemical Company Limited, which operates a zinc-lead blast furnace at Belledune, New Brunswick, produced 127 tons of zinc-cadmium alloy in 1970, and expects to recover refined cadmium by re-distillation beginning in 1971.

Because of the close association of the two metals, the world supply of cadmium is directly related to the production of refined zinc. The United States continued to be the world's largest producer with an output of 4,900 tons. Japan, the USSR and Canada follow in that order. Total world production in 1970 was estimated by the World Bureau of Metal Statistics to be 18,273 tons, 2,100 tons less than in 1969. The decline was associated with a fall in refined zinc output in a number of countries, particularly the United States, Japan, Canada, and some European countries.

Canadian consumption of cadmium in 1970 was 124,959 pounds, or 7 per cent of refined output. Plating was the largest use, taking nearly 70 per cent of the total consumed. Refined cadmium was exported to eight countries in 1970. These exports amounted to 1,549,035 pounds, of which 81 per cent went to Britain and 17 per cent to the United States.

Industrial consumption was generally lower in 1970 than in 1969 due to the reduced demand for cadmium in plating and in pigments. Both of these uses are affected by the level of motor vehicle production, which declined during the year. Consumption in the United States was 38 per cent less than in 1969. There were substantial declines also in consumption in Japan, Britain, and the Federal Republic of Germany.

The price of cadmium fell in three stages between August and the end of 1970 from $4.00 (U.S.) a pound to $2.25 (U.S.) a pound.

Following the sale in 1969 of 2.65 million pounds of cadmium from United States government stocks, authorization for the release of a further 4.18 million pounds was made on July 10, 1970. By year-end, 4,173,800 pounds of this amount remained unsold. There were no sales during the first quarter of 1971. Total United States government stocks at the end of 1970 were 10.2 million pounds, of which 6 million pounds were held as a strategic stock.

* Mineral Resources Branch.

TABLE 1

Cadmium–Production, Exports and Consumption, 1969-70

	1969		1970[p]	
	Pounds	$	Pounds	$
Production				
All forms[1]				
Ontario	3,075,505	10,825,778	2,321,000	8,778,000
British Columbia	1,141,133	4,016,788	1,000,000	3,760,000
Quebec	310,588	1,093,269	275,500	1,078,000
Manitoba	230,774	812,324	184,500	693,700
New Brunswick	110,219	387,971	170,800	642,200
Saskatchewan	84,863	298,718	91,400	343,700
Yukon	68,172	239,965	63,000	236,900
Northwest Territories	191,800	675,136	140,000	526,400
Total	5,213,054	18,349,949	4,246,200	16,058,900
Refined[2]	2,123,955		1,844,706	
Exports				
Cadmium metals				
Britain	1,136,953	3,209,000	1,257,949	4,114,000
United States	527,112	1,558,000	270,395	1,063,000
West Germany	6,100	44,000	9,223	12,000
Sweden	–	–	5,000	22,000
France	1,800	8,000	3,500	15,000
Belgium and Luxembourg	5,000	22,000	2,060	9,000
Other countries	9,608	37,000	908	3,000
Total	1,686,573	4,878,000	1,549,035	5,238,000
Consumption–Cadmium metal[3]				
Plating	98,384		85,075	
Solders	2,884		12,329	
Other products[4]	30,868		27,555	
Total	132,136		124,959	

Source: Dominion Bureau of Statistics.

[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.
[p]Preliminary; –Nil.

DOMESTIC PRODUCTION

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

NEW BRUNSWICK

Brunswick Mining and Smelting Corporation Limited operates two mines, and through a wholly-owned subsidiary, East Coast Smelting and Chemical Company Limited, an Imperial Smelting Furnace at Belledune, near Bathurst. The smelter treats concentrates from Brunswick's mines only and produces cadmium in the form of cadmium-zinc alloy. In 1970, 127 tons of this alloy was produced and exported for refining. This company expects to produce refined cadmium in 1971.

QUEBEC

The copper-zinc mines of northwestern Quebec all have small amounts of cadmium in their ores, but in most cases it is too little to be paid for under the smelter contracts. Zinc concentrates contain from

TABLE 2

Cadmium–Production, Exports and Consumption, 1961-70
(pounds)

	Production		Exports	Consumption[3]
	All Forms[1]	Refined[2]	Cadmium Metal	
1961	1,357,874	2,234,000	1,901,962	171,000
1962	2,604,973	2,435,000	2,340,289	232,000
1963	2,475,485	2,354,000	1,939,110	209,000
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
1970p	4,246,200	1,844,706	1,549,035	124,959

Source: Dominion Bureau of Statistics.
[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.
pPreliminary.

0.06 to 0.16 per cent cadmium. Canadian Electrolytic Zinc Limited at Valleyfield recovers refined cadmium from zinc concentrates produced at Quebec mines and at the Noranda Mines Limited Geco mine at Manitouwadge, Ontario. Output at Valleyfield was lower at 514,000 pounds due to a strike at Geco during the early part of the year.

ONTARIO

Ecstall Mining Limited, at Timmins, the largest producer of cadmium in Canada, is constructing an electrolytic zinc plant at Timmins which will have a cadmium refinery with a capacity of 1,000,000 pounds a year. Production is scheduled to begin in December, 1971. Other zinc-copper mines at Timmins and Manitouwadge produce zinc concentrates carrying low to moderate cadmium values. The Geco mine is the largest producer next to Ecstall.

MANITOBA AND SASKATCHEWAN

All zinc concentrates produced in these two provinces are treated at the electrolytic zinc plant of Hudson Bay Mining and Smelting Co., Limited at Flin Flon. Production at this plant was 338,343 pounds of cadmium in 1970.

BRITISH COLUMBIA

Metallic cadmium, amounting to 630 tons, was recovered at the metallurgical works of Cominco Ltd. at Trail. Cominco treates ores and concentrates from its own Sullivan and Bluebell mines, from its subsidiary Pine Point Mines Limited, and, on a custom basis, from various mining operation in British Columbia.

TABLE 3

World Production of Cadmium
(short tons)

	1969	1970[e]
United States	6,323	4,900
Japan	3,048	2,750
USSR	2,480	..
Canada	2,606	2,123
Belgium	992	900
Federal Republic of Germany	873	750
Australia	629	600
Poland	606	..
France	577	600
Italy	465	250
Other countries	1,771	5,400
Total	20,370	18,273

Sources: World Bureau of Metal Statistics; for Canada, Dominion Bureau of Statistics.
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. 1970 figures from United States Bureau of Mines, Commodity Data Summaries, Jan. 1971.
[e]Estimated; . . Not available.

TABLE 4

Companies Reporting Cadmium Production—1970 and (1969)

	Mill capacity —tons ore/day	Grade of Zinc Concentrate % Cadmium	% Zinc	% Lead	oz/ton Silver	Zinc concentrate produced —tons	Cadmium contained in zinc concentrate —pounds	Remarks
NEWFOUNDLAND								
American Smelting and Refining Company, Buchans Unit, Buchans	1,250 (1,250)	0.22 (0.22)	57.12 (56.90)	. . (. .)	4.36 (4.76)	64,325 (66,645)	284,000 (290,000)	Zinc concentrates were exported to Europe.
NEW BRUNSWICK								
Nigadoo River Mines Limited, Robertville	1,000 (1,000)	. . (0.71)	46.39 (46.03)	1.30 (1.53)	. . (4.09)	13,434 (13,503)	178,377 (191,719)	Zinc concentrates were exported to Japan and Europe.
ONTARIO								
Ecstall Mining Limited, Timmins	9,000 (9,000)	. . (. .)	52.2 (. .)	0.53 (. .)	3.5 (. .)	582,844 (582,146)	2,927,776 (3,012,957)	Electrolytic zinc plant under construction to open December 1971 with cadmium refinery.
Noranda Mines Limited, Geco Division, Manitouwadge	5,000 (4,000)	0.34 (. .)	52.53 (. .)	– –	2.06 (. .)	79,479 (. .)	. . (. .)	Milling plant expanded.
MANITOBA AND SASKATCHEWAN								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon	6,000 (6,000)	. . (. .)	47.4 (47.0)	0.3 (0.3)	1.1 (1.0)	102,100 (119,800)	338,343 (333,959)	The 338,343 pounds is metallic cadmium produced at Flin Flon.
BRITISH COLUMBIA								
Canadian Exploration, Limited, Salmo	1,900 (1,900)	. . (0.46)	56.97 (56.95)	1.5 (1.5)	. . (. .)	9,830 (22,673)	83,400 (207,086)	Zinc-lead operation stopped August 1970.
Cominco Ltd., Sullivan Mine, Kimberley	10,000 (10,000)	. . (0.12)	48.4 (48.60)	5.5 (6.30)	2.4 (2.8)	204,357 (167,151)	. . . .	Cominco's total output of metallic cadmium from all sources was 630 tons in 1970.

TABLE 4 – (Cont'd)

	Mill capacity –tons ore/day	Grade of Zinc Concentrate % Cadmium	% Zinc	% Lead	oz/ton Silver	Zinc concentrate produced –tons	Cadmium contained in zinc concentrate –pounds	Remarks
Copperline Mines Ltd. Golden	600 (–)	0.36 (–)	52.14 (–)	2.11 (–)	9.93 (–)	2,546 (–)	18,336 (–)	Operations began in October 1970; zinc concentrates exported.
Kam-Kotia Mines Limited, Silmonac Mine, Sandon	133 (–)	0.43 (–)	55.1 (–)	7.0 (–)	72.2 (–)	1,343 (–)	11,640 (–)	Operations began in September 1970; zinc concentrates exported.
Leitch Mines Limited, Beaverdell	115 (115)	0.33 (0.21)	30.29 (27.81)	2.5 (1.69)	44.35 (40.01)	444 (578)	2,938 (2,389)	Zinc concentrates treated at Trail, B.C.
Reeves MacDonald Mines Limited, Remac	1,200 (1,200)							
Reeves Mine		0.32 (0.33)	51.5 (51.93)	1.9 (1.75)	0.91 (0.67)	8,707 (16,172)	55,650 (106,388)	Operations at the Annex mine started August 1970, some development ore mined earlier in year. Mining rate at Reeves reduced. Zinc concentrate exported.
Annex Mine		0.65 (–)	50.2 (–)	1.0 (–)	8.1 (–)	11,821 (–)	150,207 (–)	
Western Mines Limited Buttle Lake, V.I.	1,000 (1,000)	0.26 (0.26)	53.65 (53.05)	2.36 (4.34)	3.36 (3.66)	35,580 (46,251)	189,061 (239,927)	
YUKON TERRITORY								
United Keno Hill Mines Limited, Elsa	500 (500)	0.64 (0.72)	51.05 (52.11)	0.54 (0.50)	7.88 (7.98)	7,505 (6,985)	104,876 (100,740)	
Venus Mines Ltd. Carcross	300 (–)	2.2 (–)	49.7 (–)	4.5 (–)	38 (–)	229 (–)	10,071 (–)	Operations began in September 1970.

– Nil; . . Not available.

YUKON TERRITORY

United Keno Hill Mines Limited mined silver-lead-zinc ore high in cadmium. The silver-lead-zinc mine of Venus Mines Ltd. was brought into production in September, 1970, mining ore that graded 0.05 per cent cadmium.

NORTHWEST TERRITORIES

Pine Point Mines Limited continued to be the only source of cadmium in the Northwest Territories. Most of the zinc concentrates are smelted at Trail while some are shipped to the United States, Japan and India.

USES

Cadmium 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 both 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 electro-deposited with less electric current per unit of area covered. 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 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 exclusively.

Another growing application is in the production of nickel-cadmium storage batteries. These batteries are considerably more expensive than the standard lead-acid battery, but have a longer life, 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.

PRICES

The Canadian price of cadmium throughout 1970, as quoted in the *Northern Miner* was as follows:

sticks, bars, balls,
99.98%

	Lots of 5,000 lb and over	Lots under and over
	per lb	per lb
Jan. 6	$4.30	$4.50
Aug. 27	3.40	3.60
Oct. 15	2.90	3.10
Dec. 24	2.35	2.55

The United States cadmium prices throughout 1970, as quoted by *Metals Week* were as follows:

	lots	less than one ton
	per lb	per lb
Jan. 2	$4.00	$4.05
Aug. 13	3.25	3.30
Oct. 13	2.75	2.80
Dec. 21	2.25	2.30

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				
601.66	Cadmium in ores and concentrates	free		
632.14	Cadmium metal, unwrought, waste and scrap (duty on waste and scrap suspended to June 30, 1971)			
	on and after Jan. 1, 1970	1¢ per lb		
	" " " Jan. 1, 1971	free		
	" " " Jan. 1, 1972	free		
633.00	Cadmium metal, wrought			
	on and after Jan. 1, 1970	12.5%		
	" " " Jan. 1, 1971	10.5%		
	" " " Jan. 1, 1972	9%		
632.84	Cadmium alloys, unwrought			
	on and after Jan. 1, 1970	12.5%		
	" " " Jan. 1, 1971	10.5%		
	" " " Jan. 1, 1972	9%		

Sources: **CANADA**
The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
UNITED STATES
Tariffs Schedules of the United States Annotated (1970).

Calcium

D. PEARSON*

Calcium is the fifth most abundant element in the earth's crust occurring chiefly in limestone, gypsum, and fluorspar. Because it is extremely reactive with oxygen and water it is never found in the free state in nature. The metal is obtained by reduction of calcium compounds by various thermal and electrolytic methods. There are only three producers in the non-communist world of which Dominion Magnesium Limited, a Canadian company, is a leader in international trade. It is also produced in the United States by Charles Pfizer and Co. Inc., Minerals, Pigments and Metals Division and in France by Planet-Wattohm S.A., a subsidiary of Compagnie de Mokta. All three producers use the Pidgeon process which is a thermal reduction method. World production and consumption statistics are not available but are believed to be between 500 and 1,000 tons.

DOMESTIC INDUSTRY

Using the same equipment as that used for its primary magnesium production, Dominion Magnesium Limited makes high purity calcium and other alkaline earth metals at its Haley, Ontario smelter. The commercial grades are obtained by heating, under vacuum, charges of briquets made from powdered lime of 200 mesh and commercially pure aluminum of 20 mesh, in chrome-nickel steel retorts.

At a temperature of about 1170°C calcium vaporizes and condenses at the water-cooled end of the retort. This grade is 98 to 99 per cent calcium with small amounts of magnesium and nitrogen. A subsequent refining operation yields grades of higher purity. There are four main grades of calcium produced which are: Grade 1 – Chemical standard, 99.9 per cent calcium. Grade 2 – Nuclear quality 99.9 per cent calcium + magnesium. Grade 3 – Commercial grade, 98 per cent calcium and Grade 4, 95 per cent calcium.

Dominion Bureau of Statistics figures for production and exports in Table 1 show a downtrend in 1970. This is a reflection of the lack of buoyancy in the United States economy as well as in other countries except Britain and Belgium. The company also produces strontium, barium, titanium, zirconium and thorium.

USES

A considerable amount of calcium is used in the manufacture of calcium hydride which is a source of hydrogen for meteorological balloons and a reducing agent in the metallurgical field for separating certain metals from their oxides. Metals which have been prepared in this manner are titanium, zirconium, vanadium, thorium, niobium and uranium. Calcium also finds a use as an additive in some aluminum, magnesium, copper and nickel alloys. In the steel industry it is added to the molten steel to remove sulphur, phosphorous and oxygen and removes bismuth from lead in certain lead alloys. In the chemical industry it is a reducing and dehydrating agent.

*Mineral Resources Branch.

TABLE 1

Canadian Calcium Production and Exports, 1969-70

	1969		1970P	
	Pounds	$	Pounds	$
Production (metal)*	942,682	953,522	400,000	338,000
Exports (metal)				
United States	662,200	619,000	129,900	120,000
Belgium and Luxembourg	22,000	12,000	22,000	13,000
Britain	9,900	18,000	11,500	21,000
West Germany	13,200	14,000	5,000	6,000
Japan	2,200	2,000	4,400	4,000
Mexico	3,600	...	1,000	1,000
Others	11,500	18,000	300	...
Total	724,600	683,000	174,100	165,000

Source: Dominion Bureau of Statistics.
* Shipments of calcium metal, and calcium metal used in production of calcium alloys.
PPreliminary; ... Less than one thousand dollars.

TABLE 2

Canadian Calcium Production and Exports, 1961-70

	Production* (pounds)	Exports (pounds)
1961	99,355	110,700
1962	123,511	124,100
1963	98,673	92,100
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
1970P	400,000	174,100

Source: Dominion Bureau of Statistics.
* Producers' shipments of calcium metal and calcium metal used in production of calcium alloys.
P Preliminary.

PRICES

According to *Metals Week*, December 28, 1970, United States calcium price was as follows:

Calcium metal
Per lb, ton lots, full crowns 95¢

TARIFFS

CANADA

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

UNITED STATES

632.16	Calcium metal, unwrought	
	On and after Jan. 1, 1970	10% ad val
	On and after Jan. 1, 1971	9% ad val
	On and after Jan. 1, 1972	7.5% ad val
633.00	Calcium metal, wrought	
	On and after Jan. 1, 1970	12.5% ad val
	On and after Jan. 1, 1971	10.5% ad val
	On and after Jan. 1, 1972	9% ad val

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–Normal Portland, High Early Strength Portland and Sulphate-Resisting Portland–all of which are covered in specifications under CSA Standard A5 - 1961 (Canadian Standards Association). Modified and low-heat cements, designed for mass concrete use such as in dam construction, are manufactured by several cement-producing companies in Canada. Masonry cement is a mixture of portland cement, finely ground, high-calcium limestone (35 to 65 per cent by weight) and a plasticizer. It is recommended that masonry cement produced in Canada conform to the CSA Standard A8 - 1970. This type of cement is sold as well under the following names–Mortar Cement, Mason's Cement, Brick Cement and Mortar Mix.

The types of cement manufactured in Canada and not covered by the 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, it 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.

Cement is one of a number of industrial mineral commodities produced in Canada in direct support of the construction industry. The value of construction in Canada in 1970 was $13.2 billion, a reduction of $0.7 billion from estimates made at the beginning of the year. Work stoppages and tight money combined to lower construction spending. The price index for concrete products rose about 3.1 per cent during the year while the average hourly wage in the construction industry rose by $0.61 or 15.5 per cent over the same period. As the volume of construction tends to lessen per unit of expenditure, advances in construction techniques and equipment tend to improve the efficiency of an industry that is subject to many outside influences over which it has little or no control.

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 and stone aggregates as well as preformed concrete products such as slabs, bricks and prestressed concrete units.

*Mineral Resources Branch.

TABLE 1

Canada, Cement–Production and Trade, 1969-70

	1969		1970p	
	Short Tons	$	Short Tons	$
Production[1]				
Ontario	3,112,697	56,650,012	3,523,000	63,480,000
Quebec	2,161,485	37,131,750	2,020,000	39,325,000
Alberta	938,844	21,302,451	894,000	20,165,000
British Columbia	795,591	18,704,967	558,000	13,150,000
Manitoba	538,057	12,919,303	443,000	10,244,000
Nova Scotia	..	4,270,098	..	4,220,000
Saskatchewan	211,342	5,677,233	142,000	4,153,000
New Brunswick	..	3,539,001	..	2,900,000
Newfoundland	..	1,896,229	..	2,803,000
Total	8,250,032	162,091,044	8,065,000	160,440,000
By type				
Portland	7,931,697	154,833,794	7,800,000e	
Masonry[2]	318,335	7,257,250	265,000e	
Total	8,250,032	162,091,044	8,065,000	160,440,000
Exports				
Portland cement				
United States	634,122	11,364,000	566,499	11,250,000
Other countries	86	2,000	22	1,000
Total	634,208	11,366,000	566,521	11,251,000
Cement and concrete basic products				
United States		1,368,000		7,217,000
Other countries		87,000		251,000
Total		1,455,000		7,468,000
Imports				
Portland cement, white				
United States	17,234	752,000	12,856	586,000
Japan	3,478	98,000	5,635	149,000
Belgium and Luxembourg	8,537	291,000	4,029	114,000
Britain	388	9,000	171	5,000
Total	29,637	1,150,000	22,691	854,000
Cement, n.e.s.[3]				
United States	8,502	573,000	64,753	2,155,000
Britain	9,850	330,000	7,406	327,000
West Germany	1,969	108,000	1,818	131,000
France	3,419	99,000	519	17,000
Other countries	19	1,000	4	1,000
Total	23,759	1,111,000	74,500	2,631,000
Total cement imports	53,396	2,261,000	97,191	3,485,000
Refractory cement and mortars				
United States		1,596,000		1,654,000
Ireland		462,000		409,000
West Germany		6,000		31,000
Other countries		20,000		75,000
Total		2,084,000		2,169,000

TABLE 1 (Cont'd)

	1969		1970p	
	Short Tons	$	Short Tons	$
Cement and concrete basic products, n.e.s.				
United States		166,000		231,000
West Germany		–		6,000
Britain		1,000		2,000
Other countries		23,000		2,000
Total		190,000		241,000
Cement clinker				
United States	15,545	401,000	13,831	353,000

Source: Dominion Bureau of Statistics.
[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.
pPreliminary; n.e.s. Not elsewhere specified; . . Not available for publication; – Nil; eEstimated.

TABLE 2

Canada, Cement–Production, Trade and Consumption, 1961-70
(short tons)

	Production[1]	Exports[2]	Imports[2]	Apparent Consumption[3]
1961	6,205,948	249,377	29,217	5,985,788
1962	6,878,729	219,164	26,525	6,686,090
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
1970p	8,065,000	566,521	97,191	7,595,670

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

Markets for cement tend to be regional because transportation costs represent a large part of the laid-down price to the consumer and only rarely, in the case of special cements, are shipments made beyond normal distribution boundaries. Production in six of the nine provinces in which cement is manufactured was lower in 1970 than in 1969, the remainder showed increases. Currently the apparent total capacity of the industry is 14.6 million tons a year, exclusive of three plants which only grind clinker, and including some capacity which could be reactivated only at considerable expenses. On a regional basis, producers in the Atlantic area operated at 68 per cent of capacity, western Canadian producers at 55 per cent of capacity, and Ontario and Quebec, which have a greater capacity concentration, operated at 54 and 44 per cent respectively. Capacity was increased in Quebec by about 220,000 tons and in British Columbia by 210,000 tons during 1970. A similar increase in capacity in Quebec should be realized in 1971. A new plant is planned for the Bath area of Ontario by Canada Cement Lafarge Ltd. for operation late in 1973 at a capacity of 1.1 million tons.

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. From available information it appears that only about 10 per cent of the cement used in the Atlantic area is imported and the ratio of highway to rail transport is probably 60 to 40.

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 63 miles south of Corner Brook. Shipments of grey, portland cement are made by rail and by sea mostly to provincial markets. Production is directly dependent upon construction activity. The values of building permits issued and of heavy construction awards were reduced in Newfoundland during 1970. It is at present unlikely that production of cement will increase greatly in the near future.

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 package under the brand name "Maritime" Cement. During 1970 the value of Nova Scotia cement production decreased slightly as the number of housing starts and the value of building permits issued were lower than in 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 Bruns-

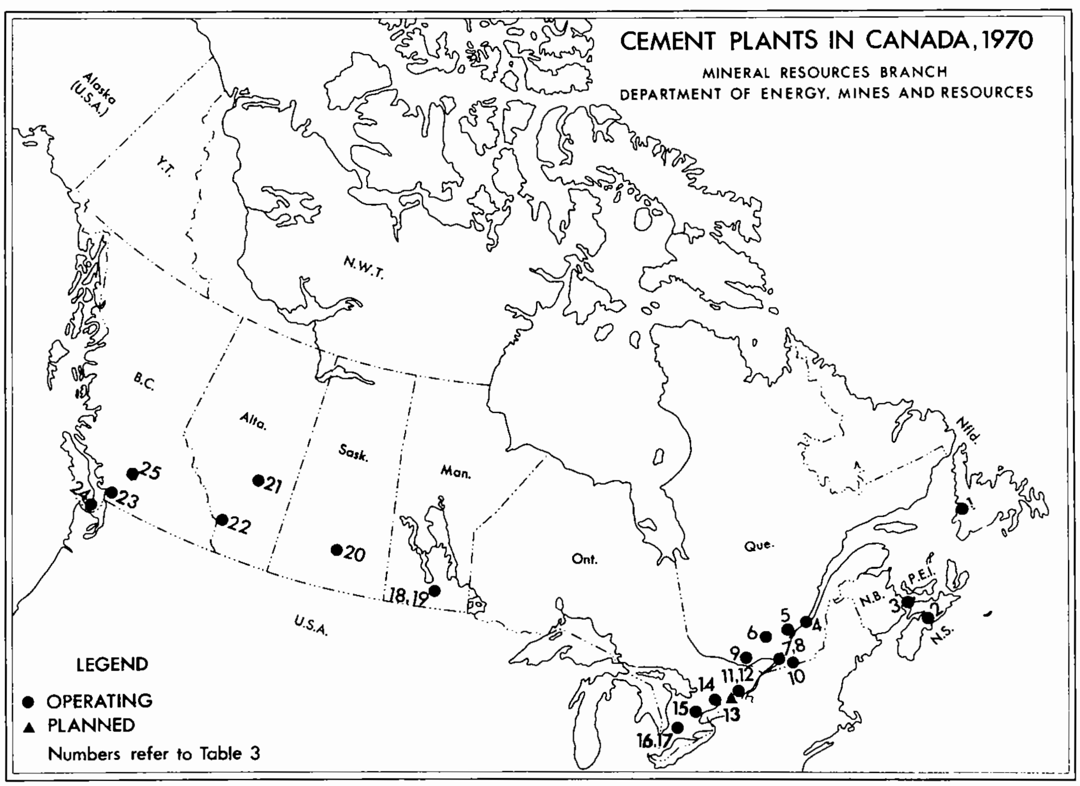


TABLE 3

Cement Plants–Approximate Annual Capacities, 1970

Company	Plant Location	Process	Short Tons
Newfoundland			
1. North Star Cement Limited	Corner Brook	dry	175,000
Nova Scotia			
2. Canada Cement Lafarge Ltd.	Brookfield	dry	246,000
New Brunswick			
3. Canada Cement Lafarge Ltd.	Havelock	dry	350,000
Quebec			
4. St. Lawrence Cement Company	Villeneuve	wet	787,500
5. Ciment Quebec Inc.	St. Basile	wet	437,500
6. Independent Cement Inc.	Joliette	dry	656,200*
7. Miron Company Ltd.	St. Michel	dry	1,050,000
8. Canada Cement Lafarge Ltd.	Montreal	wet	1,400,000
9. Canada Cement Lafarge Ltd.	Hull	wet	210,000
10. Lafarge Canada Ltd.	St. Constant	dry	525,000
Ontario			
11. Lake Ontario Cement Limited	Picton	dry	875,000
12. Canada Cement Lafarge Ltd.	Belleville	wet	770,000
13. Canada Cement Lafarge Ltd.	Bath	dry	1,100,000**
14. St. Marys Cement Limited	Bowmanville	wet	385,000
15. St. Lawrence Cement Company	Clarkson	wet/dry	1,750,000
16. Canada Cement Lafarge Ltd.	Woodstock	wet	525,000
17. St. Marys Cement Limited	St. Mary's	wet	752,500
Medusa Products Company of Canada, Limited	Paris		grinding only
Manitoba			
18. Canada Cement Lafarge Ltd.	Fort Whyte	wet	525,000
19. Inland Cement Industries Limited	Winnipeg	wet	350,000
Saskatchewan			
20. Inland Cement Industries Limited	Regina	dry	227,500
Canada Cement Lafarge Ltd.	Floral		grinding only
Alberta			
21. Inland Cement Industries Limited	Edmonton	wet	577,500
22. Canada Cement Lafarge Ltd.	Exshaw	wet	475,000
Canada Cement Lafarge Ltd.	Edmonton		grinding only
British Columbia			
23. Lafarge Canada Ltd.	Lulu Island	wet	612,500
24. Ocean Cement Limited	Bamberton	wet	700,000
25. Lafarge Canada Ltd.	Kamloops	dry	210,000
Total capacity (58 kilns)			14,572,200

Source: Published data.
*Adding approximately 220,000 tons capacity (1kiln) in 1971.
**Not included in total. Planned for 1973.

wick. This plant, built in 1951 and expanded in 1966 by the addition of a second kiln, has a capacity of 350,000 tons a year and ships portland cement in bulk or in bags. Shipments in 1970 were reduced from 1969 levels. As in Nova Scotia, both the number of housing starts and the value of building permits issued were lower than in 1969, while heavy construction awards were greater in value.

QUEBEC

In the Province of Quebec, six companies operate a total of seven cement manufacturing plants. Regionally, the six companies producing cement in Quebec province compete for the construction markets in the Quebec and Montreal areas. These markets have been recovering from the post Expo '67 slump and have increased over last year's level despite general disruptions caused by labour unrest during 1970. Total cement production in Quebec was less than in 1969 while the industry operated at an average of only 44 per cent of recognized rated capacity.

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 1 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, at 1.4 million tons a year, is second only to that of St. Lawrence Cement Company's Clarkson, Ontario plant that has a capacity of 1.75 million tons. Canada Cement Lafarge's Hull operation is on the site where cement was first produced in Canada. From this location, areas of the Ottawa Valley are served.

Miron Company Ltd., with the second largest cement-producing capacity in the Montreal area, operates a dry process plant at St. Michael. The company also supplies concrete and other building materials to the construction industry and maintains a contracting division.

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.

During 1969 Lafarge Canada Ltd. (formerly Lafarge Cement of North America Ltd.) of Vancouver, British Columbia, acquired the cement manufacturing plant of Lafarge Cement Quebec Ltd., at St. Constant, 18 miles south of Montreal. The plant has a capacity of 525,000 tons a year which has never been fully utilized since going on stream in 1966 at the height of construction activity in that province. In July, 1969, the parent company, Ciments Lafarge S.A. of Paris, France, became the largest shareholder in Canada Cement Company and subsequently a merger of the two Canadian operating companies was recommended to the respective boards of directors. The merger became effective May 1, 1970, bringing under the new company – Canada Cement Lafarge Ltd. – eleven cement-producing plants and marketing facilities operating in all provinces except Newfoundland. The Lafarge plant at St. Constant is modern, technically efficient and could conceivably replace some of the capacity of Canada Cement's older Montreal East plant.

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 was scheduled to start up early in 1970 and in 1971 a fourth kiln of similar design will be operative. 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 435,000 tons a year.

The value of building permits issued during 1970 in Quebec was slightly higher than in 1969 and the number of dwelling starts also showed an increase. Toward the end of the year 1970, heavy construction awards were increased greatly, boosting the year's total value well above that of 1969 and providing carry-over projects which will bolster construction activity during 1971 and beyond.

ONTARIO

Four companies operate a total of six cement manufacturing plants and one clinker grinding plant 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.

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. Heavy construction awards in Ontario in 1970 were increased in value over those of 1969, while the value of building permits remained about the same. Dwelling starts during 1970 decreased about 4 per cent. Despite rising costs of production and labour unrest in the construction industry, most producers of cement maintained or increased production during the year in Ontario and output was about 60 per cent of capacity.

Lake Ontario Cement Limited is Canada's largest cement exporter. 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 are also made by truck and by rail to domestic markets. Plant capacity is about 875,000 tons a year. During 1970 the company concentrated its capital expenditures in the area of improving fuel efficiency and in the face of increased solid fuel costs will, during 1971, be in a position to operate on natural gas with coal as an alternative. Sales of cement in Canada and the United States reached an all time high despite the difficulties experienced in the construction industries in both Ontario and the Rochester area of New York State, which together constitute the company's main market area.

The Belleville plant of Canada Cement Lafarge Ltd. is one of the original operations grouped to form the Canada Cement Company in 1909. Many equipment changes have been made over the years and the present three-kiln, wet process is capable of producing about 770,000 tons of cement a year. Subsequent to the company's announcement that a new 1.1 million tons a year plant will be constructed at Bath, Ontario by 1973, the company declared its intention to phase out the Belleville plant by the end of September, 1973. Located on deep water, the plant is served by ship as well as by rail and truck haulage.

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 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 and it features the largest suspension preheater kiln in North America and an Aerofall mill 27 feet in diameter by 8 feet in length, rated at 400 tons an hour of 8-inch stone. Limestone for the plant is brought in by boat from Ogden Point, 100 miles east of Toronto on the north shore of Lake Ontario. Gypsum is trucked from the 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.

St. Marys Cement Limited, operates two plants in Ontario. The original plant at St. Mary's 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 was built at Bowmanville during 1967 and 1968. First shipments were made in January 1969. The plant is favourably located with respect to the major marketing area of metropolitan Toronto and is capable of producing 385,000 tons a year from raw material at the site. Shipments are made by truck and by rail.

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.

WESTERN PROVINCES

Cement producing facilities are situated in major growth areas across the western provinces with four companies operating a total of seven clinker producing and grinding plants as well as two separate grinding plants. The Western Canada cement industry operated at 55 per cent of rated capacity during 1970 despite work stoppages in the construction industry. The value of heavy construction awards decreased by nearly 10 per cent while the value of building permits decreased by about 9 per cent from 1969 totals for the western region. The decrease in heavy construction activity was mainly in British Columbia. The value of building permits issued decreased in three provinces but showed an increase in Manitoba.

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 925,000 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 is purchased from Gypsumville, 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 east halfway across northern Ontario.

At Exshaw, Alberta, a cement plant has been operated since 1910. The present facilities are capable of producing up to 544,000 tons of cement a year from raw materials obtained locally. 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.

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 is the most recent addition to the company's facilities, having gone 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 Winnipeg and Regina plants. 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.

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. quarries limestone at Bamberton on Vancouver Island for cement manufacture and for use as an aggregate. The cement plant has a capacity of 840,000 tons a year.

WORLD REVIEW

Production of cement was recorded in 111 countries on six continents during 1969, the latest year for which such statistics are available. Because of the close relationship of cement-concrete-construction, the production and utilization of cement can be interpreted as indicators of a country's rate of development. World production of cement in 1969 was approximately 595,000,000 short tons, an increase of over 5 per cent from 1968; 52 countries reported production in excess of 1 million tons.

EUROPE

European member countries of the Organization for Economic Co-operation and Development (OECD) accounted for 56 per cent of Europe's cement production in 1969 which in turn was about 55 per cent of world production. The USSR led the world in cement production, contributing over 17 per cent of the world total and about 30 per cent of the European output. West Germany, Italy, France and Britain followed in that order from among the 24 countries producing more than 1 million tons each.

Although cement output from many European countries has been increased significantly, perhaps Italy's performance was outstanding with a 12.6 per cent increase in 1968 and a 7 per cent increase in 1969 enabling it to attain fifth position in world output.

TABLE 4

World Production of Cement
(thousand short tons)

	1959	1969	Production Increase %
USSR	42,752	98,931	131
United States	66,878	78,330	17
Japan	19,034	56,611	197
West Germany	25,534	38,567	50
Italy	15,682	34,813	121
France	15,431	30,343	97
Britain	14,098	19,191	36
Spain	6,315	17,640	179
India	7,644	14,609	91
Poland	5,857	13,033	122
China	13,525	11,017	−19
Canada	6,284	8,250	31
Czechoslovakia	5,229	7,216	38
Other countries	79,926	166,923	109
Total	324,189	595,474	84

Source: U.S. Bureau of Mines Minerals Yearbook. Preprint 1969, and U.S. Bureau of Mines Minerals Yearbook, 1960.

Additional capacity is planned in view of favourable growth forecasts in the construction industry.

In Britain, Associated Portland Cement Manufacturers Ltd. plans a new operation which will contribute about 4 million tons capacity to that nation's cement industry. The project, which will include six kilns, a 7-mile clay-slurry pipeline and 6000-hp mills, will be completed in 1971 at Northfield, Kent, England.

ASIA

Asian countries accounted for about 21 per cent of reported 1969 cement production; 15 of 31 countries

TABLE 5

World Cement Production Per Capita

Country	Pounds of Cement		Increase %
	1959	1969	
Belgium	1,074	1,432	33
West Germany	969	1,314	36
Italy	635	1,309	106
France	682	1,206	77
Japan	412	1,107	169
Spain	420	1,071	155
Czechoslovakia	771	1,001	30
Canada	719	783	9
USSR	406	781	92
United States	752	771	3

produced in excess of 1 million tons each. Japan led all producers and with an increase of 7 per cent over the previous year maintained a strong third place among world producers. Efficient plant operation, a high degree of domestic industrialization and a favourable location relative to Asian markets have contributed to the development of Japan's cement industry.

Turkey's largest cement producer is Turkiye Cimentesu Sanayii T.A.S. at Ankara. The government-owned company will construct four new cement plants and will expand three other operations, raising annual production capacity by 3 million tons.

The Iraqi government will erect a new, wet-process, cement plant at Kufa, adding 200,000 tons to the annual capacity at a cost of approximately $5 million. In Taiwan, the Cheng Tai Cement Corp. will increase production capacity from 110,000 tpy to 550,000 tpy at a cost of $3.5 million.

Although the Korean cement industry began in 1942, it did not develop until after 1956. Since then annual production has risen from about 50,000 tons to over 5 million tons. Eight plants had a total production capacity of 7.2 million tons in 1970 and with one new plant and three expansions planned, this will be increased to 11.9 million tons by 1972. Exports of cement, which have been minor because of high local demand, will increase as new capacity comes on stream.

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 American countries with the United States contributing nearly 80 per cent of the total and Canada and Mexico following in that order. Major developments in the United States in 1970 included the net addition of about 2 million tons of production capacity and the closure of several plants in face of the high costs of meeting newly-imposed, regional environmental regulations. From available information the Mexican cement industry had planned seven plant expansions and five new plants for 1970 despite expecting the demand for cement to show a lower rate of increase. Production in Mexico in 1969 was up by nearly 11 per cent.

SOUTH AMERICA

In 1969, 10 South American countries produced approximately 23 million tons of cement in total, up by about 6 per cent from 1968. Six of the 10 producing countries had outputs greater than 1 million tons, lead by Brazil, Argentina, Columbia and Venezuela in that order. South American cement accounts for nearly 4 per cent of world production but in such countries as Argentina where construction is rapidly increasing it is necessary to import cement, principally from Romania, Belgium and Peru. Increased capacity is planned for Ecuador and the largest cement producer in Venezuela plans large expenditures for automation.

AFRICA

African cement producers account for about 3 per cent of world production. Only four of 23 producing countries had outputs in excess of 1 million tpy in 1970, the leaders being the Republic of South Africa, the United Arab Republic, Algeria and Morocco, in that order.

Federale Kunsmis Group, through a subsidiary, Palcaso (Pty.) Limited, is building a $16.8 million sulphuric acid and cement clinker plant at Phalaborwa, Northern Transvaal, South Africa. Through another subsidiary, Palment (Pty) Ltd., a new milling plant will be constructed at a cost of $1.6 million in which the clinker from Palcaso will be used to make cement. The complex will be unique in that "byproduct" gypsum will be used to produce the SO_2 and cement clinker.

Angola's two cement producers have increased their capacities to 600,000 and 90,000 tpy while consumption continued to show regular increase.

OCEANIA

Production of cement in Oceania is mostly from Australia where 16 plants have a total annual capacity of over 5 million metric tons. Australia's consumption of cement is increasing at about 6 per cent a year and is close to, if not above, the United States and Canada on a per capita basis.

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

TABLE 6

Canada, Destination of Domestic Cement Shipments* 1970
(short tons)

Ontario	3,180,078
Quebec	1,750,060
Manitoba, Saskatchewan, Alberta and British Columbia	1,887,032
Newfoundland, Prince Edward Island, Nova Scotia and New Brunswick	477,560
Yukon and Northwest Territories	14,760
Canada, total	7,309,490
Exports	565,797
Total shipments	7,875,287

Source: Dominion Bureau of Statistics.

*Special compilation. Direct sales from producing plants.

TABLE 7

Canada–Mineral Raw Materials* Used by the Cement Industry
(short tons)

Commodity	1968	1969
Shale	485,981	450,359
Limestone	10,780,377	10,959,491
Gypsum	346,361	372,319
Sand	309,118	292,103
Clay	1,164,894	1,104,137
Iron oxide	67,253	75,696

Source: Dominion Bureau of Statistics.

*Includes purchased materials and materials produced from own operations.

requirements if the market volume warrants a plant. Few countries rely entirely on imports for their cement needs. Some countries do, however, 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, Canada being a net exporter in this regard. Canadian market areas are reflected in the distribution of shipments from Canadian producers, shown in Table 6.

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 have grown from about 5,000 tons in 1960 to an estimated 240,000 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.

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

The Canadian cement industry is highly competitive in a market that can accept only a definite and limited amount of its product. Despite this fact and in face of apparent overcapacity, new plants are being built and existing ones are being expanded. This is possible because of the adaptation of new equipment and techniques of manufacture and the choosing of new plant locations 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.

Company mergers, continued diversification and vertical integration by cement producers will eventually result in the write-off of some comparatively

TABLE 8

Canada–Production of Concrete Products

	Unit	1969	1970
Concrete bricks	No.	100,523,503	81,017,143
Concrete blocks (except chimney blocks)			
Gravel	No.	171,210,766	142,273,678
Other	No.	47,982,946	37,204,061
Concrete drain pipe, sewer pipe, water pipe and culvert tile	s. ton	1,010,614	1,075,706
Concrete, ready mix	cu. yd.	13,844,831	12,821,761

Source: Dominion Bureau of Statistics.

inefficient production capacity as the emphasis on a cement-concrete industry increases.

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 their share of the construction dollar. In this respect, not only practical research in the use of cement-concrete is 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.

SPECIFICATIONS

Portland cement used in Canada should conform with the specifications of CSA Standard A5 - 1961 published by the Canadian Standards Association. This standard covers the three main types of portland cement as follows: Normal, High Early Strength and Sulphate-Resisting portland cements. Modified and low-heat cements are being manufactured by several cement companies in Canada and are designed for mass concrete use in dam construction.

Masonry cement produced in Canada should conform to the CSA Standard A8 - 1970. This type of cement is also sold under the other names – Mortar Cement, Mason's Cement, Brick Cement, Mortar Mix, etc.

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).

PRICES

The average value of all Canadian shipments in 1970 was $19.89 a ton based on 1970 preliminary data and compared with $19.65 a ton in 1969. Prices varied considerably across the country reflecting principally transportation costs for both raw material and for finished cement.

TARIFFS

		British Preferential	Most Favoured Nation	General
CANADA				
Item No.				
29000–1	Portland and other hydraulic cement, n.o.p.; cement-clinker per 100 lbs	free	free	6¢
29005–1	White, non-staining Portland cement, per 100 lbs	4¢	4¢	8¢

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

UNITED STATES

Item No.		
511.11	White, non-staining Portland cement	
	On and after Jan. 1, 1970	2¢ per 100 lb incl. weight of container
	" " " Jan. 1, 1971	1.5¢ " " " " " " "
	" " " Jan. 1, 1972	1¢ " " " " " " "
511.14	Other cement and cement clinker	
	On and after Jan. 1, 1970	0.9¢ per 100 lb incl. weight of container
	" " " Jan. 1, 1971	0.4¢ " " " " " " "
	" " " Jan. 1, 1972	free
511.21	Hydraulic cement concrete	
	On and after Jan. 1, 1970	2%
	" " " Jan. 1, 1971	1%
	" " " Jan. 1, 1972	free
511.25	Other concrete mixes	
	On and after Jan. 1, 1970	10%
	" " " Jan. 1, 1971	9%
	" " " Jan. 1, 1972	7.5%

Source: Tariff Schedules of the United States annotated (1970), TC Publication 304.

Chromium

G. P. WIGLE*

Canada's imports of chromium in ores and concentrates in 1970 were 30,445 tons (Cr content) valued at $2,331,000 compared with 41,924 tons valued at $2,889,000 in 1969. Imports of ferrochromium were 22,943 tons valued at $6,198,000 compared with 25,123 valued at $5,812,000 in 1969. Chromite ($FeOCr_2O_3$) consumption was 68,484 tons in 1969 and 77,075 tons in 1968. Canadian companies manufacturing chromite refractories as a primary product used 55,205 tons of chromite valued at $2.34 million in 1968.

Canada is not a producer of chromite ($FeOCr_2O_3$), the principal ore mineral of chromium. The 64 years 1886 to 1949 covered Canada's periods of recorded, small and intermittent production of chromite. Production was reported in 47 of those years and totalled 278,326 tons valued at $5,616,401. The Province of Quebec produced 272,252 tons of the total; 5,278 tons came from Ontario and 796 tons from British Columbia. The periods of highest annual production were 1915 to 1920 and 1941 to 1945 with highs of 36,725 tons in 1917 and 29,596 tons in 1943. Canada has not produced chromite since 1949 when domestic consumption was 55,793 tons, and world production of chromite in that year exceeded 2 million tons. It is important to note that Canada's production of metallic minerals alone had grown from a valuation of $2.1 million in 1886 to $538.9 million in 1949 and increased even more rapidly to $3,115 million in 1970.

Chromium has wide and essential uses in the iron and steel industry. It is a principal constituent of stainless steel, is used in structural and tool steels, machinery parts, heating elements, and in corrosion-resistant applications. Chromium in the form of its principal mineral, chromite, is used in refractories for metallurgical furnace and ladle linings. Chromium chemical products are used in making pigments, dyes, and fungicides, and in the electroplating and leather tanning processes.

The additive alloy, ferrochromium, commonly used to add chromium to iron and steel is produced in Canada by Union Carbide Canada Limited. Union Carbide's manufacture of ferroalloys includes high-carbon ferrochrome, charge chrome and ferrochrome-silicon. Suppliers of chromite and chromium additives other than Union Carbide, include Chromium Mining & Smelting Corporation, Limited; Philipp Brothers (Canada) Ltd.; Metallurg (Canada) Ltd.; and Continental Ore Co. (Canada) Limited.

Consumers of chromium in Canada include Atlas Steels Division of Rio Algom Mines Limited; Colt Industries (Canada) Ltd.; Fahralloy Canada Limited; and the Steel Company of Canada, Limited. Among the manufacturers of chromite-bearing firebrick, cements and mortars are: Canadian Refractories Limited; General Refractories Company of Canada Limited; Kaiser Refractories Company Division of Kaiser Aluminum & Chemical Canada Limited; and Quigley Company of Canada Limited.

*Mineral Resources Branch.

TABLE 1

Canada, Chromium Trade and Consumption, 1969-70

	1969		1970p	
	Short Tons	$	Short Tons	$
Imports				
Chromium in ores and concentrates				
United States	12,923	1,069,000	13,226	1,127,000
Philippines	9,139	635,000	7,616	514,000
Russia	6,495	381,000	6,670	458,000
Turkey	7,464	417,000	1,671	120,000
Cyprus	2,125	153,000	1,064	88,000
Ireland	682	82,000	198	24,000
Other countries	3,096	152,000	–	–
Total	41,924	2,889,000	30,445	2,331,000
Ferrochromium				
United States	2,756	885,000	9,052	3,125,000
South Africa	21,604	4,713,000	13,349	2,909,000
Norway	447	122,000	331	110,000
Japan	121	21,000	110	31,000
Sweden	64	17,000	101	23,000
Other countries	131	54,000	–	–
Total	25,123	5,812,000	22,943	6,198,000
Chromium sulphates, basic, for tanning				
United States	2,493	247,000	1,023	236,000
Japan	347	57,000	285	48,000
Britain	130	24,000	48	9,000
South Africa	30	4,000	–	–
Total	3,000	332,000	1,356	293,000
Chromium oxides and hydroxides				
United States	87	70,000	175	128,000
Japan	141	73,000	218	108,000
Britain	178	116,000	74	41,000
West Germany	10	8,000	18	16,000
Other countries	–	–	46	23,000
Total	416	267,000	531	316,000
Chrome dyestuffs				
United States	11	32,000	18	45,000
West Germany	13	38,000	12	35,000
Switzerland	15	49,000	7	31,000
Japan	24	29,000	7	15,000
Britain	24	45,000	7	14,000
Other countries	24	50,000	5	8,000
Total	111	243,000	56	148,000
Consumption				
Chromite	68,484	. .	. .	. .

Source: Dominion Bureau of Statistics.
pPreliminary; –Nil; . . Not available.

TABLE 2

Canada, Chromium Trade and Consumption, 1961-70
(short tons)

	Imports		Exports	Consumption[2]	
	Chromite[1]	Ferrochromium[2]	Ferrochromium[2]	Chromite	Ferrochromium
1961	71,268	..	1,642	52,134	8,046
1962	71,969	..	6,602	70,342	9,453
1963	49,654	..	2,910	56,016	9,662
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[p]	30,445	22,943	..	..	..

Source: Dominion Bureau of Statistics.

[1]To 1963, gross weight; from 1964, chromium content; [2]Gross weight.

[p]Preliminary; .. Not available; – Nil.

CHROMIUM PRODUCTION AND TRADE

Estimated world mine production of chromite was 5.7 million tons in 1970 compared with 5.6 million tons in 1969. The USSR, Republic of South Africa, Turkey, Philippines, Rhodesia, and Albania supplied the major part of the world's chromite.

United States, the principal importer and consumer of chromite, relies on imported supplies. United States imports of chromite in 1970 were 1,405,527 tons and consumption was 1,394,104 tons compared with 1,106,424 tons imported and 1,411,100 tons consumed in 1969. The metallurgical industry used 65 per cent of 1970 United States consumption, the refractory industry 20 per cent, and the chemical industry 15 per cent. The largest supplier was USSR with 33 per cent, followed by South Africa, 29 per cent, Turkey, 18 per cent, Philippines, 15 per cent, and other countries, 5 per cent.*

The published prices for Russian chromite, 54-56 per cent Cr_2O_3, per long ton, f.o.b. cars, Atlantic ports, increased from U.S. $45.40-$49.20 in 1969 to U.S. $55.10-$59.60 in 1970.

Chromite production in the Republic of South Africa was 1,148,866 short tons in the first 9 months of 1970 compared with 967,138 short tons in the same period of 1969. Local sales of chromite in South Africa, principally to supply the domestic ferrochromium industry, increased to 259,241 tons in January-September 1970 from 213,143 tons in the same period of 1969. Chrome ore and concentrate exports were 823,435 tons and 711,980 tons in the respective 9-month-periods of 1970 and 1969 while exports of chrome sands, a product prepared for use in foundry moulds, decreased to 17,083 tons during January-September 1970 from 26,956 tons exported in the same period of 1969.**

TABLE 3

World Production of Chromium Ore, 1968-70
(thousands of short tons)

	1968	1969	1970[e]
USSR[e]	1,820	1,874	1,840
South Africa, Republic of	1,271	1,320	1,350
Turkey	459	492	500
Philippines	446	518	550
Rhodesia[e]	420	400	400
Albania	360	360	360
India	227	249[r]	
Iran[e]	99	100	
Yugoslavia	50	43	
Finland	40	79	
Malagasy Republic	..	49	(700)
Japan	31	33	
Sudan	24	24	
Pakistan	29	29	
Cyprus	28	26	
Brazil	19	18	
Greece	14[e]	33	
Total	5,337	5,647	5,700

Sources: U.S. Bureau of Mines Minerals Yearbook, Commodity Data Summaries; IM&EJ December 1970.

[e]Estimated; .. Not available; (700) estimated; [r]Revision;

CHROMIUM ORE AND THE USES OF CHROMIUM

Chromium is never found in the free uncombined state in natural occurrences and chromite is its only commercially important ore mineral. The theoretical composition of chromite is $FeOCr_2O_3$ with a chromic oxide (Cr_2O_3) content of 68 per cent, and 32 per cent of iron oxide (FeO). Chromite, in ore occurrences, is usually found as a combination of oxides of chromium and iron with varying amounts

*U.S. Bureau of Mines, Mineral Industry Surveys.

**Minerals – A Report for the Republic of South Africa, Department of Mines, Johannesburg.

of magnesium and aluminum and has the general formula $(Fe,Mg)O(Cr,Al,Fe)_2O_3$. The better ores of chromite contain from 42 to 56 per cent Cr_2O_3 and 10 to 26 per cent FeO, with mixed amounts of magnesia and alumina, and with silica and calcium also present. Representative analyses of chromium ores from different sources are listed in Table 5.

The earliest development in the use of chromium was in the chemical field. Its use in the making of paint pigments started about 1800 in France and Germany, and about 1816 in England. The use of chromium chemicals expanded during the next 25 years with their introduction into textile colouring and the tanning of leather. Chromite was used as a refractory for furnace linings in France in 1879, but it was not until 1900 to 1915 that chromium ore became metallurgically important. Since that time the uses of chromium have shown sustained important growth. Chromium ore is used in three principal industrial activities: the metallurgical, chiefly in the form of ferrochromium for addition to steel; the refractory, in making chemically neutral refractory bricks and furnace linings; the chemical, including the making of paint pigments and the chromium plating of metals.

Variations in chemical and physical properties are the basis for classifying chrome ores into three main groups: metallurgical, refractory, and chemical grades. The metallurgical industry of the United States, in recent years, used about 59 per cent of domestic chromite consumption, the refractory industry 27 per cent, and the chemical industry about 14 per cent. The consumption and chromic oxide (Cr_2O_3) content of the ores used by these industries in the United States are given in Table 4.

TABLE 4

Consumption of Chromite and Tenor of Ore Used by Primary Consumer Groups in the United States (thousand short tons)

	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 (%)
1963	632	48.7	368	34.6	187	45.1	1,187	43.8
1964	832	49.0	430	33.8	189	45.1	1,451	44.0
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

Source: Preprint from 1969 U.S. Bureau of Mines Minerals Yearbook.

TABLE 5

Representative Analyses of Chromium Ores

Country and Type	Per Cent						
	Cr_2O_3	Total Fe	Al_2O_3	MgO	CaO	SiO_2	Cr:Fe Ratio
Rhodesia							
(Selukwe)							
Metallurgical	47	9.34	12.64	15.50	1.80	5.70	3.4:1
Refractory	42.6	12.2	13.80	15.80	.32	8.60	2.4:1
(Dyke)							
Refractory	50.70	12.75	13.00	13.20	.75	4.33	2.7:1
Metallurgical	48.50	14.2	11.50	13.40	.80	5.6	2.4:1

TABLE 5 (Cont'd)

Country and Type	Per Cent						Cr:Fe Ratio
	Cr_2O_3	Total Fe	Al_2O_3	MgO	CaO	SiO_2	
Russia							
Metallurgical	53.90	9.80	9.60	13.30	1.1	5.80	3.76:1
Refractory	39.10	10.90	17.4	16.10	.7	9.4	2.5 :1
Turkey							
Metallurgical	48.30	10.95	13.00	16.84	.95	5.07	3.01:1
Refractory	37.00	11.80	24.34	17.73	.22	4.33	2.36:1
Philippines (Masinloc)							
Refractory	33.35	10.30	28.23	19.56	.45	4.58	2.2 :1
South Africa		FeO					
Chrome concentrate	50.7	21.0	11.9	12.8	0.1	1.6	..
	49.2	22.6	13.9	11.7	..	1.9	..
Friable ore	45.2	26.6	15.4	9.6	0.9	2.1	..
Hard, lumpy ore	49.7	20.9	12.0	13.0	0.1	2.5	..
	42.5	25.0	15.0	12.0	0.1	4.0	..

Sources: *E&MJ Metal and Mineral Markets*, Market Guide, Chrome, May 1966, and Minerals—A Report for the Republic of South Africa, April-June 1968.

METTALLURGICAL CHROMITE AND FERROCHROMIUM

The better grade metallurgical chromite ores are hard, lumpy ores containing 48 per cent or more Cr_2O_3 and having a chromium-to-iron (Cr:fe) ratio of three to one (3:1), or more. A high chromium to iron ratio is important in the making of ferrochromium in order to reduce losses in the submerged-arc electric smelting process commonly used in making it.

Most of the chromite used by the metallurgical industry is first converted to one of several grades of chromium ferroalloys. Some chromite is converted to chromium metal for use in special alloys and some chromite is added directly to steel. Chromium promotes hardenability and improves corrosion and wear resistance of iron and steel. It is a principal alloying constituent of stainless steels, accounting for more than 65 per cent of the consumption of chromium ferroalloys used by the metallurgical industry.

Ferrochromium is commonly made by reducing chromite with coke in submerged-arc electric furnaces. A modern 35,000-kilowatt furnace produces 175 to 200 tons of ferrochromium a day. High-carbon (3 to 6 per cent C) ferrochromium (50 to 70 per cent Cr) is used to add chromium to medium and high-carbon steels in which both chromium and carbon are required. Low-carbon ferrochromium, 60 to 73 per cent chromium, containing .010 to 2 per cent carbon, is used in producing stainless, and heat and corrosion resistant steels with low carbon specifications. Other ferroalloys of chromium contain more carbon or silicon and some contain an oxidizing agent such as sodium nitrate, to react exothermically when added to molten iron or steel.

Chromium content ranging from 16 to 26 per cent is used in the chromium-nickel and chromium-nickel-manganese types of stainless steel. Nickel-base chromium alloys are used in jet engines, turbine blades, heating elements and in handling-equipment for hot or corrosive chemicals. Chromium is used in a variety of other alloy steels ranging in content from less than one per cent to as much as 35 per cent chromium.

REFRACTORY-GRADE CHROMITE

Chromite is used directly in refractories because of its high melting point, moderate thermal expansion, and its resistant chemically neutral nature. Processing by the refractory industry involves sizing, blending and the forming, curing, and firing of the refractory shapes required. Chromite refractories are used extensively for the lining of metallurgical and glassmaking furnaces, hot-metal ladles and in lime kilns. Specifications for refractory-grade chromite are not as rigid as for metallurgical but mineral constituents are important in the making of good quality refractory brick. The refractory industry uses chromite averaging about 35 per cent Cr_2O_3. The iron and silica content should not be over 12 and 6 per cent respectively; chromic oxide (Cr_2O_3) and alumina (Al_2O_3) combined should be about 60 per cent. The ore should be hard and lumpy and about 10-mesh in size. Chromite fines are suitable for the manufacture of refractory brick cement and chrome-magnesite brick. Friable chromite ores, 43 to 50 per cent Cr_2O_3, are being used, principally in South Africa, to supply prepared chromite sands to the metallurgical industry for use in foundry moulds.

CHEMICAL-GRADE CHROMITE AND CHROMIUM CHEMICALS

Chromium chemicals are used in pigments, leather tanning, electro-plating, fungicides and in a variety of chemical processes as catalysts and oxidants. Chromium plating of plastic parts for automobiles, appliances and home furnishings is a growing industrial use.

The chemical industry uses chromite averaging about 45 per cent Cr_2O_3; the chromium to iron ratio usually about 1.6 to 1. Specifications are less rigid than for metallurgical grade. Friable ores and fines are acceptable but Cr_2O_3 content should not be less than 44 per cent, alumina (Al_2O_3) not more than 15 per cent, and not over 20 per cent total iron and 5 per cent silica.

The principal chromium chemicals derived from chromite are the chromates and dichromates of sodium. These salts are used to make other chromium compounds such as chromic oxide, chromic acid, tanning compounds, and pigments.

The finely ground chrome ore is mixed with measured amounts of soda ash (Na_2CO_3) and lime (CaO) and the dry mixture is fed to a horizontal rotary roasting kiln. Modern kilns are typically from 7 to 9 feet in diameter and 60 to 180 feet in length. They are lined with refractories and fired with oil or powdered coal, using an excess of air. The temperature in the firing zone of the kiln reaches 1100 to 1150°C as the material passes through in 1 to 4 hours at a rate of 2 to 10 tons an hour depending on kiln capacity. The cooled roasted product containing sodium chromate (Na_2CRO_4) is leached in filter boxes with water and a nearly saturated solution containing the soluble sodium chromate is recovered. The chromate solution is concentrated by evaporation to 40 or 45 per cent Na_2CrO_4 and is then treated with sulphuric acid or pressurized carbon dioxide to convert the sodium chromate to sodium dichromate in a solution containing 80 to 85 per cent hydrous sodium dichromate ($Na_2Cr_2O_72H_2O$). Cooling the solution to about 35°C obtains crystals of sodium dichromate dihydrate. The sodium dichromate dihydrate is sold in technical, and chemically pure grades, and as a 70 per cent solution.

Sodium chromate (Na_2CrO_4), also obtained from the leaching operation, is similarly cooled to cause crystallization of $Na_2CrO_44H_2O$ which may be sold as hydrous sodium chromate or redissolved and evaporated to dryness to produce anhydrous sodium chromate.

CHROMIUM ELECTROPLATING

Chromium is the plating material most familiar to the public, as the final finish on a great variety of consumer products. The process, unique in some respects, uses a solution of chromic acid (CrO_3) and a small amount of a catalyst sulphate, often sulphuric acid (H_2SO_4); in some processes various proprietary catalysts may be used. Electroplating with chromium became particularly successful following the discovery that polishing the metal base and then plating with a thin coat of nickel under the equally thin chromium gave excellent appearance and durability. In addition to its decorative uses, chromium plating is widely used for its hardness and bearing properties, generally in heavier deposits than those used for decoration or protection from discolouration.

An outstanding property of chromium plating is its extreme hardness. Expressed in Brinell numbers the hardness of nickel plate is about 300 while chromium plate is about 1000. An early use for hard chromium plate was on gauges. The plating improves resistance to wear, prevents seizing to the work, and permits replating after excessive wear. The high hardness of chromium plating is particularly useful for the moving parts of machinery, automotive parts, and drawing-dies, and for the salvage and repair of worn steel parts of mechanical equipment.

The hardness and wear resistance of chromium plate are used in many kinds of printing. Chromium-plated engraved printing plates and rolls are lasting and print sharply defined lines.

PRICES

Chrome prices published by *Metals Week* were:

	December 29, 1969	December 28, 1970
Chrome ore:		
Per long ton, dry basis, subject to penalties if guarantees not met, f.o.b. cars Atlantic ports,		
Transvaal:		
44% Cr_2O_3, no ratio	U.S.$19-21.50	U.S.$25-27
Turkish:		
48% Cr_2O_3, 3:1 ratio	37.50-38.50	55-56
Russian:		
48% Cr_2O_3, 4:1 ratio	40-42	49-52
54-56% Cr_2O_3, 4:1 ratio	45.20-49.20	55.10-59.60
Chromium metal:		
Electrolytic, 99.8%, f.o.b. shipping point, per lb	101¢	115¢
Vacuum melting (pellet) per lb	104¢	125¢

PRICES. (Cont'd)

9 per cent C per lb	142¢	156¢
Aluminothermic, delivered per lb, 99.25%	99¢	115¢
Ferrochrome:		
per lb Cr content, f.o.b. shipping point, freight equalized to nearest main producer, carload lots, lump, bulk		
High-carbon, 67-70% Cr, 5-6% C	21.7¢	28.7¢
Charge chrome, 63-71% Cr, 3% Si max., 0.04% S, 4.5-6% C	18.0¢	25.0¢
Imported charge chrome, delivered	19.25¢-19.50¢	22.5¢-23.5¢
Blocking chrome,		
10-14% Si	20.6¢	27.6¢
14-17% Si	21.6¢	28.6¢
Chromsol, 62% Cr, 5% Mn, 1.5% Si, 5.25% C, per lb alloy, f.o.b. shipping	12.65¢	16.75¢
HS Chrome-66	29.8¢	42.5¢
Low Carbon:		
67-73% Cr, 0.025% C	28.6¢	39.5¢
67-71% Cr, 0.05% C	27.6¢	38¢
Simplex, 0.01% C max.	28.6¢	39.5¢
Simplex, 0.02% C max.	27.6¢	38¢
Imported low-carbon, delivered 0.05% C	29-29.5¢	37¢
0.025% C	30-30.5¢	38¢
Ferrochrome silicon, per lb alloy,		
36/40, 0.05% C	13.5¢	
40-43, 0.05% C	14.35¢	
"L", 0.02% C	14.8¢	
Ferrochrome silicon, per lb Cr plus lb Si	Cr	Si
36/40, 0.05% C	26.25¢	16.0¢
40/43, 0.05% C	29.0¢	16.0¢
"L", 0.02% C	30.0¢	16.0¢

TARIFFS

		British Preferential	Most Favoured Nation	General
CANADA				
Item No.				
32900-1	Chrome ore	free	free	free
34700-1	Chromium metal, in lumps, powder, ingots, blocks, or bars and scrap of alloy metal containing chromium for use in alloying purposes	free	free	free
37506-1	Ferrochrome	free	5%	5%
92821-1	Chromium oxides and hydroxides	10%	15%	25%
	From Jan. 1, 1969 to Jan. 31, 1973 with the exception of the following:	free		
	Chromic oxide			
	Chromium trioxide			
92838-8	Chromium potassium sulphate	free	free	10%
92828-9	Chromium sulphate, basis	free	free	10%
UNITED STATES				
Tariff No.				
601.15	Chrome ore		free	
632.18	Chromium metal, unwrought (duty on waste and scrap suspended)			
	On and after Jan. 1, 1970		7%	
	On and after Jan. 1, 1971		6%	
	On and after Jan. 1, 1972		5%	

TARIFFS (Cont'd)

UNITED STATES (Cont'd)

Tariff No.		
633.00	Chromium metal, wrought	
	On and after Jan. 1, 1970	12.5%
	On and after Jan. 1, 1971	10.5%
	On and after Jan. 1, 1972	9%
632.84	Chromium alloys unwrought	
	On and after Jan. 1, 1970	12.5%
	On and after Jan. 1, 1971	10.5%
	On and after Jan. 1, 1972	9%
607.30	Ferrochromium	
	Not containing over 3% by weight of carbon	
	On and after Jan. 1, 1970	5.5%
	On and after Jan. 1, 1971	5.0%
	On and after Jan. 1, 1972	4.0%
607.31	Containing over 3% by weight of carbon	0.625¢ per lb on chromium content
416.45	Chromic acid	
	On and after Jan. 1, 1970	8.5%
	On and after Jan. 1, 1971	7%
	On and after Jan. 1, 1972	6%
422.92	Chromium carbide	
	On and after Jan. 1, 1970	8.5%
	On and after Jan. 1, 1971	7%
	On and after Jan. 1, 1972	6%
531.21	Chrome brick	
	On and after Jan. 1, 1970	17%
	On and after Jan. 1, 1971	15%
	On and after Jan. 1, 1972	12.5%
473.10	Chrome colours	
473.20	On and after Jan. 1, 1970	7%
	On and after Jan. 1, 1971	6%
	On and after Jan. 1, 1972	5%
420.98	Chromate and dichromate	
	On and after Jan. 1, 1970	1.2¢ per lb
	On and after Jan. 1, 1971	1.05¢ per lb
	On and after Jan. 1, 1972	0.87¢ per lb

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1969), TC Publication 272.

Clays and Clay Products

J. G. BRADY*

The situation for clays such as kaolins, fire clays and ball clays in Canada has not changed appreciably for many years. Deposits of these high-quality clays are generally scarce and contain small tonnages. Consequently most of these raw materials and many products made from them are imported. The few known deposits of fire clays and ball clays in the developed areas of Canada are already being utilized. Much work has been done on deposits containing kaolin but they have not been developed because of small size, high cost of beneficiation, or remoteness from transportation and/or industry. Countries such as the United States and Britain can supply good-quality kaolins for many years. Eventually, lower quality deposits will be utilized there, probably at increased cost and as a result of the development of improved beneficiating methods. Thus it is possible that at some time in the future, recovery of kaolin from a few Canadian areas may be possible because of high import costs (including transportation) and through improved technology.

Common clays and shales that are suitable for brick and tile manufacture occur in most regions of Canada and are used extensively by the ceramic industry. Ontario and Quebec are particularly deficient in developed deposits of refractory or kaolin-type clays. The search for new high-quality deposits and the re-examination of known deposits continued because of the possibility of replacing the large volume of imported clays with domestic supplies.

The review discusses in some detail the characteristics of Canadian Clays (except bentonite) and trade figures include those for clay products. The term "clay products" applies to such materials as fireclay refractories, common and facing brick, structural tile, partition tile, drain tile, quarry tile, sewer pipe, conduit and flue lining, which have clay as their principal ingredient; and wall tile, floor tile, electrical porcelain, sanitaryware, dinnerware and pottery, which are prepared bodies of the whiteware type and which, in addition to high quality clay such as kaolin and ball clay, may contain ground silica, feldspar, nepheline syenite, talc and various other components. Import and export figures include chrome, magnesia and silica refractories (these do not contain clay), as well as fireclay products. A list of ceramic plants is shown in Operators List 6, "Ceramic Plants in Canada", published by the Mineral Resources Branch, Department of Energy, Mines and Resources, Ottawa.

PRODUCTION, TRADE AND CONSUMPTION

Statistics on production, trade and consumption of clay and clay products are shown in Tables 1 to 6. Preliminary production, export and import figures are available for 1970 and appear in Tables 1 and 2. The production figures shown in Tables 3 and 4 for whitewares and refractories are the latest available and include those for 1967, 1968 and 1969. Some prices and tariffs are shown at the end of the review. Of interest is the decreased production in 1970 (Table 1) for clay products made from domestic clays (principally brick, tile and sewer pipe), and for clay products such as sanitaryware, electrical porcelain, dinnerware, pottery and floor and wall tile made from imported clays in 1969 (Table 3). Preliminary figures in Table 2 indicate that exports and imports of clay products (including non-clay refractories) increased in 1970. Consumption of china clay continued to increase (Table 6).

About one hundred and thirty plants manufactured clay products using domestic or imported clays. This total includes 20 plants, most of which are of a substantial size, that manufacture art pottery. Many small potteries are not included in this total because of their limited commercial operation. Brick and tile

*Mineral Processing Division, Mines Branch.

TABLE 1

Canada, Production of Clay and Clay Products from Domestic Sources, 1969-70

		1969		1970p	
		Quantities	$	Quantities	$
Production, shipments from domestic sources					
By main classes					
Clays, including bentonite			1,210,567		1,200,000e
Clay products from:					
Common clay			40,281,381		33,460,000e
Stoneware clay			6,993,191		6,900,000e
Fire clay			1,010,759		1,000,000e
Other			1,670,017		1,499,000e
Total			51,165,915		44,059,000
By products					
Clay					
Fire clay	st	284	105,559		
Other clay, incl. bentonite		..	1,105,008		
Fireclay blocks and shapes		..	114,228		
Fire brick	No.	5,957,315	896,531		
Brick					
Soft mud process					
Face	No.	14,611,285	868,831		
Common	"	2,271,268	51,630		
Stiff mud process					
Face	"	476,613,730	25,958,409		
Common	"	23,579,147	589,305		
Dry process					
Face	"	37,206,892	3,534,922		
Common	"	88,900	5,444		
Fancy, ornamental	"	17,420,509	1,289,417		
Sewer brick	"	2,534,840	110,407		
Paving brick	"	422,625	42,229		
Structural tile	st	35,944	982,965		
Drain tile	No.	84,628,324	6,847,822		
Sewer pipe	ft.	6,979,965	3,865,565		
Flue linings	"	1,558,342	1,094,645		
Pottery		..	2,032,981		
Other products		..	1,670,017		
Total			51,165,915		44,059,000

Source: Dominion Bureau of Statistics.
pPreliminary; .. Not available; eEstimated.

plants make up the largest group, where about 60 manufactured such clay products as facing brick, common brick, structural tile, quarry tile and drain tile primarily from local, common clays and shales. Six plants manufactured sewer pipe from domestic or imported clays. Most of the 18 plants manufacturing refractories used imported clay as the principal ingredient in many of their products. Only four of these plants, all in western Canada, used domestic clays.

Six whiteware sanitaryware plants, eight electrical porcelain plants, five wall tile plants (including two that also make floor tile), four dinnerware plants, and the majority of the art potteries were the principal users of ceramic-grade china clay and ball clays, which are imported mainly from the United States and Britain. Some of the art potteries and two of the dinnerware plants imported unfinished ware and completed the manufacturing process by glazing or decorating it.

The quantity of china clay imported into Canada is shown in Table 6. No statistics on the quantity of fire clay and ball clay consumed are available. About 2.5 million tons of domestic clay are consumed in the products included in Table 1.

TABLE 2

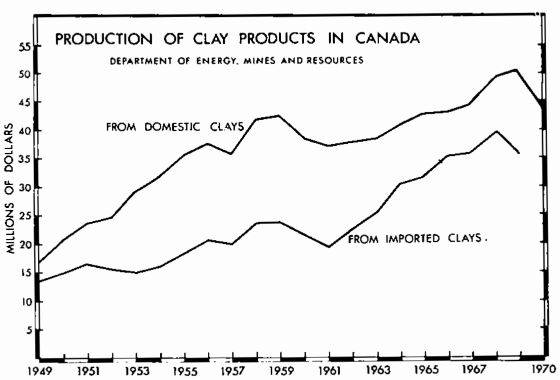
Canada, Imports and Exports of Clay, Clay Products and Refractories

		1969		1970p	
		Quantities	$	Quantities	$
Imports					
Clay, clay products and refractories					
Bentonite	st	293,972	3,110,000	344,153	3,276,000
Drilling mud	st	7,988	1,351,000	6,196	889,000
China clay, ground or unground	st	229,965	5,312,000	237,608	5,598,000
Fire clay, ground or unground	st	69,481	958,000	68,008	884,000
Clays, ground or unground	st	73,608	1,014,000	60,445	658,000
Clays and earth, activated	st	7,609	1,237,000	3,139,760	1,999,000
Brick, building					
Glazed	M	2,702	215,000	1,746	135,000
n.e.s.	M	20,819	1,329,000	19,634	1,309,000
Building blocks	M	..	289,000	..	303,000
Earthenware tile					
Under 2–½ x 2–½"	sq.ft	18,402,915	4,490,000	13,291,106	2,913,000
Over 2–½ x 2–½"	sq.ft	17,164,990	3,082,000	16,903,547	3,320,000
Clay brick, blocks and tiles, n.e.s.	M	..	145,000	..	167,000
Fire brick					
Alumina	M	3,593	4,369,000	4,102	4,806,000
Chrome	M	543	674,000	386	548,000
Magnesite	M	427	1,820,000	670	2,367,000
Silica	M	949	881,000	2,020	1,862,000
n.e.s.	M	38,763	11,809,000	39,071	14,502,000
Refractory cements and mortars		..	2,084,000	..	2,169,000
Pottery settings and firing supplies		..	302,000	..	244,000
Crude refractory materials	st	6,189	519,000	5,511	462,000
Grog (refractory scrap)	st	15,787	649,000	15,873	652,000
Refractories, n.e.s.		..	1,500,000	..	2,316,000
Acid-proof brick		..	236,000	..	280,000
Tableware, ceramic		..	25,003,000	..	24,446,000
Porcelain insulating fittings		..	3,951,000	..	5,053,000
Total clay products and refractories		..	76,329,000		81,158,000
By main countries					
United States			38,990,000		44,952,000
Britain			20,801,000		19,966,000
Japan			9,807,000		8,605,000
West Germany			1,738.000		1,762,000
France			883,000		945,000
Greece			567,000		839,000
Italy			565,000		640,000
Ireland			615,000		495,000
Hong Kong			375,000		395,000
Denmark			202,000		257,000
Other countries			1,786,000		2,302,000
Total			76,329,000		81,158,000

TABLE 2 (Cont'd)

		1969		1970p	
		Quantities	$	Quantities	$
Exports					
Clays, clay products and refractories					
Clays, ground or unground	st	832	33,000	1,863	52,000
Crude refractory materials	st	1,121,591	1,493,000	838,849	815,000
Building brick, clay	M	12,821	1,596,000	10,193	1,375,000
Clay bricks, block, tiles n.e.s.		..	341,000	..	324,000
Fire brick and similar shapes		..	6,804,000	..	8,074,000
Refractories n.e.s.		..	910,000	..	1,053,000
High tension insulators and fittings		..	900,000	..	757,000
Tableware			1,950,000	..	3,178,000
Total clays, clay products and refractories			14,027,000		15,628,000
By main countries					
United States			10,042,000		9,926,000
Britain			178,000		720,000
Dominican Republic			–		367,000
Puerto Rico			193,000		323,000
Greece			171,000		279,000
South Africa			16,000		264,000
Italy			158,000		248,000
Colombia			25,000		237,000
Chile			321,000		217,000
France			80,000		194,000
Other countries			2,843,000		2,853,000
Total			14,027,000		15,628,000

Source: Dominion Bureau of Statistics.
pPreliminary; .. Not available; n.e.s. Not elsewhere specified; M = 1,000; – Nil.



USES, NATURE AND LOCATION OF CLAY AND SHALE DEPOSITS

CHINA CLAY (KAOLIN)

China clay, frequently referred to as kaolin, is a high-quality material used as a filler and coater in the paper industry, a raw material in ceramic products and a filler for rubber and other products. The following properties are required in clays used by the paper industry: viscosity, intense whiteness, freedom from abrasive grit and high coating retention. In the ceramic industry china clay is used as a refractory raw material. In prepared whiteware bodies it is used along with such materials as nepheline syenite, silica, feldspar and talc, for the manufacture of such products as wall tile, floor tile, sanitaryware, dinnerware, pottery and electrical porcelain where such properties as viscosity, plasticity, a white fired colour, and particle size and shape are important.

Because of the problems of beneficiation and the small size of some deposits, none of the crude kaolins known to exist in Canada have been developed. Most occurrences contain a high proportion of quartz, whose particles vary in size from coarse to very fine, and such substances as mica, feldspar, magnetite, pyrite and colloidal iron. In the crude material the percentage of clay, which is principally kaolinite, is frequently small. Attempts to remove impurities from Canadian kaolins have so far not been successful.

TABLE 3

Canada, Shipments of Clay Products Produced from Imported Clay* 1967-1969

		1967		1968		1969p	
		Quantities	$	Quantities	$	Quantities	$
Glazed floor and wall tile	sq.ft	11,695,879r	5,360,000	11,878,031	5,154,000	13,271,356	5,506,000
Electrical procelains		..	12,350,000	..	12,310,000	..	9,245,000
Pottery, art and decorative ware		..	2,015,000	..	2,304,000	..	2,133,000
Pottery, tableware		..	1,638,000	..	1,506,000	–	–
Sanitaryware		..	9,268,000	..	10,499,000	..	11,163,000
All other products		..	5,093,000r	..	8,157,000	..	7,771,000
Total			35,724,000		39,930,000		35,818,000

Source: Dominion Bureau of Statistics.

*Does not include refractories.

pPreliminary; rRevised; .. Not available; –Nil.

TABLE 4

Canada, Shipments of Refractories 1967-1969

	1967		1968		1969	
	st	$	st	$	st	$
Fireclay blocks and shapes*	127,748	17,556,000	126,449r	17,708,000r	126,841	17,624,000
Cements, mortars, castables and other refractory products	69,900	9,730,000	72,020r	10,853,000r	83,578	12,731,000

Source: Dominion Bureau of Statistics.

*Includes fireclay blocks and shapes, fire brick, etc. made from domestic clays, and rigid fire brick, stove linings and other shapes made from imported clays, chrome ore, magnesite, etc. Silica brick not included.

rRevised.

TABLE 5

Canada, Clay and Clay Products Production and Trade, 1961-70
($ million)

	Production					
	Domestic Clays[1]	Imported Clays[2]	Total	Refractory Shipments[3]	Imports[4]	Exports[4]
1961	37.0	19.4	56.4	17.9	47.1	5.8
1962	37.8	22.5	60.3	20.0	48.3	5.4
1963	38.2	25.2	63.4	21.0	43.9	7.6
1964	40.8	30.2	71.0	25.3	54.7	8.9
1965	42.8	31.4	74.2	27.1	59.4	10.3
1966	43.0	36.1	79.1	29.3	71.7	12.6
1967	44.3	35.7	80.0	30.8	70.7	13.7
1968	48.7	39.9	88.6	33.0	65.4	11.8
1969	51.2	35.8p	87.0	35.2	76.3	14.0
1970p	44.1	..	..	..	81.2	15.6

Source: Dominion Bureau of Statistics.
[1]Production (shipments) of clay 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. [4]Includes refractories.
pPreliminary; .. Not available.

TABLE 6

Canada, Consumption (Available Data) of China Clay by Industries 1968-1969
(short tons)

	1968	1969
Ceramic products	15,633	13,840
Paint and varnish	3,189	3,141
Paper and paper products	121,768	142,975
Rubber and linoleum	8,796	8,829
Other products*	14,861	10,747
Total	164,247	179,532

Source: Dominion Bureau of Statistics.
Component break down by Statistics Section, Mineral Resources Branch.
*Includes miscellaneous chemicals, cleansers, detergents, soaps, medicinals and pharmaceuticals, and other miscellaneous products.

However, new and improved methods of beneficiation may be effective. In the future lower quality kaolins on this continent may be mined and more expensive processing employed as the higher quality kaolins become depleted. This situation may make the development of a few Canadian deposits more attractive, particularly if new processing techniques and equipment become available.

Deposits of sandy kaolin occur near Wood Mountain, Fir Mountain, Knollys, Flintoft and other localities in southern Saskatchewan. Despite considerable work done by the Saskatchewan government, University of Saskatchewan, and the federal government no satisfactory method of producing a good commercial kaolin from these deposits has been developed.

A deposit of refractory clay similar to a secondary china clay occurs along the Fraser River near Prince George, British Columbia. The material varies from very plastic to very sandy. The upper beds are considerably iron-stained. 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, but so far none have been considered suitable for commercial development. 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. Kaolinic clays occur near Kergwenan and are being used for the manufacture of brick and tile.

Kaolin-bearing rock occurs in Quebec at St. Remi d'Amherst, Papineau County; Brébeuf, Terrebonne County; Point Comfort, on Thirty-one Mile Lake, Gatineau County, and Château-Richer, Montmorency County. The Quebec deposits, in general, contain an excessive amount of quartz and iron minerals. The kaolinite content is variable but is usually less than 50 per cent. The Château-Richer material is mainly feldspar with about 25 per cent kaolinite. In recent years, various companies have shown considerable interest in Quebec's kaolin-bearing deposits because of their kaolinite content and because of the possible uses of the unbeneficiated material for the facing-brick and other industries.

Extensive deposits of kaolin-sand mixtures occur in northern Ontario along the Missinaibi and Mattagami Rivers. Good quality clays and glass sands have been obtained from this area and interest remains high in their commercial possibilities. Algocen Mines Limited carried out a large development program on deposits along the Missinaibi River, north of Hearst. This company has found substantial quantities of kaolin-silica mixtures but distance from markets, and the difficult terrain and climate of the area have hindered development.

BALL CLAY

Ball clays are used in whitewares, where they impart plasticity and a high green strength to the bodies. They fire white or light cream, which does not interfere with the fired colour of the whiteware products. Being extremely refractory, they are used as a plastic bond clay in various types of refractory products.

Ball clays obtained in Canada are mineralogically similar to high-grade plastic fire clays. They are made up principally of fine-particle kaolinite and quartz.

In Canada, ball clays are known to occur in the Whitemud formation of southern Saskatchewan. Good-quality deposits are known to exist 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. It has been tested in the United States. The lack of proper quality control, the distance from large markets and lack of reserves have been the principal disadvantages affecting the use of this material. Some ball clay from the Flintoft area is being used for white-to-buff facing brick and for household pottery and crocks.

FIRE CLAY

Canadian fire clays are used principally for the manufacture of medium and high-duty fire brick and refractory specialties. High-duty refractories require raw materials having a PCE (pyrometric cone equivalent) 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 superduty refractories without the addition of some very refractory material such as alumina. However, in 1967 a sample from northern Ontario having a PCE of cone 33 was examined at the Mines Branch, Ottawa.

Various grades of good-quality fire clays occur in the Whitemud formation in Saskatchewan. At a large plant at Claybank, fire clays from nearby pits are used for the manufacture of medium and high-duty refractories and refractory specialties. Good-quality fire clays occur on Sumas Mountain in British Columbia. At a large plant there the better grades are used in the manufacture of products similar to those produced at the Saskatchewan plant. 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 occur in the James Bay watershed of northern Ontario along the Missinaibi, Abitibi, Moose and Mattagami rivers. Adverse terrain and climate have made exploration difficult, but considerable exploration has been carried out in this area in recent years. Some seams of clay in the deposit at Shubenacadie, Nova Scotia, are sufficiently refractory for medium-duty refractories. Research has indicated that they 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 fire clay. These industrial provinces import most of their requirements from the United States.

STONEWARE CLAY

Stoneware clays are similar to low-grade plastic fire clays. They are used extensively in sewer pipe, flue liners, facing brick, pottery, stoneware crocks and jugs and chemical stoneware. As in fire clays the principal clay mineral is kaolinite or a similar clay mineral.

The principal source of stoneware clay in Canada is the Whitemud formation of southern Saskatchewan and southeastern Alberta. The Eastend, Saskatchewan, area was formerly the source of much of the clay used at Medicine Hat. Stoneware clay pits are now located in the Alberta Cypress Hills, southeast of Medicine Hat, and at Avonlea, Saskatchewan.

Stoneware or low-grade fire clays occur on Sumas Mountain, near Abbotsford, British Columbia. They are used in the manufacture of sewer pipe, flue lining, facing brick and tile. Similar types of materials occur at Shubenacadie and Musquodoboit in Nova Scotia. 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 close to the Alaska Highway. Quebec and Ontario import stoneware clay from the United States for the manufacture of facing brick and sewer pipe.

COMMON CLAY AND SHALE

Common clays and shales are the principal raw materials available from Canadian deposits for the manufacture of clay products. They are used mainly for the manufacture of common and facing brick, structural tile, partition tile, conduit, quarry tile and drain tile. Some common Canadian clays are mixed with stoneware clay for the manufacture of such products as facing brick, sewer pipe and flue lining.

Because of the presence of iron, common clays and shales usually fire salmon or red. Their fusion points are low—usually well below cone 15 (approximately 1,430°C), which is considered to be the lower limit of the softening point for fire clays. Ordinarily, they are a heterogeneous mixture including clay minerals and various other minerals such as quartz, feldspar, mica, goethite, siderite, pyrite, carbonaceous material, gypsum, calcite, dolomite, hornblende and many others. The clay minerals are chiefly illitic, chloritic or illitic-chloritic, although frequently a member of the montmorillonite or kaolin group, vermiculite or various mixed layer clay minerals are found in them.

Clays and shales suitable for the manufacture of clay products usually contain up to 25 to 35 per cent small-particle quartz. If the quartz exceeds this proportion and there are other non-plastic materials, the plasticity of the clay is reduced and quality of the ware is lowered. Many clays and shales contain calcite or dolomite or both. If present in sufficient quantities, these cause the clay to fire buff and adversely affect the fired strength and density. Common clays and shales are usually higher in alkalis, alkaline materials and iron-bearing minerals and much lower in alumina than the high-quality stoneware clays, fire clays and ball clays. Because shales are less plastic than clays, they must be finely ground when used for extruded ware so that plasticity may be developed if possible, or they must be combined with a plastic clay or some plasticizer.

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. Most of the common surface clays are the result of severe glaciation which has influenced the nature of deposits that cover the bedrock. These Pleistocene deposits are of interest to the ceramic industry and include stoneless marine and nonmarine sediments, re-worked glacial till, interglacial clays, and flood plain clays. Some Tertiary and Cretaceous deposits that are useful to the ceramic industry occur close to the surface. The Pleistocene clays melt at a low temperature, while those of the Cretaceous and Tertiary vary widely in their refractoriness, depending on the locality and formation.

It has been found that, in general, the common shales (as opposed to the common surface clays) provide the best source of raw material for brickmaking. 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 the west, they are very refractory.

BENTONITE

Bentonite is the subject of another review in the present series.

PRICES

According to *Oil, Paint and Drug Reporter* of December 28, 1970, United States Clay prices were as follows:

Ball clay	
Domestic crushed, moisture-repellent, bulk, car lots, f.o.b. Tennessee-per ton	\$ 8.00 - \$11.25
Imported lump, bulk, f.o.b. Atlantic ports per ton	\$40.50
China clay (kaolin)	
Water washed, calcined, bulk, car lots, f.o.b. Georgia per ton	\$60.00
Dry-ground, air floated soft f.o.b. Georgia per ton	\$12.50

TARIFFS

			Most Favoured Nation					
			Before Jan. 1, 1968	On and After Jan. 1, 1968	On and After Jan. 1, 1969	On and After Jan. 1, 1970	On and After Jan. 1, 1971	On and After Jan. 1, 1972
CANADA								
Item No.								
29500-1	Clay, including china clay, fire clay, and pipe clay		free	free	free	free	free	free
	Varying tariffs are in effect on clay products, glazed and unglazed and clay building materials							

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

			Before Jan. 1, 1968	On and After Jan. 1, 1968	On and After Jan. 1, 1969	On and After Jan. 1, 1970	On and After Jan. 1, 1971	On and After Jan. 1, 1972
UNITED STATES								
Item No.								
521.41	China clay or kaolin	per 1.t.	67¢	60¢	53¢	46¢	40¢	33¢
521.51	Fuller's earth, not beneficiated	" "	50¢	45¢	40¢	35¢	30¢	25¢
521.54	Fuller's earth, beneficiated	" "	$1.00	90¢	80¢	70¢	60¢	50¢
521.61	Bentonite	" "	$1.25	73¢	65¢	56¢	48¢	40¢
521.71	Ball clay, not beneficiated	" "	62¢	58¢	54¢	50¢	46¢	42¢
521.74	Ball clay, beneficiated	" "	$1.21	$1.13	$1.06	99¢	92¢	85¢
521.81	Other clays, not beneficiated	" "	50¢	40¢	30¢	20¢	10¢	free
521.84	Other clays, beneficiated	" "	$1.00	90¢	80¢	70¢	60¢	50¢
521.87	Any of the above activated with acid or other material		0.1¢ per lb +12.5% Ad val.	0.09¢ per lb +11% Ad val.	0.08¢ per lb +10% Ad val.	0.07¢ per lb +8.5% Ad val.	0.06¢ per lb +7% Ad val.	0.05¢ per ton +6% Ad val.
	Varying tariffs are in effect on clay products							

Source: Tariff Schedules of the United States Annotated (1970), TC Publication 344.

Coal and Coke

L. P. CHRISMAS*

The Canadian coal industry recorded the largest percentage increase in production for a single year in 1970. Total production increased 55 per cent to 16.6 million tons valued at $86 million. Regionally, production in 1970 decreased 24 per cent in eastern Canada and increased 90 per cent in western Canada. For the first time in 17 years, the industry produced more than 16 million tons of coal. Revival of the western Canada coal industry is directly attributable to the growth of two developing markets: the Japanese steel industry, and the domestic thermal electric generating industry. Export shipments, virtually all to Japan, increased 220 per cent to 4.4 million short tons, compared to 1.4 million tons in 1969. Landed coal imports increased slightly to 18.9 million tons. All imported coal entered from the United States, principally for consumption in Ontario. Of the estimated 31 million tons of all types of coal consumed in Canada in 1970, 15.2 million tons were used to generate electrical power. For the same period, 8.1 million tons of bituminous coal were carbonized to produce 5.7 million tons of coke and the remainder was used principally for industrial and commercial heating purposes.

In 1970, the Canadian coal industry began a period of unprecedented growth which is expected to continue throughout most of the decade. During the year, three new coking coal mines, Kaiser Resources Ltd., Cardinal River Coals Ltd., and McIntyre Porcupine Mines Limited commenced production. A new mine operated by Alberta Coal Ltd. also began production of subbituminous coal. Total coal production capacity was increased by 4 million tons in 1970; and 4 million additional tons are to be added in 1971 and 3 million additional tons are expected in 1972. None of the new mines reached full production capacity in 1970 but all are expected to be at full capacity by late 1971.

Some Canadian steel companies were faced with severe problems of coal supply in 1970. Labour difficulties added to coal producers problems but considering all aspects, the coal industry in North America responded well. Heavy purchases of metallurgical coal by Japanese and European interests along with a full domestic demand caused significant price increases in the United States. The combination of these factors led to a 66 per cent increase in the average per ton value of coal imported into Canada in 1970 over the previous year.

OUTLOOK AND FORECAST

Major demand for coal comes from two main consuming sectors: the electric utilities, and the iron and steel industry. In the electrical utility industry, extensive delays in the development of nuclear reactor programs have caused The Hydro-Electric Power Commission of Ontario to rely increasingly on thermal plants to meet the immediate expanding demand. This has occurred at a time when coal producers had not planned for increased production because of the nuclear programs, with the result that Ontario Hydro was not able to obtain all its coal requirements. In the iron and steel industry large increases in raw steel output are forecast, requiring tremendously large volumes of coking coal.

World coal shortages particularly of high quality coking coal, are predicted to continue for some years to come. Some major industrial countries faced with production shortages, increasing costs and foreseeable exhaustion of economical resources within their own regions, are looking to new sources of supply. Notable among these new sources are Canada and Australia.

*Mineral Resources Branch.

TABLE 1

Coal Production by Types, Provinces and Territories, 1969-70

	1969r		1970p	
	Short Tons	$	Short Tons	$
Bituminous				
Nova Scotia	2,621,330	21,780,974	2,121,856	22,211,298
New Brunswick	701,952	5,649,611	395,642	2,964,478
Alberta	1,231,108	7,866,351	2,863,705	21,238,518
British Columbia and Yukon Territory	902,432	6,151,308	3,483,062	26,078,742
Total	5,456,822	41,448,244	8,864,265	72,493,036
Subbituminous				
Alberta	3,194,952	5,403,341	3,920,206	6,379,937
Lignite				
Saskatchewan	2,020,105	3,726,698	3,819,191	7,399,872
All types				
Canada Total	10,671,879	50,578,283	16,603,662	86,272,845

Source: Dominion Bureau of Statistics.
pPreliminary; rRevised.

As the shortage of imported coal from the United States developed in Ontario, some consumers turned to western Canada to arrange for spot shipments. The future of such shipments depends on a number of yet unknown factors including the supply and price situation of United States coal, the availability of supplies from western Canada and the economical transportation of coal over the imposing distances between western Canada producing centres and the large consuming region of Ontario.

On the other hand, the future of western coal is promising for coal exports to Japan and possibly to western Europe. To date, all contracts involving export of Canadian coal have been with the Japanese. In western Canada, long term contracts for the export of low and medium volatile coking coal have been signed by six mining companies. Based on contracts finalized to the end of the year annual exports to Japan could reach 8.3 million tons in 1971, rise to 13 million tons in 1972, and surpass 14 million tons in 1975. A shortfall of 1.0 million tons is anticipated for 1971 due to initial production problems at some of the new mines. Inclusion of the tentative contract of McIntyre Porcupine Mines Limited will boost the forecast of coal exports to Japan to 16.6 million tons a year by 1975. Companies now negotiating or considering negotiations include Cardinal River Coals Ltd.; Scurry-Rainbow Oil Limited and Emkay Canada Natural Resources Ltd.; Crows Nest Industries Limited; Master Explorations Ltd.; Brameda Resources Limited; and Denison Mines Limited.

Production of subbituminous and lignitic coal from the Plains region of Alberta and Saskatchewan will continue to expand in response to an increasing demand for electricity, which will be generated in this area by thermal plants. Production from mines in New Brunswick and Nova Scotia is expected to continue at or slightly above the 1970 level for the next two or three years due to a continuing use of coal by the electric utilities in these provinces. In Nova Scotia, the Cape Breton Development Corporation will continue to use an increasing proportion of its coal production to make metallurgical coke in its associated coke plant.

Production of all types of coal in Canada is expected to reach 19 million tons in 1971, an increase of about 15 per cent over 1970. It is estimated that 8 million tons will be exported with about 7.3 million tons to Japan; and 11 million tons will be required for domestic consumption. By 1975, coal production in Canada could conceivably surpass 30 million tons a year with a minimum of 18 million tons destined for export.

TABLE 2

Coal-Production, Imports, Exports and Consumption, 1960-70
(short tons)

	Production	Imports	Exports	Domestic Demand
1960	10,776,333	13,564,836	852,921	22,480,568
1961	10,335,779	12,306,498	939,336	21,794,058
1962	10,216,618	12,614,189	893,919	22,419,224
1963	10,451,623	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	16,603,662	18,863,779	4,391,575	–

Source: Dominion Bureau of Statistics.
– Not available.

TABLE 3

Coal Resources of Western Canada, by Province
(thousands of short tons)

Province	Measured	Indicated	Inferred	Total
British Columbia	7,328,600	11,175,400	40,953,000	59,457,000
Alberta	2,203,900	32,096,100	12,940,200	47,240,200
Saskatchewan	291,500	7,024,000	4,698,400	12,013,900
Western Canada Total	9,824,000	50,295,500	58,591,600	118,711,100

Source: Department of Energy, Mines and Resources.

COAL RESOURCES IN CANADA

Exploration for coal is at a very high level in Canada. Spurred by a world shortage of coking coal in particular, but also for high quality thermal coals, companies have been exploring extensively in the southern sections of the coal belt in British Columbia and Alberta. In addition and because available coal leases in this area have been taken up, companies are now investigating the northern areas of the coal belt in the two provinces.

In early 1970, a preliminary estimate of the coal resources in western Canada was prepared* to update the coal reserve study published in 1946.† In the new report the coal resources in western Canada are estimated at 118.7 billion tons of coal in place (Table 3). Of this total, 8.3 per cent or 9.8 billion tons are measured resources; 42.4 per cent or 50.3 billion tons are indicated and 49.3 per cent or 58.6 billion tons are inferred. Only the coal resources of the three western provinces were studied as it is estimated that about 93 per cent of Canada's coal resources are in western Canada. The remaining 7 per cent is divided almost equally between Nova Scotia and the Northwest and Yukon Territories. Small deposits are also worked in New Brunswick and some coal of low rank occurs in northern Ontario south of James Bay.

*Latour, B.A. and Chrismas, L.P., 1970: Preliminary Estimate of Measured Coal Resources Including Reassessment of Indicated and Inferred Resources in Western Canada; Geol. Surv. of Can., Paper 70-58, Department of Energy, Mines and Resources.

†MacKay, B.R., 1947: Coal Reserves of Canada; Reprint of Chapter 1 and Appendix 4 of Rept. of the Royal Commission on Coal – 1946.

PRODUCTION AND MINE DEVELOPMENTS

BRITISH COLUMBIA AND YUKON TERRITORY

The most prolific coal producing region in British Columbia, the Crowsnest Pass area, has large resources of low and medium volatile bituminous coal. This area which has been mined on a small scale since about 1898, is noted for its thick coal-seams which occur within faulted and disturbed Lower Cretaceous rocks. Isolated smaller coal basins in the other parts of the province contain coal-seams ranging in rank from lignite to anthracite.

The large increase in British Columbia coal production was the result of the major mining project of Kaiser Resources Ltd. at Sparwood. Kaiser's operation consists essentially of two mines, Michel Colliery, which is an underground mine, and Harmer Ridge which is a new surface mine. The Michel Colliery has been in production for many years and was formerly owned by Crows Nest Industries Limited. Kaiser began production at its Harmer Ridge property in March 1970. Initial production from the Harmer Ridge surface mine was achieved within 34 months from the time Kaiser acquired the coal rights of Crows Nest Industries Limited. Kaiser has obtained contracts with the Japanese steel industry for delivery of more than 75 million long tons of coking coal over a 15-year period, having an estimated value of $1 billion.

Kaiser's contract with Japanese iron and steel companies called for the shipment of approximately 3 million long tons for the calendar year 1970. However, Kaiser's shipments fell short by approximately 1 million tons due to difficulties relating to its initial mining plan, and problems in its preparation plant and dryer. To overcome these difficulties, it will be necessary to purchase additional pit equipment and to revise the mining plan resulting in higher stripping ratios and the preparation plant will be modified to permit it to handle a large proportion of fine coal. Kaiser has had difficulty in reaching the acceptable ash level of 8.75 per cent called for in its contract; however, the Japanese customers have agreed to lower the ash specifications during the remedial period. The first stage of coal preparation improvement is planned for completion by July 1971. Final adjustments to the preparation plant and mining system are scheduled for the end of 1971. These improvements have been estimated by Kaiser to cost an additional $30 million above the $98 million capital costs of mine facilities and mine development incurred to date.

The official opening ceremonies of the Harmer Ridge mine in June coincided with the opening of Kaiser's wholly-owned subsidiary, Westshore Terminals Ltd. at the Roberts Bank port through which the coal from the Kaiser operation is being shipped.

During 1970, Kaiser also began to test underground hydraulic mining with the technical assistance of Mitsui Mining Co., a leading Japanese coal mining company, experienced in hydraulic mining. Kaiser plans to produce an additional 2 to 3 million tons from underground providing these tests are successful.

In a move to help alleviate a shortage of coal for its Hamilton steel plant, The Steel Company of Canada, Limited, and Kaiser signed a contract for the delivery of 200,000 tons of coking coal on a 'spot' basis. This marked the first movement of western Canada coking coal to eastern Canada to make metallurgical coke.

In 1969, the Bulkley Valley Collieries, Limited at Telkwa produced 9,753 tons, but the operation was suspended in 1970 after only 2,431 tons were mined.

Fording Coal Limited continued preproduction developments at its Elk River property. Production is planned for early 1972 although some stockpiling of raw coal can be expected to begin by mid-1971 from development work. Total cost of the project is estimated to be $80 million. Construction of office, maintenance, and preparation plant buildings and overburden stripping were progressing at 1970 year-end. Clearing of the right-of-way for the 35-mile, Canadian Pacific Railway spurline into the property, and construction of an access road, also began during 1970.

British Columbia was the scene of considerable coal exploration during the year. The area attracting the most interest was the Crowsnest Pass area in the southeastern corner of the province. In this area, Crows Nest Industries continued drilling, trenching and driving adits at its Line Creek property. On the eastern side of the Crowsnest coal basin, Scurry-Rainbow Oil Limited and its partner, Emkay Canada Natural Resources Ltd. continued exploration. Samples of coal from the Scurry-Emkay project were sent to Japan for large scale coking tests. In the northeastern part of the province, Brameda Resources Limited, continued its work on the Sukunka coal property, which is reported to contain low volatile bituminous coal. Nearby Denison Mines Limited was also actively exploring its coal properties in the Quintette and Wolverine River areas. Coal exploration companies were also active in the Telkwa and Groundhog areas in central British Columbia and also in the south central area near Princeton and Merritt.

In the Yukon Territory, Anvil Mining Corporation Limited continued to produce small amounts of coal at Carmacks for its zinc-lead operation. A number of other companies were involved in exploration of some of the small coal basins throughout the southern part of the Yukon.

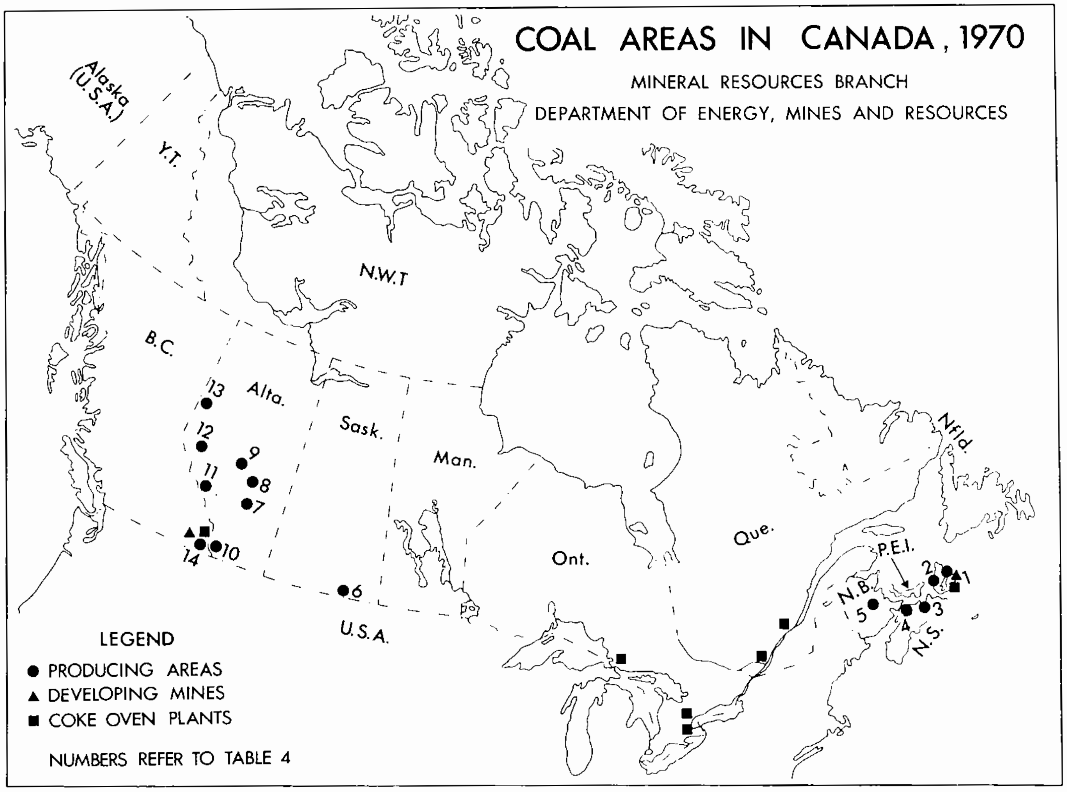


TABLE 4

Principal[1] Coal Mines in Canada – 1970

Company and Location	Rank of[2] Coal	Approximate 1970 Output (000 tons)	Remarks
NOVA SCOTIA			
1. *Sydney and Inverness Area*			
Cape Breton Development Corporation	HVB	1,900	Operates 4 underground collieries and coke oven plant; developing a new mine
2. Evans Coal Mines Limited	HVB	37	Underground
3. *Pictou Area*			
Thorburn Mining Limited	HVB	110	Underground
Drummond Coal Company Limited	HVB	36	Underground
4. *Springhill and Joggins Area*			
River Hebert Coal Company Limited	HVB	25	Underground
Springhill Coal Mines Limited	HVB	48	Underground Developing new mine

TABLE 4 (cont'd)

Company and Location	Rank of[2] Coal	Approximate 1970 Output (000 tons)	Remarks
NEW BRUNSWICK			
5. *Minto Area*			
N.B. Coal Limited	HVB	397	Operates 1 underground and 3 strip mines; took over existing operations in area
SASKATCHEWAN			
6. *Souris Valley Area*			
Battle River Coal (Alberta Coal Ltd.)	LIG	978	Surface
Manitoba and Saskatchewan Coal Company (Limited) (Luscar Ltd.)	LIG	815	Surface, operates briquetting plant
Utility Coals Ltd. (Alberta Coal Ltd.)	LIG	2,027	Surface
ALBERTA			
7. *Drumheller and Sheerness Areas*			
Century Coals Limited	SUB	85	Underground and surface
Alberta Coal Ltd.	SUB	103	Surface
8. *Castor Area*			
Alberta Coal Ltd.	SUB	371	Surface
Forestburg Collieries Limited	SUB	700	Surface
9. *Edmonton and Pembina Area*			
Alberta Coal Ltd.			Surface
Whitewood Mine	SUB	2,420	Highvale began production in 1970
Highvale Mine		239	
Star-Key Mines Ltd.	SUB	25	Underground
10. *Crowsnest Area*			
Coleman Collieries Limited	MVB	1,000	Surface and underground
11. *Cascade Area*			
The Canmore Mines, Limited	LVB & AN	330	Underground Some surface mining
12. *Mountain Park*			
Cardinal River Coals Ltd.	MVB	550	Surface Began production in 1970
13. *Smoky River Area*			
McIntyre Porcupine Mines Limited	LVB	1,000	Underground Began production in 1970
BRITISH COLUMBIA			
14. *East Kootenay Area*			
Kaiser Resources Ltd.	LVB & MVB	3,480	Surface and underground. Surface mining began in 1970, operates coke oven plant

[1]Producing 25,000 or more tons a year. [2]AN - Semianthracite; LVB - low volatile bituminous; MVB - medium volatile bituminous; HVB - high volatile bituminous; SUB - subbituminous; LIG - lignite.

TABLE 5

Coal Production by Type of Mining and Average Output per Man-day, 1970
(short tons)

	Production		Average Output per Man-day^{p}	
	Underground	Surface	Underground	Surface
Nova Scotia	2,121,856	–	2.5	–
New Brunswick	37,873	357,769	1.7	5.7
Saskatchewan	–	3,819,191	–	93.2
Alberta	2,048,634	4,735,277	7.9	46.4
British Columbia	412,729	3,070,333	3.9	17.1
Canada 1970^{p}	4,621,092	11,982,570	4.9	52.6
1969	4,271,684	6,400,195	3.6	46.5
Total, all mines 1970^{p}	16,603,662		39.3	
1969	10,671,879		29.3	

Source: Dominion Bureau of Statistics.
^{p}Preliminary; – Nil.

ALBERTA

Most of Alberta's coal resources are of bituminous and subbituminous rank, but coals of all ranks from lignite to anthracite are found there. Resources of subbituminous coal occur in the Plains region whereas bituminous coal, much of which is of good coking quality, is located in the mountain and foothills belts. Alberta is Canada's leading coal producing province and has the greatest number of coal-mines, although many are small mines with production less than 25,000 tons a year. In the past many of the small mines were forced to shut down due to competition from petroleum and natural gas but recently, the trend has been to larger but fewer mines to meet the expanding market.

In southwestern Alberta, Coleman Collieries Limited produced about a million tons of coal, a record production year for the company. During the year Coleman announced the signing of an additional export contract for 5 million long tons, which is to be delivered during a 10-year period beginning in 1972. This was the only contract signed during the year by a western Canada coal company for the sale of coking coal to off-shore markets. Based on its signed contracts, Coleman will be producing an estimated 1.7 million tons a year of coking coal for export by 1972.

The Canmore Mines, Limited situated in the Cascade coal area, was purchased by Dillingham Corporation, a Honolulu based company. Under Dillingham, studies to evaluate possible expansion of the Canmore mine near the eastern boundary of Banff National Park, were begun. The company is also investigating several potential surface mining sites in addition to the current underground and surface mining operations. With 1970 production at 330,000 tons, Canmore is the smallest of the coking coal producers which markets its coal in Japan.

The new surface mine of Cardinal River Coals Ltd., in the Luscar area, started production in February and began shipping coal to Japan via the Canadian National Railways unit-train system to Neptune Terminals Ltd. at Vancouver. The Cardinal Mine, owned jointly by Luscar Ltd. and Consolidation Coal Company, has a current production capability of approximately 1.2 million tons a year, sufficient to meet its 15-year contract with Japanese steel mills. Due to some start-up problems, Cardinal's production of about 550,000 tons in 1970 was slightly below forecasted shipments; however the company expects to deliver the required quantities beginning in 1971. In the meantime Cardinal has announced plans to negotiate with the Japanese the sale of an additional 500,000 tons of coal a year.

Approximately 80 miles northwest of Luscar, at Smoky River, the new mine of McIntyre Porcupine Mines Limited began production in May from its new, underground mine. The official openings of the mine and the new town of Grand Cache were held in September. Prior to these openings, the Alberta Resources Railway held its inaugural run. Built to serve the McIntyre mine initially, the construction of this railway reflects the Province of Alberta's support of the growing coal industry. McIntyre's current coal production is from underground using the most advanced longwall retreat methods and equipment

TABLE 6

Regional Canadian Coal Shipments, 1970
(short tons)

	Originating Province					
Destination	Nova Scotia	New Brunswick	Saskatch-ewan	Alberta	British Columbia	Canada
Railways in Canada	9,400	1,213	127,025	1,629	6,029	145,296
Newfoundland	16,061	–	–	–	–	16,061
Prince Edward Island	14,917	–	–	–	–	14,917
Nova Scotia	1,436,177	5,261	–	–	–	1,441,438
New Brunswick	52,056	248,313	–	–	–	300,369
Quebec	370,517	67,131	–	–	–	437,648
Ontario	165,482	–	538,756	28,143	178,485	910,866
Manitoba	–	–	943,594	69,387	134,921	1,147,902
Saskatchewan	–	–	2,197,225	186,972	–	2,384,197
Alberta	–	–	–	3,606,168	1,177	3,607,345
British Columbia	–	–	–	66,245	396,721	462,966
Totals, Canada	2,064,610	321,918	3,806,600	3,958,544	717,333	10,869,005
United States	–	125,924	11,880	6,126	11,083	155,013
Japan	–	–	–	2,394,255	1,786,855	4,181,110
Other*	48,700	–	–	–	128,785	177,485
Total Shipments	2,113,310	447,842	3,818,480	6,358,925	2,644,056	15,382,613

Source: Dominion Bureau of Statistics.
*Other shipments were to Peru, West Gernamy and India.

available. With a view to expansion, McIntyre successfully carried out additional exploration elsewhere on its property in the Smoky River area for coal that could be mined by surface methods. Based on these results, McIntyre at the end of 1970, was negotiating with the Japanese for the sale of an additional 3 million tons of surface-mined coal a year from a property near its current operations. Coal from the McIntyre mine is shipped by unit-trains over the Alberta Resources Railway and Canadian National Railways to the bulk loading facilities of Neptune Terminals, in North Vancouver. McIntyre announced that if an additional contract is concluded, the possible development of a deep-sea port and bulk loading facilities at Prince Rupert, British Columbia would be studied.

Exploration for coking coal continued at a high pace in the inner foothills belt of Alberta. Companies most active were Canpac Minerals Limited (a subsidiary of Canadian Pacific Investments Limited); Master Explorations Ltd. (a subsidiary of Alberta Coal Ltd.); Denison Mines Limited; Scurry-Rainbow Oil Limited; Consolidation Coal Company; Luscar Ltd.; and Woods Petroleum of Canada, Ltd.

In the Plains region of Alberta, the major producing surface mines expanded operations to meet the high demand for subbituminous coal for thermal power generation. The new Highvale mine, owned by Calgary Power Ltd., and operated by Alberta Coal Ltd., started production on the south shore of Lake Wabamun across the lake from the company's established Whitewood mine. The Highvale mine is adjacent to Calgary Power Ltd.'s new Sundance coal-fired generating station. The initial 286 megawatt generating unit is the first of a planned four unit generating plant. Approximately 1.4 million tons of subbituminous coal a year will be required to supply the first unit, so that when fully developed, this plant will require over 5 million tons of coal annually. Alberta Coal also operates mines through subsidiaries at Sheerness and at Halkirk, both in the Castor area. Forestburg Collieries Limited, a Luscar Ltd. subsidiary, operates a large surface mine at Forestburg just north of Alberta Coal's mine at Halkirk. Both mines supply coal principally to the Canadian Utilities, Limited electricity-generating station at Battle River. Two small underground mines still produce subbituminous coal in central Alberta. These are Century

Coals Limited at Drumheller and Star-Key Mines Ltd. in the Edmonton district.

There was considerable exploration activity during the year in the Plains area as companies evaluated possible sites for surface mines and power stations. Limiting factors in construction of mine-mouth thermal electric plants are the somewhat discontinuous nature of the coal-seams and the scarcity of available cooling water near the coal deposits. To assist the coal industry in the province, The Alberta Research Council, is continuing its wide spaced drilling program to outline the subbituminous coal resources of the province.

SASKATCHEWAN

In the Estevan area of southeastern Saskatchewan, lignitic coal is strip mined at three highly productive mining operations by Manitoba and Saskatchewan Coal Company (Limited), a Luscar Ltd. subsidiary and two Alberta Coal Ltd. subsidiaries–Utility Coals Ltd. and Battle River Coal. The shallow lignite seams are part of a field extending from southern Saskatchewan into North Dakota, South Dakota and Montana. The Saskatchewan lignite mines have the highest productivity in Canadian coal mining with an average output per man per day of 93.2 tons. In part, this reflects the nature of the coal occurrences at Estevan, which have shallow overburden and are fairly thick coal-seams that can be mined efficiently by large dragline and shovel operations.

Production reached a record as a result of the strong demand by the Saskatchewan Power Corporation's generating station at Estevan and from shipments to plants in Manitoba and Ontario. Due to shortages of United States coal, Saskatchewan lignite was used for the first time in significant quantities by The Hydro-Electric Power Commission of Ontario in two of its southern Ontario generating stations.

NEW BRUNSWICK

Coal production in New Brunswick was down about 43 per cent from the previous year, due to the gradual phasing down of the coal industry there. The provincially owned corporation, N.B. Coal Limited, completed its first full year of operation after it took over and amalgamated the four remaining private mines at Minto.

Within the Minto coalfield only one coal-seam has been mined in recent years. This flat-lying seam has an average thickness of only two feet and is covered by overburden ranging from 35 to 80 feet. The coal is mined by a combination of underground and surface methods. The surface mines produce nearly 95 per cent of the coal extracted. New Brunswick coal is used chiefly for local thermal power generation by the provincial utility company.

TABLE 7

Exports and Imports of Coal, 1969-70
(short tons)

	1969		1970p	
	Short Tons	$	Short Tons	$
Exports				
Bituminous				
St. Pierre	2,519	38,000	805	12,000
United States	215,821	1,915,000	150,361	1,346,000
Japan	1,155,618	7,417,000	4,123,343	26,445,000
Belgium-Luxembourg	–	–	92,922	1,029,000
France	–	–	25	–
Italy	–	–	23,931	312,000
India	500	33,000	188	11,000
West Germany	52	–	–	–
Peru	3,362	49,000	–	–
Total	1,377,872	9,451,000	4,391,575	29,155,000
Imports (for consumption)				
Anthracite				
United States	436,017	5,885,000	353,444	5,233,000
Bituminous				
United States	16,911,387	77,649,754	18,510,335	145,157,000
Total, all types	17,347,404	83,534,754	18,863,779	150,390,000

Source: Dominion Bureau of Statistics.
pPreliminary; – Nil.

NOVA SCOTIA

High volatile bituminous coal is produced mainly from mines at Sydney, on Cape Breton Island, with some output from the Inverness area also on Cape Breton, and Pictou and Springhill–Joggins areas on the mainland. The coalfields in Nova Scotia, many of which are sub-marine, are of Carboniferous age and contain the oldest coal measures produced in Canada. Some of the Sydney area coal makes satisfactory coke, which is one of the chief markets along with thermal power generation plants for Nova Scotia coal.

Nova Scotia coal production declined 500,000 tons during 1970 to 2.1 million tons from nine operating mines. The largest producer, Cape Breton Development Corporation (DEVCO), produced coal from four collieries in the Sydney region on Cape Breton Island and continued to manage the McBean Colliery at Thorburn on the Nova Scotia mainland. DEVCO is proceeding with some modernization of its existing collieries while work is continuing on the development of a new mine at Lingan scheduled for opening in 1974. There are four remaining independent coal-mines in Nova Scotia, which operate with some financial assistance from the provincial government. At Springhill, the No. 1 coal-mine owned by Springhill Coal Mines Limited, was shut down due to difficult mining conditions and work was begun on a new mine nearby.

TABLE 8

Supply and Demand of Coal, 1959 and 1969

	1959	1969
Supply		
Production	10,513,541	10,671,879
Landed imports	13,604,021	17,185,903
Total inventory change	−1,066,993	+ 24,580
Total supply	25,184,555	27,833,202
Demand		
Exports	473,768	1,377,872
Domestic sales		
Electric utilities	1,419,122	11,873,750
Mining and manufacturing	8,794,468	5,007,379
Coke making	5,654,781	7,018,322
Sub-total	15,868,371	23,899,451
Retail sales	5,611,251	878,477
Railways	1,197,406	132,321
Ship's bunker	306,516	229,181
Government and institutional	295,000	169,000
Sub-total	7,410,173	1,408,979
Coal-mine and local use	975,517	464,259
Unaccounted for	456,726	682,641
Total domestic demand	24,710,787	26,455,330
Total demand	25,184,555	27,833,202

Source: Dominion Bureau of Statistics.

TRADE AND MARKETS

Within Canada the prime markets for coal now are the thermal electric power industry and the iron and steel industry. Apparent consumption in Canada in 1970 was 31.1 million tons which is approximately 4.5 million tons higher than in 1969. Since 1961, the general trend of coal consumption in Canada has been upwards based primarily on the expanding use of coal in thermal electric plants and to a lesser extent on coal for metallurgical coke. In the last 10 years the markets for coal within Canada have changed substantially. Thermal power plants, which consumed about 6 per cent of total coal in 1960, used nearly 50 per cent in 1969. The electric power industry have become Canada's largest domestic user of coal. The coke industry remains a substantial market using roughly 26 per cent of all coal consumed in Canada.

EXPORTS

A total of 4.39 million tons of bituminous coal having a value of $29.2 million was exported in 1970 and marks the beginning of a period of growth in coal exports. Japan received 93 per cent or 4.1 million tons of Canadian coal in 1970 as compared to 1.1 million tons in 1969. This tonnage represents 7 per cent of Japan's total coal imports for the year. Also noteworthy was the shipment of coal to two new market areas, namely Italy and Belgium-Luxembourg. Exports to the United States continued to decline in 1970 and are expected to further decline in line with reduced production from New Brunswick. In total approximately 25 per cent of Canadian production was exported in 1970 and this proportion is expected to increase in the future once the mines with long term export contracts reach full production capacity.

IMPORTS

Canada imported 18.7 million tons of bituminous and anthracite coal, all from the United States in 1970. Bituminous coal used for thermal power generation accounted for nearly 50 per cent of total imports. Over 90 per cent of the imported coal entered Ontario with the remainder going primarily to Quebec and Nova Scotia. The immediate trend is at least for increased consumption of imported coal in Ontario due primarily to growth in demand for the thermal electric and metallurgical industries. However there is expected to be a decreasing use in the Atlantic provinces, Quebec and in western Canada. This decrease consumption in the Atlantic provinces and Quebec relates to the increasing availability of fuel from a host of new petroleum refineries being built in the Atlantic region, and the increasing replacement of imported coal by Cape Breton coal for the Sydney coke industry.

THERMAL POWER INDUSTRY

Coal for thermal electric power generation has had an average annual growth rate of 23.5 per cent from 1960 to 1970 increasing from 1.8 million tons in 1960 to 15 million tons in 1970. At the end of 1970, existing coal-fired electric power plants had a combined total capacity of 8,614 megawatts (MWe). Plans have been announced in several provinces which will result in the addition of thermal plants totalling about 5,000 MWe to be completed within six years. In the Prairies particularly, a trend to building mine-mouth power plants is expected to continue. In Ontario, which is the largest consumer of coal for electricity generation in Canada, the coal industry can look forward to increasing opportunities for enlarged markets. This is particularly true for the low sulphur coals of western Canada because environmental factors are now important. However, coal will be required to compete with alternative energy sources for this market so that a solution to lowering the prevailing high transportation costs for western Canada coal is necessary. In total, however, Ontario is expected to maintain a power mix of nuclear, oil, gas and coal-fired plants to have flexibility to meet cyclical demand. On the plus side for coal, the cost of electricity generated from coal-fired stations has been materially improved due to the recent increases in price for crude oil and natural gas.

In 1970, an estimated 8 million tons of coal were imported from coal-mines in northwest Virginia and Pennsylvania in the United States for thermal power generation in Ontario. The Hydro-Electric Power Commission of Ontario (Ontario Hydro) has arranged for most of its coal to be purchased on a long-term contract basis, and to buy on a spot basis to meet extra demand. However, with steam coal in the United States in short supply in 1970, Ontario Hydro had difficulty in obtaining all its coal requirements and as a result supplemented its needs with lignitic coal from Saskatchewan. An estimated 300,000 to 400,000 tons of lignite was shipped from Saskatchewan to two of Ontario Hydro's thermal generating stations in 1970. The steam coal Ontario Hydro purchases from the United States has an average sulphur content of about 2 per cent. In May 1970 the Province of Ontario announced plans to restrict the sulphur content of fuels used in the province. To cope with sulphur in stack emissions Ontario Hydro collaborated with a group of United States utilities in a research program aimed at developing a suitable system for the removal of sulphur dioxide from stack gases.

At the 1,200 MWe coal-fired R. L. Hearn Generating Station, which is situated within the municipal boundary of Toronto, public pressure has forced Ontario Hydro to convert the station from a coal-fired station to one that burns primarily natural gas. As to the short term future of other coal-fired stations in Ontario, a 300 MWe expansion is planned for the Thunder Bay plant near Fort William and a new 4,000 MWe plant (Nanticoke) will be built near Port Dover. During 1970 the fourth 500 MWe unit at the coal-fired Lambton Generating Station at Sarnia came on stream.

In both Saskatchewan and Manitoba, Saskatchewan lignitic coal is used for power generation. Lignite consumption in these two provinces increased by 1.4 million tons from the 1969 level because of significantly reduced hydraulic generation due to low river flows. In Saskatchewan's Estevan area, the second 150 MWe extension to the Boundary Dam Power Station was officially put into operation during the year by Saskatchewan Power Corporation bringing the total plant capacity there to 432 MWe. Work was started on the third 150 MWe unit with completion scheduled for 1973. Upon completion, this station will be one of the largest lignite plants in North America, consuming more than 2 million tons per year. Construction of a 100 MWe extension to the lignite-fired Queen Elizabeth Power Station at Saskatoon continued on schedule with completion planned for the fall of 1971. In Manitoba, the two coal-fired plants at Brandon and Selkirk are being expanded to double the present combined capacity of 396 MWe.

In Alberta, Calgary Power Ltd.'s first 286 MWe unit was put in operation at the Sundance generating station on the south side of Lake Wabamun. A second similar size unit is planned for completion early in 1974. Coal for this plant comes from an adjacent surface coal mine (Highvale). Approximately 1.4 million tons of subbituminous coal a year will be required for this first unit. With an ultimate capacity of nearly 1,200 MWe tentatively planned for the Sundance station, the adjacent mine will need a production capacity of 5 to 6 million tons a year.

At Grande Cache, location of McIntyre's coking coal-mine and townsite, Canadian Utilities, Limited is building the H. R. Milner station which will have an initial 145 MWe unit in operation by mid-1972. The Milner station is designed to accommodate three 145 MWe units that will use middling coal separated from the coking coal in the preparation plant.

In Alberta three other operating coal-fired plants are located at Drumheller, Battle River and at Whitewood on the north side of Lake Wabamun.

TABLE 9

Contractual Amounts of Bituminous Coal
as of January 1, 1971, for Export to Japan
(millions short tons)

	1971*	1972	1973	1974	1975
British Columbia					
Kaiser Resources Ltd.	4.0	5.6	5.6	5.6	5.6
Fording Coal Limited	–	2.2	3.4	3.4	3.4
Total, British Columbia	4.0	7.8	9.0	9.0	9.0
Alberta					
Cardinal River Coals Ltd.	1.0	1.1	1.1	1.1	1.1
Coleman Collieries Limited	1.0	1.7	1.7	1.7	1.7
McIntyre Porcupine Mines Limited	2.0	2.2	2.2	2.2	2.2
The Canmore Mines, Limited	0.3	0.4	0.4	0.4	0.4
Total, Alberta	4.3	5.4	5.4	5.4	5.4
Total	8.3	13.2	14.4	14.4	14.4

*Adjusted due to start-up difficulties and rail strike.
– Nil.

TABLE 10

Coal Used by Thermal Electric Generating Stations[1] by Provinces,
1955-1970p
(000's short tons)

Year	Nova Scotia	New Brunswick	Ontario	Manitoba	Saskatch-ewan	Alberta	Total Canada
1955	423	240	223	2	353	99	1,340
1956	399	291	469	1	225	1	1,386
1957	459	213	724	1	303	–	1,700
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
1970p	604	125	8,483	555	2,170	3,253	15,190

Source: Dominion Bureau of Statistics, Electric Power Statistics.
[1] Electric Utilities publicly and privately operated.
pPreliminary; – Nil.

COKE INDUSTRY

Coke production in Canada totalled 5.7 million tons in 1970, up slightly from the 5.0 million tons produced in 1969. Contributing to the increased output of coke was a record production of iron and steel. Pig iron production in 1970 increased an estimated 23 per cent from 7.4 million tons to 9.1 million net tons. In 1970, approximately 8.1 million tons of coking coal were carbonized compared to 6.9 million tons of coal used in 1969.

About 90 per cent of the coking coal used to make coke in Canada was imported from the United States primarily because the iron and steel industry in Ontario is in closer proximity to high quality coking coals in Pennsylvania, Ohio, West Virginia, and Kentucky than those in western Canada. The three major steel companies that operate coke oven plants in Hamilton and Sault Ste. Marie have captive coal-mines in the United States.

Approximately 4.6 million tons or 80 per cent of the coke produced in Canada is charged to blast furnaces for pig iron production. In absolute terms the quantity of coke for raw steel production is increasing, whereas other uses of coke such as for foundries, chemical plants, and nonferrous smelters, are declining. Coke trade has been small as illustrated by the 273,890 tons of coke exported in 1970 to seven countries of which the United States was the largest purchaser. Production statistics are not available for the production of coal byproducts such as coke oven gas, ammonia, tar and light oils, that are produced from coking coal volatiles during carbonization. This aspect of the coke industry is small in Canada because they are readily available as petroleum based products. Coke oven gas is the primary byproduct and is now used chiefly at the steel plants by recycling to the blast and open-hearth furnaces and for general heating and steam raising.

In 1970, an average of 1.42 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, was 1,080 pounds in 1970 compared to the rate of 1,100 pounds in 1969. Based on the coking rate and the amount of coal required for each ton of coke, it is estimated that in 1970 in Canada, about 1,620 pounds (0.81 ton) of coking coal were required per ton of pig iron produced.

About 95 per cent of the coke produced in Canada is manufactured in standard slot-type ovens in five 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. Details of the individual coke oven plants are listed in Table 9. Coke production and trade data is shown in Tables 10 and 11.

The Algoma Steel Corporation, Limited (Algoma) has one of the largest coke making plants in Canada, located at Sault Ste. Marie, Ontario. The coking coal used in the company's plant comes from two subsidiary coal mining firms in West Virginia. Algoma's coke plant has a present capacity of 1.85 million tons a year of coke generated by 260 standard slot-type byproduct ovens. Algoma currently is developing two new coal-mines in West Virginia and plans to develop a new low volatile mine on a property purchased in 1965.

The Steel Company of Canada, Limited (Stelco) imports the bulk of its coking coal from subsidiary mines in the United States for its coke oven plant in Hamilton,. Ontario. Stelco's coke plant has a capacity of 1.94 million tons of coke from 264 ovens of the slot-type byproduct variety. In 1970, Stelco announced plans to add 83 high (5 metre) Otto Underjet ovens bringing the total number of its ovens to 347. Coke oven capacity will increase by 25 per cent by this addition to approximately 2.6 million tons of coke annually requiring about 3.6 million tons of coking coal. To ensure the continuing availability of coal to support future steelmaking operations, Stelco is developing a new mine in West Virginia. This mine will have an annual production capacity of 700,000 tons of metallurgical coal, with production to begin in the summer of 1972. Coal deposits in the eastern United States and western Canada were examined in 1970.

Dominion Foundries and Steel, Limited (Dofasco) is also located in the Hamilton area where it has a coke oven plant with an annual capacity of 950,000 tons of coke. In 1970, Dofasco began construction of an additional battery of 53 coke ovens. The new $18 million coking facility, planned for completion in July 1971 will increase the company's coking capacity by 30 per cent to approximately 1.2 million tons of coke annually.

Cape Breton Development Corporation (DEVCO) after a record production year of 616,176 tons of coke in 1969, produced 586,268 tons of coke in 1970. The slight decline in production was attributed to coke oven problems. About 60 per cent of the coal that went into coke production was Nova Scotia coal from DEVCO's mines; and the remainder was imported from the United States.

Environmental factors are now of concern to the coke industry, particularly those in Ontario. Consequently, companies are investigating the most suitable means to improve anti-pollution techniques in the coke oven operations. Gas scrubbing equipment for sulphur removal, equipment for reducing emissions from quench towers, and smokeless charging equipment have or are being installed.

TABLE 11

Coke Oven and Other Carbonization Plants in Canada

Coke Plant	Battery and No. of Ovens	Oven Type	Year Built	Plant Capacity (000 tpy coal)	1970 Coke Production (000 tpy coke)	Byproducts
The Algoma Steel Corporation Limited Sault Ste. Marie, Ontario	No. 5 – 86	Koppers-Becker Underjet	1943	2,700	1,619	Naphthalene light oil, gas Tar
	No. 6 – 57	Koppers-Becker Underjet	1953			
	No. 7 – 57	Wilputt Underjet	1958			
	No. 8 – 60	Wilputt Underjet	1967			
The Steel Company of Canada, Limited Hamilton, Ontario	No. 3 – 61	Wilputt Underjet	1947	2,670	1,874	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			
Dominion Foundries and Steel, Limited Hamilton, Ontario	No. 1 – 25	Koppers-Becker Gun Type Comb	1956	1,400	960	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			
Cape Breton Development Corporation, Sydney, Nova Scotia	No. 5 – 53	Koppers-Becker Underjet	1949	900	586	Tar, crude oil, gas
	No. 6 – 61	Koppers-Becker Underjet	1953			
Gaz Métropolitain, Inc., Ville La Salle, Quebec	No. 1 – 59	Koppers-Becker	1928	626	266	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	n.a.	Creosote, lignite, tar, lignite pitch
Kaiser Resources Ltd. Natal, British Columbia	10 units	Curran-Knowles	1939	245	190	Crude tar, gas
	10 units	Curran-Knowles	1943			
	16 units	Curran-Knowles	1949			
	16 units	Curran-Knowles	1952			
	3 units	Mitchell	1963			

TABLE 12

Coke–Production and Trade

	1969		1970p	
	Short Tons	$	Short Tons	$
Production				
Coal Coke				
Ontario	3,915,686	*	4,590,000	*
Other provinces	1,086,589	*	1,078,219	*
Total	5,002,275	*	5,668,219	*
Imports				
Coal Coke				
United States	241,115	7,078,000	331,984	10,666,000
West Germany	39,790	872,000	62,969	2,462,000
Total	280,905	7,950,000	394,953	13,128,000
Exports				
Coal Coke				
United States	155,319	2,873,000	129,077	2,562,000
Romania	–	–	48,968	1,447,000
West Germany	–	–	36,420	393,000
Italy	34,271	231,000	24,091	233,000
Spain	–	–	18,105	242,000
Venezuela	24,112	225,000	13,914	149,000
Belgium-Luxembourg	13,609	88,000	3,315	188,000
Netherlands	40,199	496,000	–	–
Argentina	1,646	83,000	–	–
Brazil	3,841	203,000	–	–
Total	272,997	4,200,000	273,890	5,214,000

Source: Dominion Bureau of Statistics.
*Practically all coke production is used by producers in the iron and steel industry and is not given a value.
pPreliminary; – Nil.

TABLE 13

Coke–Production and Trade, 1960-70

	Production		Imports		Exports	
	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke
1960	3,872,802	534,979	297,707	403,391	124,148	37,042
1961	3,899,545	964,494	288,815	365,744	174,295	52,408
1962	4,021,774	201,985	247,304	338,068	126,024	31,858
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	8,436
1969	5,002,275	231,679	280,905	703,582	272,997	2,606
1970p	5,668,219	207,649	394,953	779,079	273,890	53,289

Source: Dominion Bureau of Statistics.
pPreliminary.

TABLE 14

World Coal Production
(thousand short tons)

Continent	1965	1966	1967	1968	1969[p]
North America	540,776	560,567	578,944	570,615	579,381
South America	8,318	7,542	8,274	8,395	8,998
Europe	1,893,611	1,870,657	1,841,241	1,856,496	1,867,914
Africa	59,063	58,124	59,154	62,236	63,270
Asia	515,452	552,915	441,024	529,005	567,757
Oceania	61,318	64,640	67,721	73,325	79,058
World					
Lignite (estimate)	812,785	808,386	792,304	811,071	832,677
Bituminous and Anthracite (by subtraction)	2,265,753	2,306,059	2,204,382	2,280,606	2,338,713
Total, all types*	3,078,538	3,114,445	2.996,636	3,091,677	3,171,390

Source: United States Bureau of Mines.

*Total are of listed figures only; no undisclosed data included.

[p]Preliminary.

Cobalt

G.P. WIGLE*

Canada's cobalt production in 1970 was 5,228,900 pounds valued at $11.9 million compared with 3,255,623 pounds valued at $6.8 million in 1969 when production was reduced by strikes at Sudbury nickel-copper mines. Canada is one of the major cobalt producing countries recovering nearly 90 per cent of its cobalt as a byproduct of nickel-copper ores and the balance, also a byproduct, from silver-cobalt ores.

Approximately half the world's current annual supply of some 22,000 tons of cobalt metal is produced, as a byproduct of copper recovery, in the Democratic Republic of the Congo. The other principal cobalt producing countries are Canada, Zambia, Finland, Morocco and USSR.

The United States General Services Administration sold 2,484,730 pounds of cobalt from stockpile surplus in 1970. Sales of 2.3 million pounds in January and February were made on an "off-the-shelf" basis at $2.20 a pound. The sale of 40.2 million pounds excess cobalt in stockpile was authorized in July. Sales totalling about 100,000 pounds were made in the last three months of 1970 on a sealed-bid basis at $2.15 a pound of contained cobalt. Total sales from United States cobalt stockpile in 1969 were 8.9 million pounds; sales in 1968 and 1967 were 5.5 million and 6 million pounds.

Published prices for cobalt were unchanged since November 1969 when the producer's price of cobalt metal shot was increased to $2.20 a pound at New York and Chicago. Producers in other countries generally based their prices on the United States figure.

*Mineral Resources Branch.

OUTLOOK

The large volume of sales from United States cobalt stockpile in 1969 were made in a period of high demand and rising prices. Part of that unusual demand was because of a temporary shortage of nickel and the substitution of nickel by cobalt to meet a part of the requirements of the nickel plating industry. Expensive substitution has not continued but cobalt gained and could retain some broader markets due to growing diversification in the uses of this important alloying metal.

New and increased production from the Congo, Finland, Canada, and other sources will more than replace declining production of cobalt from Morocco. Sales from stockpile will extend over several years assuring reasonably stable prices and adequate supply. Byproduct production of cobalt from new nickel mines will provide additional supplies over the longer term.

CANADIAN PRODUCTION

Canada's production of 5.2 million pounds of cobalt in 1970 compared with 3.2 million pounds in 1969 reflected, because of its recovery as a byproduct, the increased and growing domestic production of nickel which rose from 427 million pounds in 1969 to 616 million in 1970. Nickel production, however, and cobalt production as a byproduct, was restricted in 1969 by strikes at nickel operations.

The International Nickel Company of Canada, Limited (Inco) delivered 1.98 million pounds of cobalt

TABLE 1

Canada, Cobalt Production, Trade and Consumption, 1969-70

	1969		1970p	
	Pounds	$	Pounds	$
Production[1] (all forms)				
Ontario	2,553,583	5,421,046	4,387,000	9,910,000
Manitoba	702,040	1,430,000	841,900	1,983,000
Total	3,255,623	6,851,046	5,228,900	11,893,000
Exports				
Cobalt metal				
United States	787,698	1,613,000	699,798	1,701,000
South Africa	–	–	47,631	342,000
Japan	882	1,000	49,859	80,000
France	22,150	49,000	26,738	69,000
Britain	60,260	118,000	10,710	40,000
Other countries	284,301	502,000	5,113	16,000
Total	1,155,291	2,283,000	839,849	2,248,000
Cobalt oxides and salts[2]				
Britain	1,199,700	2,095,000	1,642,700	2,396,000
Belgium and Luxembourg	–	–	202,300	394,000
Jamaica	100	..	–	–
Total	1,199,800	2,095,000	1,845,000	2,790,000
Consumption[3]				
Cobalt contained in:				
Cobalt metal	294,777	..	..	..
Cobalt oxide	58,516	..	..	..
Cobalt salts	40,365	..	..	..
Total	393,658	..	..	..

Source: Dominion Bureau of Statistics.
[1] Production (cobalt content) from domestic ores. [2] Gross weight. [3] Available data reported by consumers.
pPreliminary; – Nil; .. Not available.

compared with 1.87 million pounds in 1969. Production increased in 1970; further production increases are expected with new nickel mines coming into production in 1971-72.

Falconbridge Nickel Mines Limited also increased its cobalt deliveries in 1970. The company produces cobalt at its refinery at Kristiansand, Norway, from nickel-copper matte shipped from Canada.

Sherritt Gordon Mines, Limited produced 828,000 pounds of cobalt compared with 668,000 pounds in 1969. Cobalt is recovered as a byproduct of Sherritt's nickel-refining operations at Fort Saskatchewan, Alberta. The refinery treats nickel-copper concentrates from the company's Lynn Lake mine in Manitoba and from nickel- and cobalt-bearing materials received on a toll basis.

Cobalt is recovered as a byproduct of the smelting and refining of silver-cobalt concentrates from the mines of the Cobalt and Gowganda areas of Ontario. The Cobalt Refinery Division of Kam-Kotia Mines Limited did not operate the cobalt-oxide part of its plant in 1969. The speiss (cobalt-nickel-silver) byproduct of its smelting and refining of silver-cobalt concentrates, was shipped to Belgium for treatment and sale.

WORLD PRODUCTION

Non-communist world production of cobalt in 1970 was estimated at 23,964 tons (cobalt content) compared with 18,446 tons in 1969. The large increase was due to higher output in the Congo, Canada, and Zambia, following a period of restricted production in Canada and declining Moroccan output. Sales from United States stockpile surplus were only 1,200 tons compared with 4,450 tons in 1969.

TABLE 2

Canada, Cobalt Production, Trade and Consumption, 1961-70
(pounds)

		Exports		Imports		
	Production[1]	Cobalt Metal	Cobalt Oxides and Salts[2]	Cobalt Ores[2]	Cobalt Oxides[2]	Consumption[3]
1961	3,182,897	603,931	1,521,000	–	28,364	390,091
1962	3,481,922	542,565	1,629,900	–	40,936	383,442
1963	3,024,965	739,227	1,098,300	2,500	28,291	364,594
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
1970p	5,228,900	839,849	1,845,000	..	..	..

Source: Dominion Bureau of Statistics.
[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.

TABLE 3

World Production of Cobalt
(short tons of contained cobalt)

	1968	1969p	1970e
Congo (Kinshasa)	11,628	11,000	11,500
Finland	1,875	1,800	..
Morocco	1,840	1,700	1,600
Cuba	1,400	1,700	..
USSR	1,500	1,650	..
Zambia	1,319	1,650	1,700
Canada	2,015	1,628	2,614
West Germany	892	864	..
Australia	237	330	..
Total	22,706	22,322	23,964

Sources: U.S. Bureau of Mines Minerals Yearbook Preprint 1969; U.S. Commodity Data Summaries January 1971. For Canada, Dominion Bureau of Statistics.
pPreliminary; .. Not available; eEstimated.

CONSUMPTION AND USES

Consumption of cobalt in Canada in 1969 was 393,658 pounds, 75 per cent of it as cobalt metal, 15 per cent in cobalt oxide, and 10 per cent in cobalt salts.

The United States is the largest consumer of cobalt but produces only minor amounts as a byproduct of iron ore that contains some cobalt-bearing pyrite. Domestic refiners and processors produce a range of cobalt products from duty-free imported ores, concentrates, and unwrought cobalt metal.

Consumption of cobalt in the United States in 1970 was 6,300 tons compared with 7,695 tons in 1969. Cobalt was supplied to users and processors in the form of metal, 77 per cent; salts and driers, 17 per cent; oxide, 4 per cent; and other unspecified forms including scrap, 2 per cent.

The more important uses of cobalt are in high-temperature, high-strength alloys, magnet alloys, high-speed and tool steel, hardfacing rod, cemented carbides, and other ferrous and nonferrous alloys. The series of cobalt-chromium hardfacing alloys called "Stellites" were forerunners of the high-temperature alloys used near their melting temperatures which are designated "superalloys". The cobalt-base superalloys contain 50 per cent or more cobalt with chromium, nickel, tungsten and molybdenum, and many of the nickel-base and iron-base superalloys contain 10 to 20 per cent cobalt.

Cobalt is used in a wide variety of magnetic materials in electrical and electronic applications. The principal types of cobalt-containing magnetic materials are the magnet steels for permanent and soft magnets (easily magnetized) containing cobalt in amounts varying from a fraction of one per cent up to 50 per cent. The Alnico alloys which contain aluminum, nickel and cobalt include the important permanent magnet alloy, Alnico 5, containing 8 per cent aluminum, 14 per cent nickel, 24 per cent cobalt, 51 per cent iron and 3 per cent copper. The magnetic iron oxides called "ferrites" such as $CoFe_2O_4$, and various soft magnet materials, contain up to 50 per cent cobalt with iron, chromium, nickel, tungsten, vanadium, titanium or aluminum.

Metallic uses account for about 70 per cent of cobalt consumption. Nonmetallic uses include organic and inorganic cobalt salts used as driers, in paints, varnishes and enamels, ground-coat frit, pigments, dyes, catalysts and in animal feeds. The radioactive isotope, cobalt 60, is used for therapeutic purposes and in the examination of metal castings and forgings for flaws.

TABLE 4

United States, Consumption of Cobalt by Use, 1968-69
(thousands of pounds cobalt content)

	1968	1969
Steel (ingots and castings):		
High-speed and tool	553	575
Stainless steel	145	73
Alloy (excluding stainless and tool)	470	282
Cutting and wear resistant materials:		
Cemented or sintered carbides	516	1,747
Other materials	191	39
Welding and hardfacing rods, materials	495	302
Magnetic alloys	2,700	2,560
Nonferrous alloys	3,061	4,334
Electrical materials	954	1,108
Chemical and ceramic uses:		
Catalysts	721	286
Ground coat frit	201	133
Glass decolorizer	67	74
Pigments	211	191
Other	29	5
Miscellaneous and unspecified	863	1,104
Salts and driers: lacquers, varnishes, paints, inks, pigments, enamels, feeds, electroplating (estimate)	1,826	2,577
Total	13,003	15,390

Source: U.S. Bureau of Mines, Minerals Yearbook.

MINERALS AND OCCURRENCES

Cobalt is widely dispersed in the rocks of the earth's crust, constituting about 0.0023 per cent, compared with 0.0080 per cent for nickel, and ranks thirty-fourth in order of relative abundance. The amount of cobalt estimated to be in the earth's crust is more than that of lead (.0016 per cent) and about one third that of copper (.0070 per cent). Non-communist world production of cobalt is about 22,000 tons a year while annual production of lead is approximately 2.7 million tons and of copper 5.8 million tons. Unlike lead, it seldom occurs in concentrations and is usually recovered as a minor byproduct associated with the ores of copper, nickel, iron, silver, manganese, lead and zinc.

The important types of cobalt minerals are sulphides, arsenides, and oxides. The principal sulphide minerals are linnolite (Co_3S_4) and carrollite (Co_2CuS_4). The principal arsenides are smaltite ($CoNiAs_2$), cobaltite (CoAsS), safflorite ($CoFeAs_2$), and skutterudite ($CoNiAs_3$). The principal oxide minerals are erythrite, or cobalt bloom (3 CoO As_2O $8H_2O$), heterogenite (CoO_2 Co_2O_3 $6H_2O$), and asbolite (CoO_2 MnO_2 $4H_2O$). The cobalt minerals are seldom found in sufficient quantity to be mined for cobalt alone.

PRICES

Prices of cobalt in the United States published by *Metals Week*, December 28, 1970, unchanged from November 17, 1969, were:

Cobalt metal per lb f.o.b. New York, Chicago, effective November 17, 1969	
Shot 99%+	
less than 50 kilograms	U.S. $2.30
50-kg drums	2.25
250-kg	2.20
Powder	
99%+, 300 mesh,	
50-kg drums	2.91
extra fine, 125-kilo drums	3.49
Fines	
95-96%, per lb contained Co	
Regular, 500 lb	2.76
300 mesh	2.78
Briquettes, 10 ton lots, per lb contained	2.38
Cobalt oxide	
per lb, 250 lb	
Ceramic, delivered, 5¢ more west of Mississippi	
70-71%	2.20
72½-73½%	2.26
Metallurgical	
f.o.b. N.Y.	
75-76% (per lb contained)	2.85

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 metal, in bars	free	10%	25%
92824-2	Cobalt oxides	free	10%	20%
92824-1	Cobalt hydroxides	10%	15%	25%

UNITED STATES		
601.18	Cobalt ore	free
632.20	Cobalt metal, unwrought, waste and scrap	free
632.84	Cobalt metal alloys, unwrought	
	On and after Jan. 1, 1970	12.5%
	On and after Jan. 1, 1971	10.5%
	On and after Jan. 1, 1972	9%
633.00	Cobalt metal, wrought	
	On and after Jan. 1, 1970	12.5%
	On and after Jan. 1, 1971	10.5%
	On and after Jan. 1, 1972	9%
418.60	Cobalt oxide and	
418.62	Cobalt sulphate	
	On and after Jan. 1, 1970	1¢ per lb
	On and after Jan. 1, 1971	0.9¢ per lb
	On and after Jan. 1, 1972	0.7¢ per lb
418.68	Other cobalt compounds	
	On and after Jan. 1, 1970	8%
	On and after Jan. 1, 1971	7%
	On and after Jan. 1, 1972	6%
426.24 } 426.26 }	Cobalt salts	
	On and after Jan. 1, 1970	8%
	On and after Jan. 1, 1971	7%
	On and after Jan. 1, 1972	6%

Sources: The Customs Tariff and Amendments, Department of National Revenue, and Excise Division, Ottawa.
Tariff Schedules of the United States Annotated (1970) TC Publication 304.

Columbium (Niobium) and Tantalum

G.P. WIGLE*

St. Lawrence Columbium and Metals Corporation produced 4,886,957 pounds of columbium pentoxide (Cb_2O_5) in its fiscal year ended September 30, 1970, compared with 3,059,052 pounds in the 12 months of the prior fiscal year. Production during the 1970 calendar year was 4,919,000 pounds of Cb_2O_5. St. Lawrence Columbium, near Oka, Quebec, is the only Canadian producer of columbium and has one of only two mines in the world that produce columbium in pyrochlore concentrates as a principal primary product; the other, larger operation, is near Araxá, Brazil. Three countries accounted for 93 per cent of United States Columbium supply in 1970: Brazil 60 per cent, Canada 21 per cent, and Nigeria 12 per cent.**

The demand for columbium continued to improve in 1970 as it had in 1969. Published spot prices for Canadian pyrochlore concentrates, f.o.b. mine site, were U.S. $1-1.05 a pound of contained Cb_2O_5 at the beginning of 1970. A price of U.S. $1.15-1.20 a pound of Cb_2O_5 was established on July 1 for contract sales and this remained the published price in the latter part of the year.

The United States General Services Administration sold 1,004,215 pounds of combined columbium-tantalum pentoxide in concentrates containing 616,698 pounds of columbium from surplus stockpile material in 1970 to the end of October. The average price was U.S. $1.24 a pound of combined pentoxides compared with sales in December 1969 at U.S. $1.19 a pound of combined Cb_2O_5 and Ta_2O_5.

Canada's first commercial production of tantalum began in 1969 at the Bernic Lake, Manitoba, mine of Tantalum Mining Corporation of Canada Limited. Concentrates were first shipped in the second half of 1969 and in September the company announced a price of U.S. $7 a pound of Ta_2O_5 in 50 per cent concentrates, f.o.b. mine, for deliveries contracted through 1970. Tantalum Mining Corporation completed its first full production year in 1970 and it was expected that shipments would be about 315,000 pounds of tantalum pentoxide. The Canadian producer supplied about 47 per cent of United States imports of tantalum in 1970 and became the principal of United States' suppliers followed by the Congo (Kinshasa) (18 per cent) and Brazil (18 per cent).

OUTLOOK

Columbium, in common with other refractory and reactive ferroalloy metals, such as molybdenum, tungsten, and vanadium, was in growing demand at modestly improved but relatively stable prices in 1970. Output of columbium pentoxide was increased by producers in Canada and Brazil; further increases in production capacity were planned for 1971.

New mine production was expected from the Republic of the Congo (Kinshasa). Columbium should be in adequate supply for two to three years at moderately increased prices unless annual growth of 7 per cent in consumption, as indicated in the years 1964 to 1968, is exceeded. Sustained demand in 1969-70 and recent expanded uses in the steel alloy field suggest a growth rate of about 10 per cent.

The demand for tantalum was sustained in 1970 and prices were reasonably stable at about $7 a pound of Ta_2O_5 in 50 per cent or better grade concentrates. The improved supply situation during the near future should encourage consumption growth and contribute to price stability.

*Mineral Resources Branch.

**U. S. Bureau of Mines, Mineral Industry Surveys, December 30, 1970.

TABLE 1

Canada, Columbium (Niobium) and Tantalum Production, Trade and Consumption, 1969-70

	1969		1970p	
	Pounds	$	Pounds	$
Production (Cb_2O_5 content of products shipped)	3,414,495	3,172,845	4,919,000	5,303,600
Imports[1] from United States				
Columbium and columbium alloys, wrought	1,178	21,983	–	–
Tantalum and tantalum alloys wrought, n.e.s.	1,871	105,095	570*	36,134*
Tantalum and tantalum alloys, unwrought waste and scrap	4,405	18,310	1,870*	15,988*
Tantalum and tantalum alloy powder	7,488	158,607	1,780*	56,274*
Exports[2] to United States				
Columbium ore and concentrates	919,577	472,836	1,134,883**	563,483**
Consumption by the steel industry				
Ferrocolumbium and ferrotantalum-columbium (Cb and Ta-Cb content)	244,000	..	..	..

Source: Dominion Bureau of Statistics, 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.
*1st 9 months. **1st 11 months.
pPreliminary; – Nil; . . Not available.

DEVELOPMENTS

Quebec Mining Exploration Company (SOQUEM) entered into an agreement with Copperfields Mining Corporation Limited for joint exploration and development of the columbium-bearing property of SOQUEM about 8 miles north of Chicoutimi, Quebec. Earlier estimates based on diamond drilling of the carbonatite (carbonate-rich) occurrence suggest a deposit of columbium-bearing pyrochlore in the order of 45,000 tons per vertical foot with an average grade of 0.48 per cent columbium pentoxide. Drilling in 1970 extended the dimensions of a higher grade zone within the deposit. Two drill intersections of 300 to 400 feet assayed over 12 pounds (0.62 to 0.65 per cent) of Cb_2O_5 to the ton, and two 100-foot intersections assayed 20 pounds and 40 pounds of Cb_2O_5 to the ton. The participating companies are reported to be arranging for sale of concentrates and tentatively planning for production on a basis related to the volume of sales that can be confidently expected.

St. Lawrence Columbium and Metals Corporation increased its mining and milling rate from 1,300 tons a day in 1969 to 2,100 tons a day in 1970 and planned an increase of about 20 per cent to 2,500 tons a day in 1971. Proven ore reserves down to a depth of 1,000 feet were increased by 25 per cent to 3,125,000 tons grading 0.487 per cent (9.7 pounds a ton) Cb_2O_5. Ore zone extensions below 1,000 feet depth have been partly explored by diamond drilling and enabled the calculation of more than 2 million tons of additional drill-proven-reserves grading 0.544 per cent (10.88 pounds a ton) Cb_2O_5.

Columbium Mining Products Ltd., controlled by Coulee Lead and Zinc Mines Limited, has a columbium property also in the Oka, Quebec, area with drill indicated reserves estimated at 38.2 million tons grading 0.40 per cent Cb_2O_5.

Imperial Oil Enterprises Ltd., Consolidated Morrison Explorations Limited, and associated companies have a large columbium-pyrochlore property in the James Bay Lowlands area about 31 miles south of

TABLE 2
Production of
Columbium (Cb) and Tantalum (Ta) Concentrates, 1968-70†,*
(thousands of pounds, gross weight)

	Concentrates								
	1968			1969			1970[e]		
	Cb	Ta	Cb-Ta	CB	Ta	Cb-Ta	Cb	Ta	Cb-Ta
Brazil									
pyrochlore	11,021	–	–	19,100	–	–	20,000	–	–
columbite-tantalite	138	599	–	19,099	600	–	–	600	–
Canada									
pyrochlore	4,363	–	–	6,021	–	–	6,500	–	–
tantalite		–	–	–	400	–	–	600	–
Nigeria	2,528	25	–	3,340	13	–	3,500	15	–
Congo (Kinshasa)	–	–	249	–	–	220[e]	–	–	115
Mozambique									
columbite-tantalite			136			132[e]	–	–	141
microlite	–	199	–	. .	. .	. .	. .	. .	. .
Malaysia	–	–	114	–	–	132[e]			145
Australia	–	–	231	–	–	95[e]	. .	. .	. .
Thailand	–	–	88	–	–	57	. .	. .	. .
Rwanda	–	–	61	–	–	48	. .	. .	. .
Portugal	–	–	26	–	–	21[e]	. .	. .	. .
South Africa, Rep. of	–	39	–	–	13[e]	–	. .	. .	. .
Other countries							200	310	
Totals**	18,050	862	905	28,461	1,026	705	30,200	1,525	401

Source: U.S. Bureau of Mines, annual publications.

†Excludes columbium tantalum-bearing tin slag.

*Concentrates containing important amounts of both elements are shown under Cb-Ta when composition data is insufficient.

**Other countries that produce columbium and/or tantalum minerals include: Argentina, French Guiana, Ivory Coast, Spain, Uganda, USSR.

[e]Estimated; – Nil; . . Not available.

Moosonee, Ontario. It was reported that drilling indicated about 80,000 tons per vertical foot averaging 0.52 per cent columbium pentoxide (Cb_2O_5).

WORLD PRODUCTION

Non-communist world production of columbium and tantalum mineral concentrates in 1970 was an estimated 16,000 tons consisting of concentrates of columbite, tantalite, and columbium-bearing pyrochlore. Production in 1969 was 14,500 tons.

Brazil has maintained its position as the leading producer of columbium pyrochlore concentrates since 1966. The world's largest producer of columbium is Companhia Brasileira de Metalurgia e Mineração (CBMM) at its mine near Araxá, Brazil, where the ore occurs as a large deposit of high-grade (3-4 per cent Cb_2O_5) columbium-bearing pyrochlore. The company's production of columbium pentoxide in pyrochlore concentrate increased from 1.4 million pounds (Cb_2O_5 content) in 1965 to 11.3 million pounds in 1969. Plant capacity was increased in 1969-70, and production in 1970 was 17 million pounds of contained Cb_2O_5. CBMM is jointly owned by Brazilian interests (50.5 per cent), Molybdenum Corporation of America (33 per cent), and Pato Consolidated Gold Dredging Limited. Molybdenum Corporation announced the development of a new process for making high-purity columbium oxide; a small plant was constructed in Brazil for operation in 1971.

Union Carbide Corporation, Belgian interests, and the Congo government were jointly preparing a columbium-pyrochlore mine for production at Bingo in Kivu Province of the Congo (Kinshasa).

Nigeria had been the perennial leader, until 1965, in the production of columbium since recovery began there about 1933. In contrast to the recent producers of columbium pyrochlore, its columbite concentrates are a co-product of tin mining where the columbium occurs in the mineral columbite.

CONSUMPTION AND USE

Canada's consumption of columbium and tantalum in the form of ferroalloys was 244,000 pounds in 1969 compared with 288,000 pounds in 1968 and 78,000 pounds in 1967. The market for columbium in ferroalloy form is growing in its use in the iron and steel industry for such applications as the manufacture of oil and gas transmission pipe and in a range of steel alloys.

The United States is the largest consumer of columbium and tantalum. Imports of columbium concentrates were about 6 million pounds in 1970, a considerable increase over the quantity imported in 1969. Imports of tantalum concentrates were about 1 million pounds.

The major part of its wholly-imported supply is used to make ferrocolumbium and ferrotantalum-columbium. The steel industry uses these ferroalloys in alloy and stainless steels, high-temperature alloys, nickel-base alloys and in some carbon steels. A primary reason for the addition of columbium to steel is to control and refine grain size. The improved strength-to-weight ratio, due to columbium in steel, gives weight savings in the making of oil and gas transmission piping. Both columbium and tantalum are finding increasing use through nuclear research, and in high-temperature alloys for jet engines, turbines, and rocket-engine parts. Tantalum is used in high-performance capacitors, electronics, chemical equipment, alloys and carbides. The use of columbium in industries in the United States was approximately: steel – 73 per cent, superalloys – 24 per cent, columbium metal and columbium-base alloys – 2 per cent, and of tantalum: electronic equipment – 55 per cent, superalloys – 25 per cent, chemical equipment – 15 per cent, and carbides – 5 per cent.

The principal Canadian suppliers of ferrocolumbium are Union Carbide Canada Limited; Metallurg (Canada) Ltd.; Masterloy Products Limited; and St. Lawrence Columbium and Metals Corporation.

Among the Canadian users of columbium and tantalum are Atlas Steels Division of Rio Algom Mines Limited; the Algoma Steel Corporation, Limited; Black Clawson-Kennedy Ltd.; Dominion Foundries and Steel, Limited; The Steel Company of Canada, Limited; and Colt Industries (Canada) Ltd.

PRINCIPAL MINERALS AND ORE OCCURRENCES

The principal commercial minerals of columbium and tantalum have been columbite and tantalite from pegmatites and from residual and placer deposits. Both minerals are co-products 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 recovered. Major sources of columbium are now the columbium-bearing pyrochlore from carbonatite rock complexes in Canada and Brazil.

Canadian occurrences of columbium minerals in the complexes of carbonate-rich rocks, called carbonatites, include the columbium-pyrochlore producing mine of St. Lawrence Columbium and Metals Corporation near Oka, Quebec, and, in Ontario, the James Bay property of Consolidated Morrison Explorations Limited, the Manitou Islands deposits of Nova Beaucage Mines Limited near North Bay, and the Lackner Lake property of Multi-Minerals Limited. There are 30 or more known carbonatite occurrences in Ontario, several in Quebec and Labrador and possibly four in British Columbia.

Columbite and tantalite have the theoretical compositions (FeMn)O. Cb_2O_5 and (FeMn)O. Ta_2O_5. They are closely related minerals and frequently associated in ore occurrences. The two minerals vary in composition from the nearly pure columbite ($FeO.Cb_2O_5$), containing 82.7 per cent Cb_2O_5, to nearly pure tantalite ($FeO.Ta_2O_5$), containing 86.1 per cent Ta_2O_5. The iron and manganese contents vary widely; tin and/or tungsten may be present.

Pyrochlore is the columbium-rich member of the pyrochlore-microlite series of minerals which also contain small amounts of the oxides of other elements including the rare earths (e.g. cerium) and radioactive elements (e.g. uranium, thorium). Microlite is the tantalum-rich member of the mineral series.

The Bernic Lake, Manitoba, ore deposit of Tantalum Mining Corporation is a complex zoned pegmatite containing a variety of minerals. Most of the tantalum in this deposit occurs as stanniferous tantalite in small disseminated reddish-brown to black grains varying in size from pin-point to axe-shaped crystals one-eighth inch long. The chemical composition of the tantalite shows that it contains 70 per cent Ta_2O_5, 1.3 per cent Cb_2O_5, and, an unusually high amount (13.2 per cent) of tin oxide (SnO_2).

PRICES

The following prices are from *Metals Week* of December 28, 1970; (1969 year end prices are shown in brackets underneath where differing).

	U.S. Currency
Columbium ore	
Columbite, per lb Cb_2O_5, 8 to 1 ratio, c.i.f. U.S. ports, spot	$1.00 (10 to 1 ratio – $1.12 to 1.17)
Pyrochlore, per lb Cb_2O_5	
Canadian, f.o.b. mine or mill	$1.15 to 1.20 ($1.00 to 1.05)
Brazilian, f.o.b. shipping point, spot, contract only	$1.15 (95.5¢)
Ferrocolumbium	
per lb Cb, ton lots, f.o.b. shipping point	
Low alloy, standard grades	$2.85-4.12 (2.65-3.52)
High-purity grades	$4.79-6.76 (4.28-5.53)

	Powder Roundel	Ingot
Columbium metal per lb 99.5-99.8%, depending on size of lot		
Reactor	$12-23	$17.50-28
Metallurgical	$11-22	$16-27
Tantalum ore		
About 60% combined columbium and tantalum pentoxide, per lb Ta_2O_5		
Tantalite, spot		$6.75-$7.50
Tantalum metal		
powder, per lb, f.o.b. shipping point, depending on size of lot		$28.50-$38.50
Mill products, depending on grade		
Sheet		$36-60
Rod		$36-50

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Item No.			
32900-1 Columbium and tantalum ores and concentrates	free	free	free
35120-1 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 October 31, 1971)	free	free	25%
UNITED STATES			
Item No.			
601-21 Columbium ores and concentrates		free	
601.42 Tantalum ore and concentrates		free	
628.15 Columbium metal, unwrought, waste and scrap (Duty on waste and scrap suspended to June 3, 1971)			
On and after Jan. 1, 1970		7%	
" " " Jan. 1, 1971		6%	
" " " Jan. 1, 1972		5%	
628.17 Columbium, unwrought alloys			
On and after Jan. 1, 1970		10%	
" " " Jan. 1, 1971		9%	
" " " Jan. 1, 1972		7.5%	

TARIFFS (Cont'd)

628.20 Columbium metal, wrought	
On and after Jan. 1, 1970	12.5%
" " " Jan. 1, 1971	10.5%
" " " Jan. 1, 1972	9%
629.05 Tantalum metal, unwrought, waste and scrap (Duty on waste and scrap suspended to June 3, 1971)	
On and after Jan. 1, 1970	7%
" " " Jan. 1, 1971	6%
" " " Jan. 1, 1972	5%
629.07 Tantalum, unwrought alloys	
On and after Jan. 1, 1970	10%
" " " Jan. 1, 1971	9%
" " " Jan. 1, 1972	7.5%
629.10 Tantalum metal, wrought	
On and after Jan. 1, 1970	12.5%
" " " Jan. 1, 1971	10.5%
" " " Jan. 1, 1972	9%

Sources: The Customs Tariff and Amendments, Department of National Revenues, Customs and Excise Division, Ottawa.
Tariff Schedules of the United States Annotated (1970), TC Publication 304.

Copper

ROBERT J. SHANK*

The production of copper from Canadian mines in 1970 rose to a record 673,747 short tons, 100,502 tons over the previous year when operations at some mines were interrupted by labour strikes. Canada, with about 10 per cent of total world output, remained the fifth largest producer in the world after the United States, USSR, Zambia and Chile. Mine production is expected to grow strongly for the next three or four years as large deposits in British Columbia become operational.

The two domestic copper refineries operated at 99 per cent of their rated capacity in 1970 to produce a record 543,069 tons of refined metal. This was a rise of 92,915 tons over 1969 when the refineries, affected by strikes, operated at 88 per cent of capacity.

Canadian consumption of refined copper fell slightly in 1970 to 237,838 tons from 240,256 tons in 1969, probably reflecting lower foreign demand for fabricated and semi-fabricated copper products.

On the international scene, the supply-demand balance for copper changed about mid-year from a situation of short supply to one of more than adequate supply. This allowed stocks, that had been depleted over the past five years, to be replenished.

World mine production of copper rose by just over 5 per cent to 6.9 million tons in 1970. Substantial increases over 1969 were recorded in the United States and Canada, while lesser increases occurred in the Congo, South Africa, Philippines, and Australia. Chile which had previously indicated a large increase in production, actually showed a slight decline from 1969.

World production of refined copper in 1970 also rose, by about 4 per cent over 1969, to 8.2 million tons. Most of this increase occurred in nations having large refinery capacity; Canada, Japan, Belgium and the United States.

The world consumption of refined copper rose marginally by about 1 per cent in 1970, reflecting slower business growth in North America and Japan. Consumption amounted to about 7.8 million tons, indicating some build-up of stocks.

The copper industry faced a number of uncertainties at the end of 1970. On the one hand was the spectre of over-production due to slow sales and increasing productive capability. On the other hand was the possibility of a major strike at mid-year in the United States mines and smelters coupled with doubts about the future of the industry in Chile. It appears likely that unless some kind of involuntary interruption of output occurs, producers will be faced with a build-up of stocks that could lead to production cutbacks.

*Mineral Resources Branch.

TABLE 1

Canada, Copper Production, Trade and Consumption, 1969 – 70

	1969		1970[p]	
	Short Tons	$	Short Tons	$
Production[1]				
Ontario	238,810	244,300,501	291,908	339,022,800
Quebec	160,068	164,646,440	173,533	201,542,000
British Columbia	83,708	86,081,211	109,647	127,343,700
Manitoba	37,097	38,158,178	51,445	59,748,800
Saskatchewan	18,230	18,751,559	15,548	18,058,000
Newfoundland	20,464	21,049,062	15,412	17,898,600
New Brunswick	6,791	6,984,742	7,933	9,213,100
Yukon	7,433	7,645,623	7,750	9,000,800
Northwest Territories	625	643,761	544	631,100
Nova Scotia	19	19,520	27	31,400
Total	573,245	588,280,597	673,747	782,490,300
Refined	450,154		543,069	
Exports				
Copper in ores, concentrates and matte				
Japan	108,891	128,350,000	127,225	153,098,000
Norway	22,855	18,331,000	32,168	33,855,000
United States	12,507	9,742,000	7,868	7,238,000
Spain	2,766	2,924,000	4,294	4,089,000
West Germany	3,207	2,806,000	3,244	4,022,000
Sweden	3,735	4,559,000	2,000	2,018,000
Others	3,855	3,869,000	2,320	2,249,000
Total	157,816	170,581,000	179,119	206,569,000
Copper in slag, skimmings and sludge				
United States	–	–	151	162,000
Sweden	–	–	38	6,000
Britain	244	235,000	33	10,000
Japan	6	7,000	–	–
Total	250	242,000	222	178,000
Copper scrap (gross weight)				
West Germany	14,350	16,067,000	8,166	10,324,000
Belgium and Luxembourg	5,576	5,004,000	8,759	9,011,000
Spain	7,834	8,856,000	4,994	6,630,000
United States	4,052	3,833,000	4,093	4,615,000
Yugoslavia	1,866	1,962,000	1,280	1,593,000
Britain	2,128	2,303,000	1,023	1,285,000
Japan	1,287	1,264,000	953	1,071,000
Hungary	1,866	1,962,000	841	967,000
Other countries	1,076	1,411,000	1,298	1,545,000
Total	40,035	42,662,000	31,407	37,041,000
Brass and bronze scrap (gross weight)				
West Germany	9,032	8,675,000	7,043	7,149,000
Japan	4,204	3,595,000	4,074	3,487,000
Belgium and Luxembourg	1,814	1,483,000	3,151	2,591,000
United States	4,715	3,612,000	2,196	1,621,000
Italy	1,270	936,000	1,302	1,089,000
Other countries	1,555	1,246,000	2,431	2,420,000
Total	22,590	19,547,000	20,197	18,357,000

TABLE 1 (Cont'd)

	1969		1970[p]	
	Short Tons	$	Short Tons	$
Copper alloy scrap, n.e.s. (gross weight)				
West Germany	178	178,000	267	217,000
Japan	88	68,000	152	124,000
Belgium and Luxembourg	122	71,000	118	95,000
Britain	40	79,000	50	59,000
Other countries	286	299,000	94	110,000
Total	714	695,000	681	605,000
Copper refinery shapes				
Britain	80,814	90,720,000	111,950	158,865,000
United States	83,690	86,714,000	92,112	104,184,000
West Germany	10,860	12,384,000	39,077	54,131,000
France	15,312	17,315,000	16,251	22,013,000
Belgium and Luxembourg	1,461	2,025,000	6,798	8,406,000
India	2,948	3,875,000	4,194	6,655,000
Italy	2,172	2,323,000	4,297	5,582,000
Brazil	2,634	2,903,000	3,777	5,344,000
Portugal	903	1,016,000	2,909	4,178,000
Switzerland	930	1,007,000	2,332	3,154,000
Spain	789	842,000	2,099	3,046,000
Other countries	7,521	7,905,000	6,607	9,472,000
Total	210,034	229,029,000	292,403	385,030,000
Copper bars, rods and shapes, n.e.s.				
Norway	1,433	1,653,000	3,260	4,730,000
Denmark	1,146	1,374,000	2,680	3,785,000
United States	2,269	3,023,000	1,961	3,213,000
Pakistan	348	368,000	2,026	3,144,000
Switzerland	2,456	3,014,000	2,123	2,739,000
Britain	726	740,000	1,745	2,237,000
Belgium and Luxembourg	328	436,000	830	1,056,000
Yugoslavia	–	–	763	997,000
Costa Rica	–	–	601	848,000
Venezuela	190	242,000	363	508,000
Other countries	2,198	2,622,000	1,228	1,639,000
Total	11,094	13,472,000	17,580	24,896,000
Copper plates, sheet, strip and flat products				
United States	7,360	10,279,000	6,859	10,923,000
Britain	632	841,000	334	553,000
Venezuela	278	406,000	308	514,000
Colombia	60	83,000	136	227,000
Pakistan	9	1,000	113	194,000
New Zealand	155	233,000	36	64,000
Other countries	199	305,000	77	127,000
Total	8,693	12,148,000	7,863	12,602,000

TABLE 1 (Cont'd)

	1969		1970[p]	
	Short Tons	$	Short Tons	$
Copper pipe and tubing				
United States	11,562	13,876,000	7,483	10,913,000
New Zealand	812	1,364,000	1,014	2,054,000
Britain	657	971,000	917	1,631,000
Israel	567	833,000	1,009	1,595,000
Puerto Rico	554	811,000	480	801,000
Other countries	1,801	2,652,000	2,106	3,669,000
Total	15,953	20,507,000	13,009	20,663,000
Copper wire and cable (not insulated)				
United States	678	873,000	798	1,178,000
Iraq	716	798,000	375	547,000
Iran	743	903,000	287	461,000
Jamaica	240	292,000	231	376,000
Other countries	1,119	1,465,000	952	1,415,000
Total	3,496	4,331,000	2,643	3,977,000
Copper alloy refinery, shapes, section and flat products				
United States	11,075	13,524,000	9,449	13,517,000
Japan	605	601,000	3,143	3,656,000
Venezuela	130	181,000	325	555,000
Italy	–	–	378	396,000
Switzerland	379	447,000	332	393,000
Hong Kong	–	–	264	280,000
Other countries	527	715,000	543	844,000
Total	12,716	15,468,000	14,434	19,641,000
Copper alloy pipe and tubing				
United States	973	1,674,000	1,768	2,982,000
Puerto Rico	55	81,000	458	598,000
Japan	190	419,000	154	479,000
Britain	14	32,000	105	217,000
New Zealand	67	103,000	98	174,000
Venezuela	18	36,000	45	80,000
Other countries	409	963,000	59	141,000
Total	1,726	3,308,000	2,687	4,671,000
Copper alloy wire and cable, not insulated				
United States	526	707,000	294	585,000
Britain	9	16,000	27	57,000
Australia	40	81,000	23	9,000
Other countries	68	100,000	35	65,000
Total	643	904,000	379	716,000
Copper alloy fabricated materials, n.e.s.				
United States	701	1,470,000	543	1,128,000
Brazil	–	–	384	1,100,000
New Zealand	26	40,000	21	36,000
Other countries	153	226,000	44	130,000
Total	880	1,736,000	992	2,394,000

TABLE 1 (Cont'd)

	1969		1970[p]	
	Short Tons	$	Short Tons	$
Wire and cable insulated[2]				
United States	11,770	20,962,000	26,913	54,784,000
Puerto Rico	176	357,000	605	1,353,000
Turkey	–	–	1,735	1,229,000
Dominican Republic	109	201,000	633	1,091,000
Panama	484	553,000	579	786,000
Trinidad and Tobago	17	40,000	345	573,000
Belgium and Luxembourg	–	–	339	473,000
Philippines	–	–	265	466,000
Saudi Arabia	–	–	295	438,000
Venezuela	143	187,000	187	360,000
Jamaica	105	150,000	225	339,000
Bermuda	166	206,000	213	339,000
Other countries	3,721	4,551,000	2,544	4,230,000
Total	16,691	27,207,000	34,878	66,461,000
Imports				
Copper in ores, concentrates, scrap	7,839	7,579,000	7,362	5,566,000
Copper refinery shapes	18,137	20,883,000	14,542	18,789,000
Copper bars, rods and shapes (sections) n.e.s.	543	711,000	500	621,000
Copper plates, sheet, strip and flat products	644	1,151,000	347	737,000
Copper pipe and tubing	1,350	2,344,000	1,282	2,518,000
Copper wire and cable, except insulated	531	1,002,000	206	420,000
Copper alloy scrap (gross weight)	2,696	2,167,000	3,771	3,093,000
Copper powder	400	724,000	264	498,000
Copper alloy refinery shapes, rods and sections	4,433	6,467,000	5,480	6,954,000
Brass plates, sheet, strip and flat products	4,051	4,939,000	2,105	3,184,000
Copper alloy pipe and tubing	1,421	2,683,000	1,184	2,517,000
Copper alloy wire and cable, except insulated	785	1,668,000	294	850,000
Copper alloy castings	239	610,000	337	733,000
Copper and alloy fabricated materials, n.e.s.	1,062	1,858,000	951	1,816,000
Insulated wire and cable	..	15,755,000	..	10,277,000
Copper oxides and hydroxides	167	221,000	212	317,000
Copper sulphate	1,398	535,000	2,268	941,000
CONSUMPTION[3]				
Refined	240,256		237,838	

Source: Dominion Bureau of Statistics.
[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; n.e.s. Not elsewhere specified.

TABLE 2

Canada, Copper Production, Trade and Consumption, 1961 – 70
(short tons)

	Production		Exports			Imports	Consumption[2]
	All Forms[1]	Refined	Ore and Matte	Refined	Total	Refined	Refined
1961	439,088	406,359	42,894	266,247	309,141	3	141,808
1962	457,385	382,868	89,374	223,043	312,417	147	151,525
1963	452,559	380,075	92,930	214,987	307,917	6,549	169,750
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	613,313	499,846	128,976	275,919	404,895	5,310	219,680
1968	633,312	524,474[r]	161,835	276,619	438,454	5,824	250,104[r]
1969	573,245	450,154	157,816	210,034	367,850	18,137	240,256
1970[p]	673,747	543,069	179,119	292,403	471,522	14,542	237,838

Source: Dominion Bureau of Statistics.

[1]Blister copper plus recoverable copper in matte and concentrates exported. [2]Producers' domestic shipments, refined copper.

[p]Preliminary; [r]Revised.

CANADIAN SUPPLY AND DEMAND

MINE PRODUCTION

Ten new copper mines were placed in production in 1970 and six mines were closed, resulting in a net increase in annual productive capability of about 95,000 tons of contained copper. There were few interruptions of operations caused by labour difficulties during the year, the more important ones being at the Geco mine of Noranda Mines Limited, and at Brunswick Mining and Smelting Corporation Limited.

Eight new mines are scheduled to begin operations in 1971 and six are expected to close. These changes should result in a net gain in annual productive capability of about 56,000 tons of copper in concentrates. By the end of 1971, Canadian mines should have an installed operating capacity to produce about 835,000 tons a year of copper in concentrates. However, because of start-up difficulties and unscheduled shut-downs, production in 1971 is expected to be about 740,000 tons.

Information pertaining to individual mines can be obtained from the accompanying tables. Table 3 lists all mines that produced copper in 1969 and 1970 along with production statistics and a brief description of events that occurred in 1970. The statistics used have been largely obtained directly from each company. Table 4 lists the mines for which production plans have been announced. Table 5 lists some of the properties that are actively being explored and may become producers in the near future.

METAL PRODUCTION

A comprehensive summary of the six Canadian smelters that treat copper-bearing materials is given in Table 6. Output at Gaspé was back to normal following decreased production in 1969 due to a strike. The strike at the Geco mine that continued into 1970 caused a significant drop in output from the Noranda smelter. Operations at other smelters were normal.

The operations of the two Canadian copper refineries are summarized in Table 7.

Noranda Mines Limited has announced plans for a major program, to be completed in 1973, to expand its copper smelting and refining facilities in Quebec. At Gaspé, smelter capacity will be raised to produce an additional 27,000 tons of anode copper a year. In addition, a 132,000-ton-a-year sulphuric acid plant will be built to supply acid for leaching low grade oxide ores. At Noranda, the smelter will be expanded by the construction of a Noranda Continuous Smelting Process reactor capable of producing 55,000 tons a year of blister copper in one furnace directly from concentrates. This will be the first such smelter in commercial production in the world. Its operation will be watched closely as the potential savings in smelting costs are substantial. In conjunction with increases in smelter capacity, Noranda will expand its copper refinery at Montreal East by about 80,000 tons of annual capacity of refined copper.

Four companies sell refined copper in Canada. They are Noranda Mines Limited, The International Nickel Company of Canada, Limited (Inco), Texas

TABLE 3

Principal Copper Mines in Canada 1970 and (1969)

Company and Location	Mill or Mine Capacity (tons ore/day)	Grade of Ore: Copper (%)	Zinc (%)	Nickel (%)	Silver (oz/ton)	Ore Produced (tons)	Contained Copper Produced (tons)	Remarks
NEWFOUNDLAND								
American Smelting and Refining	1,250	1.11	12.68	–	3.73	359,000	3,700	
Company, Buchans	(1,250)	(1.12)	(12.78)	–	(4.01)	(371,000)	(3,807)	
Atlantic Coast Copper	–	–	–	–	–	–	–	Mine closed October 30, 1969.
Corporation Limited, Little Bay	(1,200)	(0.84)	–	–	–	(295,070)	(2,311)	
British Newfoundland Exploration	. .	. .	. .	. .	. .	. .	. .	
Limited, Whalesback mine, Springdale	(2,000)	(0.86)	–	–	–	(718,490)	(5,637)	
Consolidated Rambler Mines	1,200	0.79	–	–	–	418,447	3,191	Discovered new orebody at Mings
Limited, East mine, Baie Verte	(1,500)	(0.99)	–	–	–	(404,181)	(3,759)	Bight.
First Maritime Mining Corporation	2,500	0.70	–	–	–	723,715	4,675	Milling rate increased.
Limited, Gullbridge mine, Badger	(2,000)	(0.97)	–	–	–	(611,898)	(5,278)	
NOVA SCOTIA								
Dresser Minerals, Division of	140	0.33	0.50	–	3.58	27,263	89	Developing lower levels of mine.
Dresser Industries, Inc., Walton	(125)	(0.28)	(0.58)	–	(5.50)	(49,870)	(138)	
NEW BRUNSWICK								
Anaconda American Brass	1,000	. .	. .	–	. .	3,000	53	Open-pit mine prepared for
Limited, Caribou mine, Restigouche Co.	–	–	–	–	–	–	–	production. Mill operated on tune-up basis only late in year.
Brunswick Mining and Smelting Corporation Limited, Bathurst								Closed by strike for 41 days in March and April.
No. 6 mine	3,500	0.33	5.86	–	1.84	1,100,703	28	
	(2,500)	(0.35)	(5.78)	–	(1.87)	(1,134,224)	(1,336)	
No. 12 mine	6,000	0.32	7.54	–	2.19	1,519,981	2,200	
	(5,000)	(0.33)	(8.05)	–	(2.13)	(1,696,408)	(3,218)	
Heath Steele Mines Limited,	3,000	0.97	5.40	–	2.20	1,030,899	6,453	Plan to sink No. 4 shaft to explore
Newcastle	(3,000)	(1.46)	(4.00)	–	(1.71)	(321,403)	(3,485)	A, C, D zones.
Nigadoo River Mines Limited,	1,000	. .	. .	–	. .	313,354	677	Development work will be speeded
Robertville	(1,000)	(0.37)	(2.66)	–	(3.85)	(328,709)	(949)	up.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Grade of Ore Copper (%)	Zinc (%)	Nickel (%)	Silver (oz/ton)	Ore Produced (tons)	Contained Copper Produced (tons)	Remarks
QUEBEC								
Bell Allard Mines Limited, Matagami	900 (370)	0.58 (0.88)	9.26 (8.50)	– –	1.11 (0.95)	61,265 (97,354)	281 (669)	Open-pit operation terminated in November.
Campbell Chibougamau Mines Ltd., Original, Kokko Creek, Merrill Island, Cedar Bay and Henderson mines, Chibougamau	4,000 (3,500)	1.55 (1.56)	– –	– –	0.28 (0.26)	1,309,718 (1,196,849)	18,492 (17,395)	Development adding to ore reserves.
Delbridge Mines Limited, Noranda	500 (500)	0.71 (0.70)	10.29 (10.30)	– –	3.48 (3.25)	196,844 (57,494)	1,217 (274)	Ore trucked to Quemont mill. Shaft deepening and underground exploration continuing. Existing ore reserves will be exhausted in 1971.
Gaspé Copper Mines, Limited, Murdochville	11,000 (11,000)	0.95 (1.01)	– –	– –	– –	4,070,853 (2,997,800)	35,040 (27,092)	Mill capacity to be expanded to 34,000 tpd by mid-1973.
Grandroy Mines Limited, Chibougamau	– –	– (0.49)	– –	– –	– (0.04)	– (8,931)	– (42)	Mine closed in 1968. Clean-up in 1969. Ore trucked to Campbell Chibougamau mill.
Icon Syndicate, Chibougamau	650 (600)	2.83 (3.23)	– –	– –	0.19 (0.18)	219,764 (214,154)	6,046 (6,825)	Installation of a heavy media pre-concentration plant completed. Ore trucked to Merrill Island mill.
Joutel Copper Mines Limited, Joutel	700 (700)	2.17 (2.26)	– –	– –	– –	246,760 (241,899)	5,361 (5,001)	Ore trucked to Mines de Poirier mill.
Lake Dufault Mines Limited, Norbec mine, Noranda	1,300 (1,300)	1.36 (1.71)	1.82 (2.21)	– –	0.53 (0.77)	419,171 (405,790)	5,558 (6,554)	Sinking of Millenbach shaft completed. New mine development under way.
Louvem Mining Company Inc., Louvicourt	800 –	2.76 –	– –	– –	0.50 –	98,910 –	2,644 –	Ore trucked to Manitou-Barvue mill. Open-pit production started August 4, 1970. Underground mining to begin in June 1971.
Madeleine Mines Ltd., Gaspé Provincial Park	2,500 (2,500)	1.26 (1.20)	– –	– –	0.30 . .	848,570 (402,146)	9,868 (4,159)	Two marginal ore zones redefined.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Grade of Ore: Copper (%)	Zinc (%)	Nickel (%)	Silver (oz/ton)	Ore Produced (tons)	Contained Copper Produced (tons)	Remarks
Manitou-Barvue Mines Limited, Val d'Or	1,600 (1,300)	0.59 (0.54)	2.19 (2.72)	– –	4.66 (2.27)	362,170 (368,675)	524 (869)	New installations for handling custom milling ores from Louvem.
Mattagami Lake Mines Limited, Matagami	3,850 (3,850)	0.59 (0.62)	9.1 (9.6)	– –	0.86 (1.02)	1,430,864 (1,413,651)	7,182 (6,439)	Twelve new houses added to townsite. Installing an underground crusher and conveyor system.
New Hosco Mines Limited, Matagami	900 (900)	0.94 (0.94)	0.76 (1.79)	– –	0.38 (0.33)	64,248 (277,768)	515 (2,075)	Production ceased in April 1970 as reserves exhausted. Ore trucked to Orchan mill.
Noranda Mines Limited, Horne mine, Noranda	3,000 (3,200)	2.01 (2.25)	– –	– –	0.41 (0.16)	654,262 (754,365)	12,572 (21,926)	Ore reserves declining.
Normetal Mines Limited, Normetal	980 (1,000)	1.77 (1.67)	6.72 (6.65)	– –	1.47 (1.48)	348,100 (355,495)	5,777 (5,518)	Ore reserves expected to be exhausted in 1972.
Opemiska Copper Mines (Quebec) Limited, Perry, Robitaille and Springer mines, Chapais	3,000 (2,000)	2.46 (2.61)	– –	– –	0.33 (0.37)	835,942 (792,549)	19,662 (19,822)	Increasing production to 3,000 tpd. Flotation cells in mill replaced with flotation tanks.
Orchan Mines Limited, Matagami	1,900 (1,900)	1.03 (1.04)	11.10 (11.53)	– –	1.36 (1.09)	414,521 (308,732)	3,483 (2,563)	Small tonnage of low grade ore added to reserves. Milled ore from New Hosco and Bell Allard. Developing Garon Lake mine.
The Patino Mining Corporation, Copper Rand Mines Division, Copper Rand, Copper Cliff, Jaculet and Portage mines, Chibougamau	3,000 (2,000)	1.98 (2.06)	– –	– –	0.21 (0.20)	837,187 (731,953)	15,931 (14,401)	Underground crusher installed. Six new levels developed at No. 4 shaft of the Copper Rand mine. Copper Cliff mine began production. Shaft sinking under way at the Portage mine.
Quemont Mines Limited, Noranda	2,400 (2,300)	0.78 (0.78)	1.89 (1.96)	– –	0.91 (0.74)	299,636 (334,432)	2,077 (2,341)	Mine scheduled for closing in 1971 because of diminishing ore reserves. Mills ore from Delbridge.
Renzy Mines Limited, Hainault Township	1,000 (800)	0.51 (0.57)	– –	0.46 (0.54)	– –	. . . .	. . . .	Mill capacity increased, but full output hampered by shortage of power.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Grade of Ore: Copper (%)	Zinc (%)	Nickel (%)	Silver (oz/ton)	Ore Produced (tons)	Contained Copper Produced (tons)	Remarks
Rio Algom Mines Limited,	2,500	2.30	–	–	–	561,559	12,338	Mills ore from Joutel.
Mines de Poirier mine, Joutel	(2,500)	(1.98)	–	–	–	(521,886)	(8,808)	
Sullivan Mining Group Ltd.,	1,400	1.78	2.95	–	1.14	375,447	6,108	Solbec mine closed in December
Cupra, D'Estrie and Solbec Divisions, Stratford Centre	(1,500)	(. .)	(. .)	–	(. .)	(431,297)	(7,724)	1970 as ore exhausted.
ONTARIO								
Big Nama Creek Mines Limited,	–	0.80	3.76	–	0.99	88,965	622	Ore trucked to Willroy mill.
Manitouwadge	–	(0.88)	(3.90)	–	(1.08)	(57,472)	(464)	Production in early 1970 at 10,000 tons per month.
Canadian Jamieson Mines Limited,	575	1.77	3.07	–	–	207,885	3,328	Ore reserves nearly exhausted.
Timmins	(450)	(2.50)	(4.40)	–	–	(196,140)	(4,471)	
Consolidated Canadian Faraday	1,100	. .	–	. .	–	105,504	326	Mills ore from Dumbarton.
Limited, Werner Lake Division, Gordon Lake	(1,200)	(0.39)	–	(0.82)	–	(177,726)	(525)	
Copperfields Mining Corporation	200	3.98	–	–	–	50,271	2,002	
Limited, Timagami	(200)	(3.45)	–	–	–	(40,936)	(1,377)	
Ecstall Mining Limited, Kidd	10,000	. .	. .	–	. .	3,584,124	44,583	Shaft for U/G mining to be
Creek mine, Timmins	(9,000)	. .	. .	–	. .	(3,617,226)	(42,002)	completed in 1971.
Falconbridge Nickel Mines	14,100	. .	–	. .	. .	4,627,000	28,461[d]	1969 production reflects 3-month
Limited, East, Falconbridge, Fecunis, Hardy, Longvac South, North, Onaping, and Strathcona mines, Falconbridge	(12,900)	. .	–	. .	. .	(3,118,000)	(24,728)	strike that year.
The International Nickel Company	70,500	. .	–	. .	. .	. .	174,050[d]	Production at Totten temporarily
of Canada, Limited, Clarabelle, Copper Cliff North, Crean Hill, Creighton, Frood-Stobie, Garson, Kirkwood, Levack, MacLennan, Murray and Totten mines, Copper Cliff	(70,500)	. .	–	. .	. .	(14,578,700)	(104,110)	suspended to permit expansion.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Grade of Ore Copper (%)	Zinc (%)	Nickel (%)	Silver (oz/ton)	Ore Produced (tons)	Contained Copper Produced (tons)	Remarks
Jameland Mines Limited, Timmins	700 (700)	1.35 (1.38)	0.28 (0.25)	– –	– –	191,810 (26,931)	2,112 (305)	Production began in 1970. Milled at Kam-Kotia.
Kam-Kotia Mines Limited, Timmins	2,500 (2,500)	0.78 (1.21)	2.78 (3.22)	– –	.. ..	650,869 (817,716)	4,128 (8,035)	Mills Jameland ore.
McIntyre Porcupine Mines Limited, Schumacher	2,200 (2,000)	0.75 (0.78)	– –	– –	0.12 (0.12)	751,830 (741,440)	5,223 (5,406)	Exploring for extension of copper ore below 3,625 level.
Noranda Mines Limited, Geco Division, Manitouwadge	5,000 (4,000)	1.86 (2.48)	3.89 (4.90)	– –	1.82 ..	1,366,176 (1,320,000)	23,840 (..)	73-day strike ended Feb. 2, 1970. Milling capacity increased late in year.
North Canadian Enterprises Limited, Coppercorp mine, Port Mamainse	500 (500)	1.32 (1.46)	– –	– –	– –	140,830 (161,488)	1,800 (2,276)	
Rio Algom Mines Limited, Pronto Division, Spragge	750 (750)	1.72 (1.90)	– –	– –	– –	57,154 (241,622)	950 (4,294)	Mine closed on April 30, 1970 as ore reserves exhausted.
Spanish River Mines Limited, Sudbury	500 (500)	.. (1.30)	– –	– –	– –	.. (80,000)	.. ..	Ore trucked to Kidd Copper mill. Operations suspended September 1970.
Tribag Mining Co., Limited, Batchawana Bay	500 (400)	2.06 (1.93)	– –	– –	.. (0.40)	173,270 (177,339)	3,493 (3,336)	Underground exploration continuing.
Upper Beaver Mines Limited, Dobie	300 (150)	1.44 (1.29)	– –	– –	0.14 (0.16)	65,548 (62,297)	906 (765)	Ore trucked to Upper Canada Mines Limited. Ore reserves declining.
Willroy Mines Limited, (includes Willecho) Manitouwadge	1,600 (1,700)	0.85 (0.57)	4.02 (3.58)	– –	1.99 (1.70)	388,005 (445,449)	3,504 (2,347)	Ore treated at Willroy mill. Willecho amalgamated with Willroy on December 31, 1970.
MANITOBA								
Dumbarton Mines Limited, Bird River	700 (700)	.. (0.26)	– –	.. (0.77)	– –	252,552 (66,395)	761 (153)	Mine started production in September 1969. Capacity production achieved in 1970.

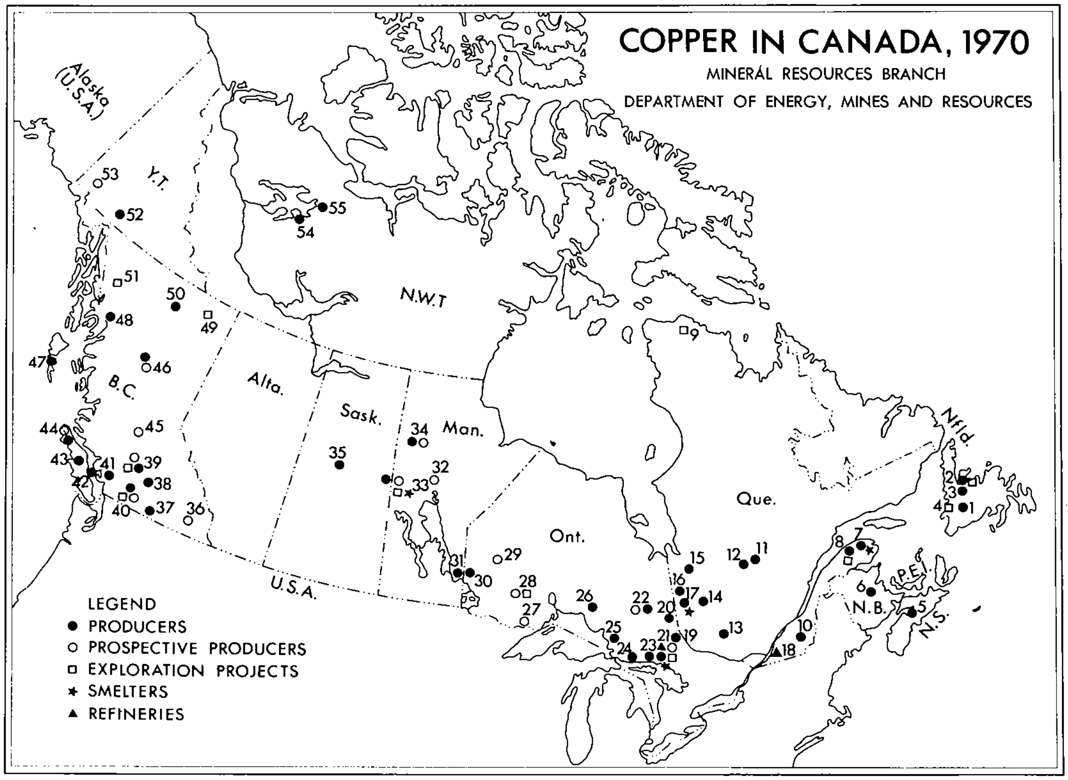
TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Grade of Ore: Copper (%)	Grade of Ore: Zinc (%)	Grade of Ore: Nickel (%)	Grade of Ore: Silver (oz/ton)	Ore Produced (tons)	Contained Copper Produced (tons)	Remarks
Hudson Bay Mining and Smelting Co., Limited, Anderson, Chisel, Dickstone, Flin Flon, Osborne, Schist, and Stall Lake mines, Flin Flon and Snow Lake	7,500 (6,000)	2.67 (2.70)	3.94 (4.30)	– –	0.61 (0.60)	1,709,130 (1,702,000)	45,767 (44,590)	Anderson Lake mine went into production on Nov. 9, 1970 at 800 tons a day and Dickstone mine on Nov. 2, 1970 at 500 tons per day.
Sherritt Gordon Mines, Limited, Lynn Lake mine, Lynn Lake	3,500 (3,500)	0.51 ..	– –	0.77 ..	– –	1,090,000 (1,258,193)	5,010 (6,129)	Farley mine being deepened by driving a decline.
Fox Lake mine, Lynn Lake	3,000 (–)	3.07 –	1.13 –	– –	– –	389,000 –	10,273 –	Production started May 5, 1970.
SASKATCHEWAN								
Hudson Bay Mining and Smelting Co., Limited, Flexar and Flin Flon mines, Flin Flon				See Manitoba				Flexar mine started production in April 1969. Ore trucked to Flin Flon mill.
Rio Algom Mines Limited, Anglo-Rouyn mine, La Ronge	900 (900)	1.68 (1.79)	– –	– –	0.22 ..	314,902 (274,523)	4,885 (5,045)	Declines under two ore zones completed.
BRITISH COLUMBIA								
Anaconda Britannia Mines Ltd., Britannia Beach	3,000 (3,000)	.. (1.18)	.. (0.17)	– –	– –	320,642 (605,273)	2,735 (6,656)	
Bethlehem Copper Corporation Ltd., Highland Valley	15,000 (14,000)	.. (0.53)	– –	– –	– –	5,450,746 (5,236,914)	24,221 (23,966)	Heustis orebody prepared for open-pit mining.
Brenda Mines Ltd., Peachland	24,000 –	0.22 –	– –	– –	– –	7,326,559 –	14,311 –	Production started in February 1970 from open pit.
Churchill Copper Corporation Ltd., Magnum Creek	750 –	3.20 –	– –	– –	– –	171,277 –	5,291 –	Production started in April 1970.
Cominco Ltd., Coast Copper mine, Benson Lake, V.I.	750 (750)	.. ..	– –	– –	– –	290,911 (281,000)	5,757 (3,964)	Ore reserves increased due to development work on newly-acquired Benson Lake mine.
Craigmont Mines Limited, Merritt	5,000 (5,000)	1.03 (1.02)	– –	– –	– –	1,797,213 (1,810,855)	17,055 (17,260)	Added iron ore recovery circuit to mill.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Grade of Ore: Copper (%)	Grade of Ore: Zinc (%)	Grade of Ore: Nickel (%)	Grade of Ore: Silver (oz/ton)	Ore Produced (tons)	Contained Copper Produced (tons)	Remarks
Falconbridge Nickel Mines Limited, Wesfrob mine, Tasu Harbour, Q.C.I.	8,000 (10,000)	0.81 (0.90)	– –	– –	. . (0.19)	1,200,000 (871,809)	9,142 (7,548)	Copper concentrate produced as a byproduct of iron mining and beneficiation.
Giant Mascot Mines Limited, Hope	1,500 (1,300)	0.43 (0.40)	– –	0.84 (0.83)	– –	211,460 (337,056)	749 (1,046)	Fire destroyed the concentrator and all surface facilities on August 2, 1970. New concentrator under construction. Converting to trackless mining.
Greyhound Mines Ltd., (formerly Aabro Mining & Oils Ltd.), Greenwood	2,000 –	0.79 –	– –	– –	– –	. . –	. . –	Production started in September 1970.
The Granby Mining Company Limited, Granisle mine, Babine Lake	6,500 (5,000)	0.55 (0.60)	– –	– –	– –	2,393,161 (2,329,957)	11,396 (12,558)	Ore reserves increased to 89.6 million tons at 0.44% Cu.
The Granby Mining Company Limited, Phoenix Copper Division, Greenwood	2,400 (2,400)	0.77 (0.74)	– –	– –	0.24 (0.26)	862,156 (759,299)	5,733 (4,739)	
Granduc Operating Company, Stewart	7,000 –	1.32 –	0.23 –	– –	0.43 –	105,230 –	1,302 –	Production started on November 1, 1970.
Texada Mines Ltd., Vananda	4,500 (4,000)	0.26 (0.22)	– –	– –	0.02 (0.02)	1,230,153 (1,263,326)	1,872 (1,525)	
Western Mines Limited, Buttle Lake, V.I.	750 (1,000)	1.97 (1.83)	6.38 (7.67)	– –	1.36 (1.69)	386,976 (383,931)	7,158 (6,579)	Lead circuit installed in mill.
YUKON TERRITORY								
New Imperial Mines Ltd., Whitehorse	2,500 (2,500)	1.04 (1.09)	– –	– –	. . (0.24)	852,461 (805,519)	8,042 (7,585)	Production mainly from War Eagle open pit. Little Chief underground mine being developed.
NORTHWEST TERRITORIES								
Echo Bay Mines Ltd., Port Radium	100 (100)	1.17 (1.10)	– –	– –	70.00 (67.99)	36,925 (34,797)	390 (341)	Internal shaft deepened 750 feet to provide 5 new levels.
Terra Mining and Exploration Limited, Sawmill Bay, Great Bear Lake	200 (150)	0.90 (2.50)	– –	– –	13.70 (40.00)	32,867 . .	275 . .	Mill destroyed by fire in February 1970. Production resumed in May and to be increased to 400 tpd.

– Nil; . . Not available; [d]Deliveries.



PRODUCERS

(Numbers refer to numbers on map)

1. American Smelting and Refining Company (Buchans)
2. Atlantic Coast Copper Corporation Limited (Little Bay)
   British Newfoundland Exploration Limited (Whalesback Pond Mine)
   Consolidated Rambler Mines Limited (East mine)
3. First Maritime Mining Corporation Limited (Gullbridge mine)
5. Dresser Minerals, Division of Dresser Industries, Inc. (Walton)
6. Anaconda American Brass Limited (Caribou mine)
   Brunswick Mining and Smelting Corporation Limited (No. 6 and No. 12 mines)
   Heath Steele Mines Limited (Newcastle)
   Nigadoo River Mines Limited (Robertville)
7. Gaspé Copper Mines, Limited (Murdochville)
8. Madeleine Mines Ltd. (Gaspé Provincial Park)
10. Sullivan Mining Group Ltd. (Cupra, D'Estrie, Solbec mines)
11. Campbell Chibougamau Mines Ltd. (Original, Kokko Creek, Merrill Island, Cedar Bay, Henderson mines)
    Grandroy Mines Limited (Chibougamau)
    Icon Syndicate (Chibougamau)
    The Patino Mining Corporation, Copper Rand Mines Division (Copper Rand, Portage, Jaculet, Copper Cliff mines)
12. Opemiska Copper Mines (Quebec) Limited (Perry, Robitaille, and Springer mines)
13. Renzy Mines Limited (Hainault Township)
14. Louvem Mining Company Inc. (Louvincourt)
    Manitou-Barvue Mines Limited (Val d'Or)
15. Bell Allard Mines Limited (Matagami)
    Joutel Copper Mines Limited (Joutel)
    Mattagami Lake Mines Limited (Matagami)
    New Hosco Mines Limited (Matagami)
    Orchan Mines Limited (Matagami)
    Rio Algom Mines Limited (Mines de Poirer mine)
16. Normetal Mines Limited (Normetal)
17. Delbridge Mines Limited (Noranda)
    Lake Dufault Mines Limited (Norbec mine)
    Noranda Mines Limited (Horne mine)
    Quemont Mines Limited (Noranda)
19. Copperfields Mining Corporation Limited (Temagami mine)
20. Upper Beaver Mines Limited (Dobie)
21. Falconbridge Nickel Mines Limited (Falconbridge, East, Strathcona, Hardy, Fecunis Lake, Onaping, North, Longvac South mines)
    The International Nickel Company of Canada, Limited (Frood – Stobie, Creighton, Garson, Levack, Copper Cliff North, Crean Hill, Totten, Murray, MacLennan, Clarabelle, and Crean Hill mines)

22. Canadian Jamieson Mines Limited (Timmins)
Ecstall Mining Limited (Kidd Creek mine)
Jameland Mines Limited (Timmins)
Kam-Kotia Mines Limited (Timmins)
McIntyre Porcupine Mines Limited (Schumacher)
23. Spanish River Mines Limited (Sudbury)
24. Rio Algom Mines Limited (Pronto Division)
25. Tribag Mining Co., Limited (Batchawana Bay)
North Canadian Enterprises Limited (Coppercorp mine)
26. Big Nama Creek Mines Limited (Manitouwadge)
Noranda Mines Limited (Geco Division)
Willroy Mines Limited (Willecho and Willroy mines)
30. Consolidated Canadian Faraday Limited (Werner Lake Division)
31. Dumbarton Mines Limited (Bird River)
33. Hudson Bay Mining and Smelting Co., Limited (Anderson, Chisel, Dickstone, Flexar, Flin Flon, Osborne, Schist, and Stall mines)
34. Sherritt Gordon Mines, Limited (Lynn Lake and Fox Lake mines)
35. Rio Algom Mines Limited (Anglo-Rouyn mine)
37. Greyhound Mines Ltd. (Greenwood)
The Granby Mining Company Limited, Phoenix Copper Division
38. Brenda Mines Ltd. (Peachland)
39. Bethlehem Copper Corporation Ltd. (Highland Valley)
Craigmont Mines Limited (Merritt)
40. Giant Mascot Mines Limited (Hope)
41. Anaconda Britannia Mines Ltd. (Britannia Beach)
42. Texada Mines Ltd. (Vananda)
43. Western Mines Limited (Buttle Lake, V.I.)
44. Cominco Ltd. (Coast Copper Mine, V.I.)
46. The Granby Mining Company Limited (Granisle mine)
47. Falconbridge Nickel Mines Limited (Wesfrob mine, Q.C.I.)
48. Granduc Operating Company (Stewart)
50. Churchill Copper Corporation Ltd. (Magnum Creek)
52. New Imperial Mines Ltd. (Whitehorse)
54. Terra Mining and Exploration Limited (Sawmill Bay)
55. Echo Bay Mines Ltd. (Port Radium)

PROSPECTIVE PRODUCERS

21. Falconbridge Nickel Mines Limited (Lockerby and Thayer Linsley mines)
The International Nickel Company of Canada, Limited (Coleman, Copper Cliff South, Levack West, and Little Stobie mines)
22. Noranda Mines Limited (Langmuir mine)
Texmont Mines Limited (Timmins)
27. The International Nickel Company of Canada, Limited (Shebandowan)
28. Mattabi Mines Limited (Sturgeon Lake)
29. Selco Exploration Company Limited (Uchi Lake)
32. Falconbridge Nickel Mines Limited (Manibridge mine)
33. Hudson Bay Mining and Smelting Co., Limited (Ghost Lake and White Lake mines)
34. Sherritt Gordon Mines, Limited (Ruttan Lake)
36. Placid Oil Company (Bull River deposit)
39. Lornex Mining Corporation Ltd. (Highland Valley)
40. Newmont Mining Corporation of Canada Limited (Ingerbelle and Similkenameen deposits)
44. Utah Construction & Mining Co. (Island Copper mine, V.I.)
45. Gibralter Mines Ltd. (McLeese Lake)
46. Noranda Mines Limited (Bell Copper deposit)
53. Hudson-Yukon Mining Co., Limited (Wellgreen Mine)

EXPLORATION PROJECTS

2. British Newfoundland Exploration Limited (Little Deer Pond deposit)
4. Big Nama Creek Mines Limited (York Harbour)
8. Sullipeck Mines Inc. (Pekan Brook)
9. New Quebec Raglan Mines Limited (Wakeham Bay)
21. The International Nickel Company of Canada, Limited (Cryderman, Victoria and Whistle mines)
28. New Brunswick Uranium Metals & Mining Limited (Sturgeon Lake)
33. Hudson Bay Mining and Smelting Co., Limited (Centennial Rail Lake, Reed Lake, and Wim mines)
Stall Lake Mines Limited (Snow Lake)
39. Alwin Mining Company Ltd. (Highland Valley)
Highmont Mining Corp. Ltd. (Highland Valley)
Valley Copper Mines Limited (Highland Valley)
40. Giant Mascot Mines Limited (Canam mine)
49. Davis-Keays Mining Co. Ltd. (Fort Nelson)
51. Liard Copper Mines Ltd. (Telegraph Creek)
Stikine Copper Limited (Galore Creek)

SMELTERS

7. Gaspé Copper Mines, Limited (Murdochville)
17. Noranda Mines Limited (Noranda)
21. The International Nickel Company of Canada, Limited (Coniston)
The International Nickel Company of Canada, Limited (Copper Cliff)
Falconbridge Nickel Mines Limited (Falconbridge)
33. Hudson Bay Mining and Smelting Co., Limited (Flin Flon)

REFINERIES

18. Canadian Copper Refiners Limited
21. The International Nickel Company of Canada, Limited (Copper Cliff)

TABLE 4

Prospective* Copper Producers

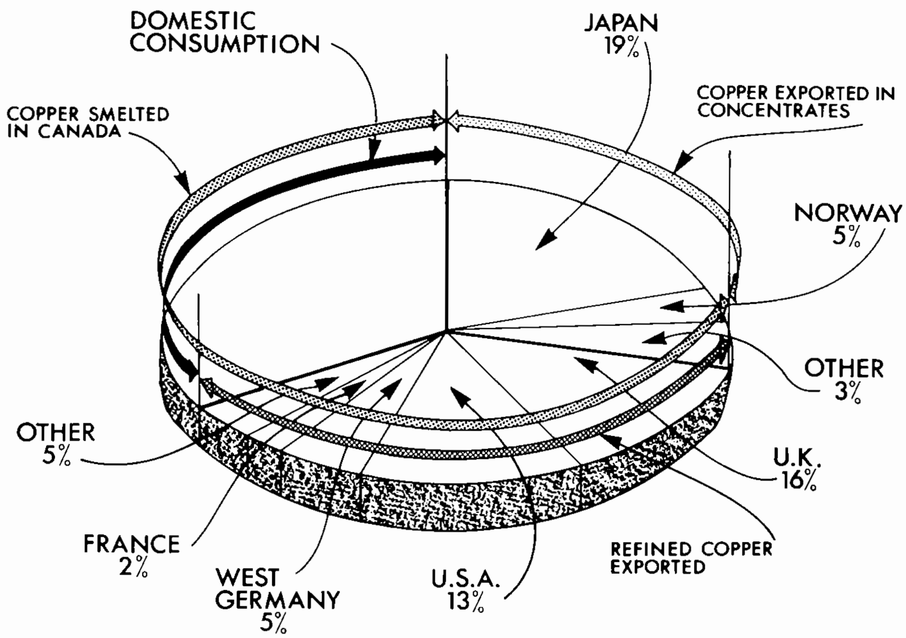
Company and Location	Mill Capacity** and Ore Grade (%)	Year Production Expected	Destination of Copper Concentrates	Remarks
ONTARIO				
Falconbridge Nickel Mines Limited,				
Falconbridge				
Lockerby mine	–	1975	Own smelter	Ore will be shipped to Falconbridge mill.
Thayer Lindsley mine	–	1973	Own smelter	" " " " " "
	Cu (. .)			
	Ni (. .)			
The International Nickel Company of				
Canada, Limited,				
Copper Cliff				
Coleman mine	–	1971	Own smelter	4,000 tons a day to company's mill.
Copper Cliff South	–	1971	Own smelter	6,000 " " " "
Levack West mine	–	1975	Own smelter	2,500 " " " "
Little Stobie mine	–	1971	Own smelter	8,000 " " " "
	Cu (. .)			
	Ni (. .)			
The International Nickel Company of	3,000	1972	Own smelter	
Canada, Limited,	Cu (. .)			
Shebandowan	Ni (. .)			
Mattabi Mines Limited,	3,000	1972	Noranda	Company owned 60 per cent by Mattagami
Sturgeon Lake	Cu (0.91)			Lake Mines and 40 per cent by Abitibi Paper Co.
	Pb (0.85)			
	Zn (7.60)			
Noranda Mines Limited,	700	1972	Noranda	Joint agreement with The International Nickel
Longmuir mine,	Cu (. .)			Company of Canada, Limited has been initiated.
Timmins	Zn (1.87)			
Selco Exploration Company Limited,	500	1971	Noranda	
South Bay mine,	Cu (2.24)			
Uchi Lake	Zn (14.11)			
Texmont Mines Limited,	500	1971	. .	
Timmins	Cu (. .)			
	Ni (1.00)			
MANITOBA				
Falconbridge Nickel Mines Limited,	1,000	1971	Falconbridge	
Manibridge mine,	Cu (0.27)			
[illegible]				

Company and Location	Mill Capacity** and Ore Grade (%)	Year Production Expected	Destination of Copper Concentrates	Remarks
Hudson Bay Mining and Smelting Co., Limited, Flin Flon				
Ghost Lake mine	. . Cu (1.42) Zn (11.60)	1972	Own smelter	240 tons a day to Flin Flon mill. Using trackless methods.
White Lake mine	. . Cu (2.22) Zn (6.20)	1972	Own smelter	275 tons a day to Flin Flon mill.
Sherritt Gordon Mines, Limited, Ruttan Lake	10,000 Cu (1.47) Zn (1.61)	1973	Noranda	Open-pit mining at first, followed by underground mining later.
BRITISH COLUMBIA				
Gibralter Mines Ltd., McLeese Lake, Cariboo District	30,000 Cu (0.39) MoS_2 (0.016)	1972	Japan	
Lornex Mining Corporation Ltd., Highland Valley	38,000 Cu (0.44) MoS_2 (0.014)	1972	Japan	Operations managed by Rio Algom Mines Limited.
Newmont Mining Corporation of Canada Limited, Ingerbelle and Similkenameen deposits, Princeton	15,000 Cu (0.53)	1972	Japan	
Noranda Mines Limited, Bell copper deposit, Babine Lake	10,000 Cu (0.53)	1972	Noranda or Gaspé	Refined copper from here sold under long term contract in West German interests.
Placid Oil Company, Bull River deposit, Cranbrook	750 Cu (2.40)	1971	. .	
Utah Construction & Mining Co., Island Copper mine, Coal Harbour, V.I.	33,000 Cu (0.52) MoS_2 (0.029)	1971	Japan	
YUKON TERRITORY				
Hudson-Yukon Mining Co., Limited, Wellgreen mine, Kluane Lake	600 Cu (1.42) Ni (2.04)	1972	Japan	

* Only mines with announced production plans. **Mill capacity in tons of ore a day.
– Nil; . . Not available.

DISPOSITION OF CANADIAN MINE PRODUCTION OF COPPER, 1970

MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES



DATA SOURCE: DOMINION BUREAU OF STATISTICS

Gulf Sulphur Company, 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 shipped on a custom basis, and from scrap. Inco sells copper produced from its nickel-copper mines at Sudbury, Ontario, and Thompson, Manitoba. Texas Gulf produces copper concentrates at its Ecstall mine at Timmins, Ontario; these are smelted and refined by Noranda on a toll basis. Noranda also toll refines blister copper from the Hudson Bay smelter at Flin Flon, Manitoba.

CONSUMPTION

Eight fabricating and semi-fabricating 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. Some reserve capacity exists in this segment of the industry which enables the companies to expand output quickly when markets develop. Fluctuating world prices since 1964 have periodically created circumstances when the reserve capacity has been used. The utilization of the reserve capacity has led to increased demand for refined copper by the fabricators. The difficulty of obtaining extra copper at North American prices when higher export prices were obtainable, has led to government regulations to control the amount of copper available to the domestic industry. Regulations that were adopted during 1970 are outlined in the following section.

FEDERAL GOVERNMENT ACTION

Periodically since 1964, the Canadian government has exerted increasing influence on the marketing of copper in Canada to assure an adequate supply of refined copper for domestic fabricators in the face of strong world demand for copper in all forms.

On January 1, 1970, the government announced that, on the basis of a survey made of the expected

TABLE 5

Copper Exploration Projects

Company and Location	Indicated Ore Tonnage (tons)	Grade of Ore (%)	Remarks
NEWFOUNDLAND			
Big Nama Creek Mines Limited, York Harbour	240,000	Cu (2.40) Zn (7.00)	Underground exploration continuing.
British Newfoundland Exploration Limited, Little Deer Pond deposit, Springdale	. .	Cu (. .)	Being explored underground from the Whalesback mine.
QUEBEC			
New Quebec Raglan Mines Limited, Wakeham Bay	16,050,000	Cu (0.71) Ni (2.58)	Feasibility study under way.
Sullipeck Mines Inc., Pekan Brook, Gaspé Peninsula	. .	Cu (1.00)	
ONTARIO			
The International Nickel Company of Canada, Limited, Copper Cliff		Cu (. .) Ni (. .)	
Cryderman mine	. .		
Victoria mine	. .		
Whistle mine	. .		
New Brunswick Uranium Metals & Mining Limited, Sturgeon Lake	. .	Cu (. .) Zn (. .)	Currently being explored by Falconbridge Nickel Mines Limited.
MANITOBA			
Hudson Bay Mining and Smelting Co., Limited, Flin Flon			
Centennial mine	1,400,000	Cu (2.06) Zn (2.60)	
Rail Lake mine	325,000	Cu (3.00)	
Reed Lake mine	787,000	Cu (2.00)	
Wim mine	1,000,000	Cu (3.00)	
Stall Lake Mines Limited, Snow Lake	672,000	Cu (5.38) Zn (2.28)	
BRITISH COLUMBIA			
Alwin Mining Company Ltd., Highland Valley	1,250,000	Cu (2.33)	Financial agreement signed with Furukawa Mining Co. of Japan. Considering production at 500 tons a day.
Davis-Keays Mining Co. Ltd., Fort Nelson	1,500,000	Cu (3.56)	Feasibility study completed. Considering production at 1,000 tons a day.
Giant Mascot Mines Limited, Giant Copper (Canam) Mine, Hope	2,600,000	Cu (1.28)	
Highmont Mining Corp. Ltd., Highland Valley	150,000,000	Cu (0.285) MoS_2 (0.051)	Considering production in 1972 at 25,000 tons a day.
Liard Copper Mines Ltd., Telegraph Creek	282,000,000	Cu (0.42) MoS_2 (0.036)	

TABLE 5 (Cont'd)

Company and Location	Indicated Ore Tonnage (tons)	Grade of Ore (%)	Remarks
Stikine Copper Limited, Galore Creek	100,000,000	Cu (1.00)	
Valley Copper Mines Limited, Highland Valley	(600,000 tons a vertical ft)	Cu (0.46) MoS_2 (. .)	Negotiations for sales contract with Japanese continuing.

. . Not available.

requirements of copper by the domestic fabricators for 1970, the producers of refined copper in Canada would have to make 26,500 tons of copper a month available to the fabricators. This was an increase of 3,000 tons a month over the quantity required in 1969. One of the leading producers raised its domestic price from 57 cents a pound to 66 cents, a price roughly equal to the then current, theoretical "blended" or average price being paid by fabricators in the United States.

At this point, the Prices and Incomes Commission took an interest in copper pricing and, to control inflation, asked the producers to roll their prices back to 57 cents until March 1. At the same time, the supply requirements were re-set at 23,500 tons a month. On March 1, the Prices and Incomes Commission granted the producers a 2-cent-a-pound increase in the price of copper. In addition, the Minister of Industry, Trade and Commerce reimposed quotas on the export of copper scrap, and specified that all mines east of the Rocky Mountains, including those exporting copper concentrates, contribute to the domestic supply of refined copper.

The London Metal Exchange (LME) price for copper continued to rise during March, but midway through April expanded world production coupled with softening demand caused the LME price to ease, a trend that continued to the end of the year. On August 31, the Canadian government removed all controls on the export of copper, and freed the eastern concentrate exporters from any obligation to supply refined copper domestically.

PROVINCIAL GOVERNMENT LEGISLATION

Early in 1970, the British Columbia Legislative Assembly passed the Mineral Processing Act with the view to encouraging the construction of a copper smelter in that province. The Act gave the Minister of Mines and Petroleum Resources the power to order any producing mine within the province to deliver a maximum of 50 per cent of the minerals produced by that mining operation to a processing plant, smelter, or refinery in the province designated by the Minister. Regulations under the Act specifically state that the Minister may order a mine to ship 12½ per cent of its production to a copper smelter located in British Columbia, when such a smelter exists.

WORLD SUPPLY AND DEMAND

MINE PRODUCTION

The world mine production of copper for 1969 and 1970 is shown in Table 9.

Production in Chile did not expand as expected due, in some measure, to a series of minor work stoppages and also to uncertainty in the political sphere pertaining to nationalization of the industry. Zambian production was affected by a major ground subsidence at the Mufulira mine that caused a serious curtailment of output from that source.

There was no action by the major producers to reduce output late in the year to keep the supply of copper in line with demand. There were probably two reasons why this did not happen. Firstly, there was the inability of the CIPEC (Intergovernmental Council of Copper Exporting Countries) nations (Chile, Zambia, Congo and Peru) to agree on how production should be controlled. Secondly, there was undoubtedly reluctance on the part of the North American producers to initiate production cuts that might not be emulated by the CIPEC producers. These two examples illustrate the complexity of the problems facing the world copper industry and the difficulty of maintaining a balance in world supply and demand.

The world copper industry is entering a period of expansion that could see mine production of copper increase by 37 per cent between 1970 and 1975. Much of this new production will come from Chile, Peru, Zambia, Congo, Canada, Bougainville, West Irian, Spain, Mauritania, Australia and Turkey. Other large deposits are being explored in Iran and USSR. Whether or not this expansion will lead to surplus production depends on the ability of Chile and Peru to secure the capital needed to finance their plans, the possibility of prolonged strikes in the United States' copper industry in mid-1971, the level of business activity during the next five years, and the ability of the producers to control the output of the metal.

TABLE 6

Canadian Copper and Copper-Nickel Smelters, 1970

Operator and Location	Product	Rated Annual Capacity (short tons)	Remarks	Ore and Concentrate Treated (short tons)	Blister or Anode Copper Produced (short tons)
Falconbridge Nickel Mines Limited, Falconbridge, Ont.	Copper-nickel matte	650,000 (ores and concentrates)	Copper-nickel ore and sintered concentrate smelted in blast furnaces; converted to produce matte for shipment to company's electrolytic refinery in Norway.	..	..
Gaspé Copper Mines, Limited, Murdochville, Que.	Copper anodes metallic bismuth	370,000 (ores and concentrates)	One reverberatory furnace for green or wet-charge concentrates, 2 Pierce-Smith converters, 1 anode furnace, 1 Walker casting wheel. Also smelts custom concentrates.	369,300 (of which 141,500 were custom concentrates)	69,890
Hudson Bay Mining and Smelting Co., Limited, Flin Flon, Man.	Blister-copper cakes	575,000 (ores and concentrates)	Roasting furnaces, 1 reverberatory furnace, 3 converters, for treating copper flotation concentrates and zinc-plant residues in conjunction with slag-fuming furnaces. Treats some concentrates on toll.	381,300 (of which 33,400 were custom concentrates)	42,816
The International Nickel Company of Canada, Limited, Coniston, Ont.	Copper-nickel Bessemer matte	800,000 (ores and concentrates)	Sintering; blast-furnace smelting of nickel-copper ore and concentrate; converters for production of copper-nickel Bessemer matte	..	..
Copper Cliff, Ont.	Blister copper, nickel sulphide and nickel sinter for company's refineries; nickel oxide sinter for market	4,000,000 (ores and concentrates)	Oxygen flash-smelting of copper sulphide concentrate; converters for production of blister copper. Blast furnaces, 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 to blister copper.	..	..

TABLE 6 (Cont'd)

Operator and Location	Product	Rated Annual Capacity (short tons)	Remarks	Ore and Concentrate Treated (short tons)	Blister or Anode Copper Produced (short tons)
Noranda Mines Limited, Noranda, Que.	Copper anodes	1,700,000 (ores and concentrates and scrap)	Roasting furnaces, 2 hot-charge reverberatory furnaces, 1 green-charge reverberatory furnace, 5 converters. Also smelts custom material.	1,545,800 (of which 776,800 were custom material)	210,900

Source: Company reports.
. . Not available.

TABLE 7

Copper Refineries in Canada, 1970

Refinery	Products
Canadian Copper Refiners Limited, Montreal East, Quebec (subsidiary of Noranda Mines Limited)	Rated annual capacity: 350,000 tons. Output 349,000 tons. Refines anode copper 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. CCR 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.	Rated annual capacity: 198,000 tons. Refining of blister copper from Copper Cliff smelter. Also custom refining. Precious metals, selenium and tellurium are recovered from anode slimes. ORC brand electrolytic copper, cathodes, wire bars, cakes, billets, ingots and ingot bars.

Source: Company reports.

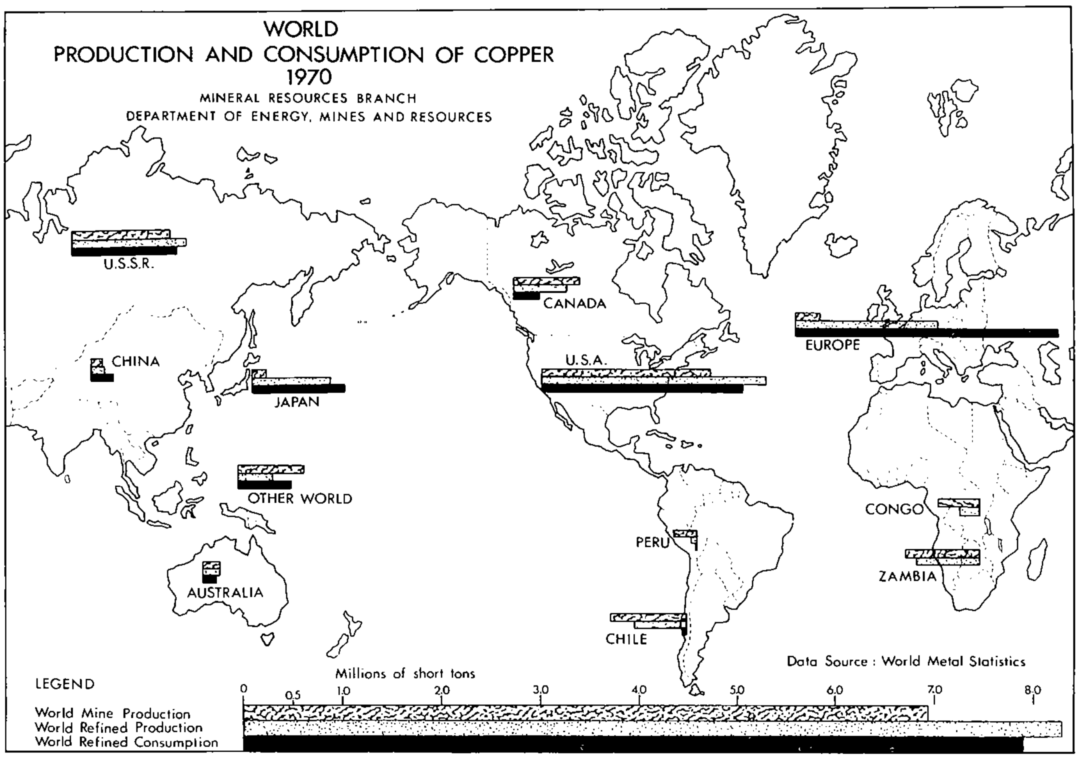


TABLE 8

Canada, Consumption of Primary Copper in Manufacture of Semi-Fabricated Products, 1967-69
(short tons)

	1968	1969	1970
Copper mill products, sheet, strip, bars, rolls, pipe, tube, etc.	78,217	63,100	66,833
Brass mill products – plate, sheet, strip, rods, bars, rolls, pipe, tubes, etc.	30,874	45,497	28,483
Wire and rod mill products	93,812	92,863	97,806
Miscellaneous	1,372	1,420	1,745
Total	204,275	202,880	194,867

Source: Statistics, Canada.
[r]Revised.

TABLE 9

World Mine Production of Copper, 1969-70
(000 short tons)

	1969	1970
United States	1,544.5	1,705.8
USSR	964.5[e]	992.1[e]
Chile	758.5	755.7
Zambia	793.1	754.1
Canada	573.2	676.0
Congo (Kinshasa)	401.2	425.5
Peru	219.4	226.0
Philippines	144.8	171.3
Australia	144.5	160.5
Republic of South Africa	140.1	151.2
Japan	132.6	131.6
China	121.3[e]	121.3[e]
Yugoslavia	99.9	108.0
Mexico	73.0	78.0
Poland	53.2	55.1
Other communist countries	91.5[e]	97.0[e]
Other non-communist countries	311.1	312.2
Total	6,566.4	6,921.4

Source: World Metal Statistics, June 1971.
[e]Estimated.

METAL PRODUCTION

The world production of refined copper for 1969 and 1970 is shown in Table 10.

The United States supplied most of the news in 1970 insofar as smelting and refining is concerned.

TABLE 10

World Production of Refined Copper, 1969-70
(000 short tons)

	1969	1970
United States	2,242.0	2,274.4
USSR	1,124.3[e]	1,150.8[e]
Japan	693.6	777.5
Zambia	664.9	640.1
Canada	449.2	543.1
Chile	499.2	508.5
Germany (Federal Republic)	443.2	447.3
Belgium	316.0	372.1
Britain	218.5	227.3
Congo (Kinshasa)	200.9	209.7
Australia	152.8	158.0
China	132.3[e]	132.3[e]
Yugoslavia	90.4	98.4
Spain	83.8	91.3
Republic of South Africa	67.5	75.6
Poland	60.3	61.7
Mexico	62.8	60.3
Sweden	57.1	56.4
Other communist countries	115.6[e]	116.8[e]
Other non-communist countries	242.7	250.9
Total	7,917.1	8,252.5

Source: World Metal Statistics, June 1971.
[e]Estimated.

Early in the year, production at two United States smelters was curtailed because of mechanical difficulties to equipment that had been overworked to keep up with the heavy demand for copper in the previous year. Later, some of the western States passed laws limiting the amount of sulphur gases that can be emitted. Some smelters found it necessary to curtail production to meet the laws and surplus concentrates were therefore exported for treatment.

The problem of pollution is being attacked at present in two practical ways in the United States. To meet the immediate requirements of the new laws, smelters are attempting to install equipment to remove sulphur from the furnace gases. For the longer term, they are developing hydrometallurgical methods of separating copper from its ores or concentrates in which sulphur is precipitated in the elemental form.

By installing equipment to remove sulphur from gases produced by their present plants, the Americans are running a risk of installing equipment that is not designed to do what is expected of it, and thus may end up with inefficient and expensive plants. Companies not rushing in to pollution abatement equipment at this time stand to profit from the research in hydrometallurgy being carried out. It seems reasonable to assume that hydrometallurgical plants will be the saviour of the copper industry in densely populated areas, but large scale commercial adaptation of such plants is four or five years away at the earliest.

CONSUMPTION

The consumption of refined copper in the world for 1969 and 1970 is shown in Table 11.

The growth in the use of copper in most countries in 1970 was quite modest. However, in the United States, a strike at General Motors in mid-September removed a major consumer from a weakening market. The resulting easier supply situation in North America led to lower fabricators' stocks, higher producers' stocks, and two price cuts. The demand for copper slackened at about the same time in Japan, but European demand was normal late in the year.

TABLE 11

World Consumption of Refined Copper, 1969-70
(000 short tons)

	1969	1970
United States	2,142.3	2,030.5
USSR	1,025.1[e]	1,058.2[e]
Japan	889.4	916.9
Germany (Federal Republic)	722.8	768.9
Britain	602.7	602.4
France	369.1	364.5
Italy	262.3	302.0
Canada	244.4	252.4
China	198.4[e]	220.5[e]
Australia	109.3	122.2
Belgium	123.7	120.7
Germany (Democratic Republic)	99.2	99.2
Sweden	97.2	90.9
Spain	106.0	86.6
Yugoslavia	82.7	86.2
Other communist countries	187.4[e]	198.4[e]
Other non-communist countries	523.5	550.3
Total	7,785.4	7,870.8

Source: World Metal Statistics, June 1971.
[e]Estimated.

TRADE

To point up the interdependency of nations or groups of nations on the production and marketing of copper, Table 12 and the map "World Copper Balance, 1970" have been prepared.

An analysis of this table shows that USSR is self-sufficient in copper, but the communist bloc as a whole must still rely on imports. Virtually all of these net imports can be attributed to China which for the past few years has been purchasing its needs on the London Metal Exchange. China is currently contracting for part of this to come from Chile. The United States is still a net importer of copper but there is a good chance that the large American companies, that will lose their mines in Chile due to nationalization, will invest in new properties at home. This could bring the United States closer to self-sufficiency. Europe and Japan will continue to be large net importers of copper in both concentrates and refined metal. Presently-planned expansion in the CIPEC nations, Canada, and other non-communist countries will have to vie for European and Japanese markets. It should be pointed out that the USSR could become an exporter of copper to the western world and this copper would also have to compete with that coming from underdeveloped nations for the two large markets.

TABLE 12

World Copper Production and Consumption, 1970
(000 short tons)

	Mine Production	Refined Production	Consumption
United States	1,705.8	2,274.4	2,030.5
USSR	992.1[e]	1,150.8[e]	1,058.2[e]
Japan	131.6	777.5	916.9
CIPEC	2,161.3	1,397.9	27.0
Europe	232.7	1,438.6	2,649.3
Canada	676.0	543.1	252.4
Other communist countries	273.4[e]	310.8[e]	518.1[e]
Other non-communist countries	748.5	359.4	418.4
Total	6,921.4	8,252.5	7,870.8

Source: World Metal Statistics, June 1971.
[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 transmissions, 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 non-corrosive 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.

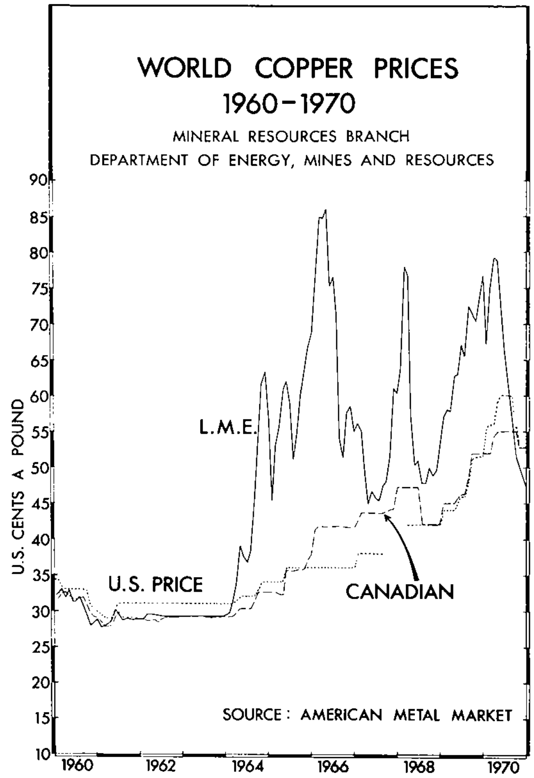
The principal copper and brass fabricators in Canada are: in British Columbia – Norco Industries Ltd. (formerly Noranda Metal Industries Ltd.), Vancouver; in Ontario – Anaconda American Brass Limited, Toronto; Phillips Cables Limited, Brockville; Ratcliffs (Canada) Limited, Richmond Hills; Wolverine Tube Division of Calumet & Hecla (Canadian) Limited, London; in Quebec – The Noranda Copper Mills Limited, Montreal East; Pirelli Canada Ltd. (Pirelli Cables Limited), St. John's; and Northern Electric Company, Limited, Montreal.

PRICES

The London Metal Exchange (LME) copper price was equivalent to 76.1 cents U.S. a pound at the start of 1970. It declined steadily to 71.4 cents late in January and then rose to a high of 81.4 cents in March, primarily on the news of trouble with a Chilean smelter and strikes by transportation workers in Zambia and Chile. The LME price then fell rather sharply to end the year at the 47 to 48 cent level.

The United States producers price, which closed in 1969 at 52 cents a pound, rose on January 2 to 56 cents, and on April 7 to 60 cents. This latter price held until October 22, when it returned to 56 cents, and was reduced again on December 2 to 53 cents.

The Canadian producers attempted to increase their domestic price for copper from 57 cents (Canadian) a pound to 66 cents on January 2, but were persuaded by the government to rescind the increase as part of the fight on inflation. A 2-cent rise to 59 cents was allowed, however, on March 1. On October 22, this price was lowered to 57.3 cents in line with the decrease in the United States price, and again on December 2 to the split level of 53.75 to 54.00 cents.



OUTLOOK

The short-term outlook for the Canadian industry is somewhat clouded by the possibility of strikes in the United States mines and smelters in mid-1971. If the strike does not occur, some form of production curtailment in the non-communist world will probably be necessary. If the strike does occur and lasts for two months or more, the overproduction possible in 1971 will have been taken care of. Effective Canadian mine production capability in 1971 should total about 775,000 tons.

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¢

TARIFFS (Cont'd)

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 January 31, 1972)	free	free	10%
34845-1	Electrolytic copper wire bars – per lb (expires January 31, 1972)	free	free	1½¢
35800-1	Anodes of copper	free	free	10%

UNITED STATES

602.30	Copper ores and concentrates	
	On and after Jan. 1, 1970	1.1¢ per lb on Cu cont.
	" " " Jan. 1, 1971	1¢ " " "
	" " " Jan. 1, 1972	0.8¢ " " "
	(under suspension to June 30, 1972)	
612.06	Unwrought copper	
	On and after Jan. 1, 1970	1.1¢ per lb on Cu cont.
	" " " Jan. 1, 1971	1¢ " " "
	" " " Jan. 1, 1972	0.8¢ " " "
	(under suspension to June 30, 1972)	
612.10	Copper waste and scrap	
	On and after Jan. 1, 1970	1.1¢ per lb on 99.6% of Cu cont.
	" " " Jan. 1, 1971	1¢ " " " "
	" " " Jan. 1, 1972	0.8¢ " " " "
	(under suspension to June 30, 1972)	

View of Highland Valley with Bethlehem Copper in foreground and Lornex in background. (Photo by Hunter)

Fluorspar

P.R. COTE*

Fluorspar is an essential industrial mineral and is utilized in a broad spectrum of industrial applications, the more important being: 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 there has been a rapid growth in world fluorspar consumption because of increasing demands in the steel, aluminum and chemical industries. In 1969 world consumption reached an estimated 3.8 million long tons and, based on forecast increased demands by the major consuming industries, consumption is forecast to reach some 6.2 million tons by 1975. 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, the latter process using approximately 3-5 pounds per ton of steel produced, the former approximately 8-10 pounds per ton of steel. Increasing world consumption of aluminum coupled with ever widening usage of fluorocarbons and other fluorine chemicals will greatly stimulate world demand for acid-grade material.

PRODUCTION AND DEVELOPMENTS IN CANADA

Increasing demand, coupled with a somewhat stagnant world reserve growth picture and higher prices for all grades of fluorspar may provide, in the near future, sufficient impetus for the development of new fluorspar deposits in Canada. During the year considerable interest was shown by various companies in reassessing known fluorspar occurrences.

The mineral fluorite (CaF_2), also commonly referred to as fluorspar, is the principal source of the element fluorine. Fluorite 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 area in Newfoundland by one company.

During 1970, Newfoundland Fluorspar Limited, a wholly owned subsidiary of the Aluminum Company of Canada, Limited (Alcan) was merged into its parent company and fluorspar operations are now carried out by the Newfoundland Fluorspar Works of Aluminum Company of Canada, Limited. This company produces fluorspar from two mines, the Director and the Tarefare both located near the village of St. Lawrence in Newfoundland. The Director mine has been in operation for approximately 26 years. In August 1968, the Tarefare was brought into production and is scheduled to produce some 25,000 tons a year of fluorspar concentrate, all of which will be shipped, together with virtually all the production from the Director mine, to Alcan's aluminum smelter at Arvida. The concentrate is upgraded and then converted to artificial cryolite, an essential requirement for the reduction of alumina to aluminum. Small tonnages are sold to Newfoundland Steel (1968) Company Limited for steel slagging. A third mine in the same area may be developed by the mid-1970's. The deposits on the

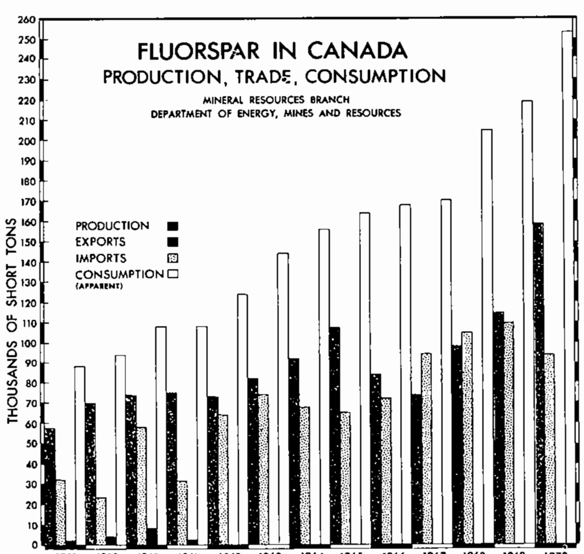
*Mineral Resources Branch.

TABLE 1

Canada, Fluorspar, Production, Trade and Consumption

	1969		1970p	
	Short Tons	$	Short Tons	$
Production (shipments)				
Newfoundland	..	3,036,931	..	4,185,000
Imports				
Mexico	85,135	2,624,000	63,314	2,669,000
United States	16,010	676,000	13,637	804,000
Britain	3,237	156,000	17,731	692,000
Total	104,382	3,456,000	94,682	4,165,000
	1968		1969	
Consumption[1] (available data)				
Metallurgical flux[2]	35,027		39,571	
Glass and glass wool	1,257		2,762	
Enamels and frits	254		310	
Others[3]	142,363		158,184	
Total	178,901		200,827	

Source: Dominion Bureau of Statistics.
[1]As reported by consumers. Breakdown by Mineral Resources Branch. [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.



Burin Peninsula constitute a major domestic fluorsp reserve.

In 1970, shipments totalled 158,000 tons valued $4.2 million. This represents a substantial increase value over $3.0 million recorded in 1969.

Allied Chemical Canada, Ltd. imports acid-gra fluorspar for the production of hydrofluoric acid the company's plant located at Valleyfield, Quebec. portion of the acid is utilized in the manufacture various fluorine chemicals. Allied Chemical operat mines in Mexico and the United States in order ensure an uninterrupted supply of fluorspar. T company intends to establish a hydrofluoric acid pla at Amherstburg, Ontario. Completion date for tl facility is scheduled for mid-1971.

Huntingdon Fluorspar Mines Limited with a pla at North Brook, Ontario, imports metallurgical-gra fluorspar to make 5-pound briquettes for foundry u

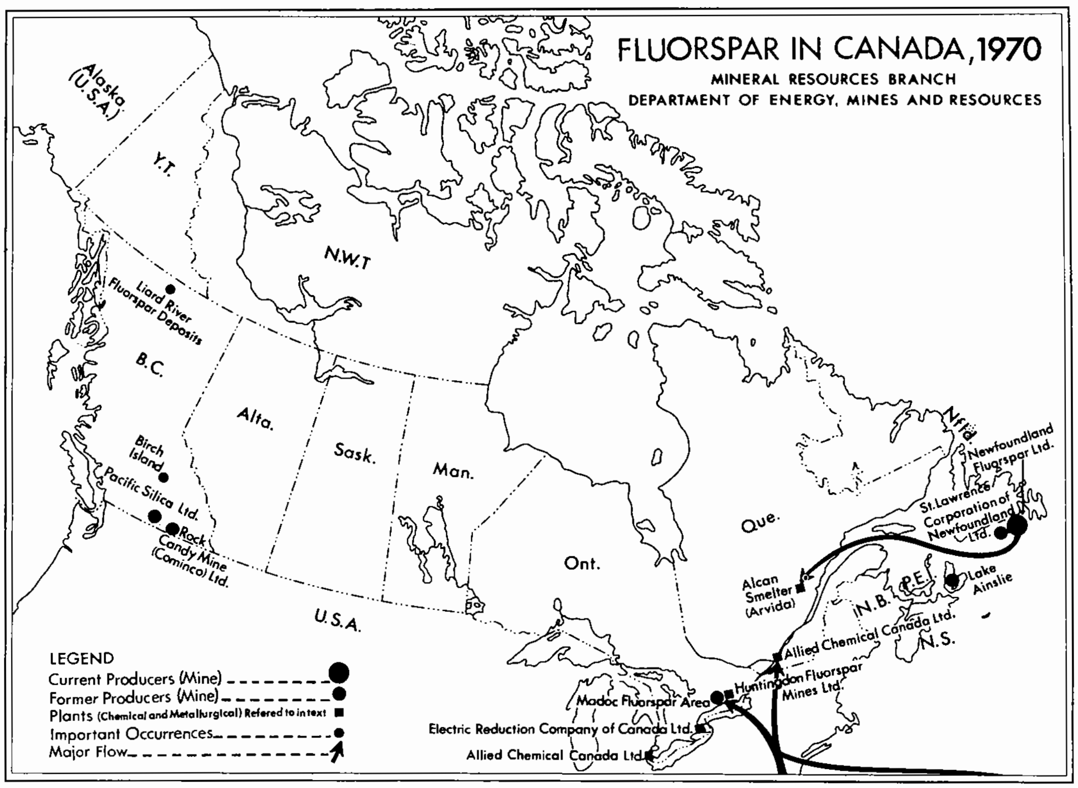
Some fluorine is being recovered as fluosilicic ac from the processing of phosphate rock by Elect Reduction Company of Canada, Ltd., at Po Maitland, Ontario and by Cominco Ltd., at Tra British Columbia.

International Mogul Mines Limited continued assessment of barite-fluorite deposits east of Lake Ainslie, Cape Breton Island, Nova Scotia. Recent drilling has indicated 2,027,300 tons of ore grading 40.30 per cent barite and 17.61 per cent fluorite. Approximately 1 million tons of marginal ore has been outlined and pilot-plant tests have been initiated to determine the most economically attractive milling process. During 1970 pilot-plant testing continued and difficulties were experienced in producing concentrates which would meet market specification at acceptable recovery rates. However, the company reports that testing toward years end has indicated that these problems can be overcome and completion of the feasibility studies is expected in 1971. From 1940 to 1949, approximately 1,400 tons of fluorspar, along with some barite was recovered from this deposit.

OTHER DOMESTIC SOURCES

Fluorite is known to occur as fracture fillings within pink granites and rhyolite porphyry in the St. Lawrence area of the Burin Peninsula, Newfoundland. Altogether some forty veins have been outlined in this area and the granite complex forming the peninsula must be considered as a prime exploration target for additional discoveries. Several mining companies have shown interest in this area and in the near future it is anticipated that an accelerated exploration program in the Burin Peninsula region will take place.

Prior to World War I, small tonnages of fluorspar were mined from vein-type deposits in the Madoc district of Ontario. Fluorite, a strategic material of great importance, showed a marked increase in production during the war years. After World War I 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 problems, lack of export markets, and increased mining cost made mining uneconomic. Altogether, some 150,000 tons of fluorspar were mined in the Madoc area; production being derived from twenty-four separate properties. The majority of significant producing properties were along a prominent linear vein structure, the southern



extension of which could still contain economically attractive reserves.

Fluorite occurs in several areas in British Columbia. The Rock Candy mine, near Grand Forks, was mined intermittently from 1918 to 1942 and is still controlled by Cominco Ltd. Substantial reserves probably remain but Cominco recovers all the fluorine it requires from the processing of phosphate rock for fertilizer manufacture. Consolidated Rexspar Minerals & Chemicals Limited has a large medium-grade fluorite deposit adjacent to Canadian National Railways line at Birch Island, about 60 miles north of Kamloops. The fluorite is fine-grained and difficult to concentrate, but higher prices and the greater use of pelletized metallurgical-grade fluorspar may result in production at some future time. In 1970 a drilling program in this deposit was undertaken to supplement earlier drill core results. Metallurgical testing was carried out through the year and according to the company considerable progress was made in recovery and grade of product. Denison Mines Limited is conducting these investigations under terms of an agreement with Consolidated Rexspar.

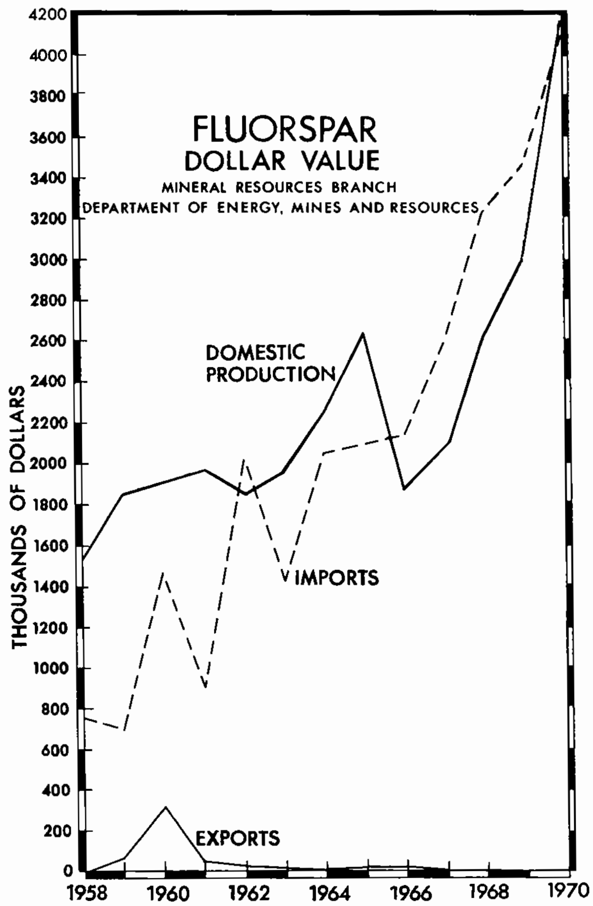
Shallow flat-lying deposits along the Liard River in northern British Columbia apparently contain large quantities of fluorite, barite and witherite, but without higher prices and a much improved means of transportation the deposits are uneconomic.

Although not located in Canada, a Canadian Company, Lost River Mining Corporation Limited, a subsidiary of PCE Explorations Limited is now working on an extensive potential fluorspar deposit in Alaska. To date, some 26.5 million tons of ore grading 14.5 per cent CaF_2 have been indicated in one ore zone and an additional 6 million tons grading 31.0 per cent CaF_2 in another. In addition to fluorite, the ore contains tin and tungsten. A continuing program including additional drilling and metallurgical testing is planned for 1971.

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.

Fluorite is marketed in three grades according to end use; although in times of shortage, high-grade material may be substituted for use in applications normally requiring lower grade materials. These three grades are: acid grade containing a minimum of 97 per cent CaF_2; metallurgical grade containing 60-80 per cent CaF_2; and ceramic grade containing 88-97 per cent CaF_2.



ACID GRADE

A high percentage 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 in order to achieve the high CaF_2 content required. Approximately one half of the world's fluorspar output is acid-grade quality. In general 1.5-2 tons of ore must be mined to produce 1 ton of acid-grade fluorspar concentrate and the production of one ton of hydrofluoric acid requires 2 tons of acid-grade concentrate and almost 3 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 fluorocarbons industries.

Some 40 per cent 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 1 ton of primary aluminum. This is equivalent to approximately 130-140 pounds of acid-grade fluorspar concentrate. Allowing for increased cell efficiencies and fluorite recoveries from pot lines the above figure should be reduced to 125 pounds per ton of primary aluminum. Because fluorite is an essential raw material, many primary aluminum producers operate or participate in the operation of fluorspar mines in order to ensure uninterrupted and adequate supplies.

The other major use of hydrofluoric acid, accounting for some 35 per cent of consumption, is for the manufacture of fluorocarbons. Fluorocarbons, used in the manufacture of solvents, resins, plastics, films, refrigerants, aerosol propellants, are produced by reacting hydrofluoric acid with carbon tetrachloride or 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. One and two-third tons of fluorspar are required for each ton of uranium processed into uranium hexafluoride.

METALLURGICAL GRADE

Approximately 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 due to a combination of increased steel output and changing technology. The latter parameter has been most significant as steelmaker's have shifted increasingly from the basic open-hearth process to the basic oxygen process for steelmaking. The latter process consumes from 10-15 pounds of metallurgical grade fluorspar compared to 3-5 pounds in the open-hearth process. The electric furnace process consumes from 8-10 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. It is anticipated that within the next decade older basic open-hearth furnaces will be replaced by the more efficient new basic oxygen or electric furnaces. Faced with possible shortages of metallurgical grade fluorspar, the steel industry will attempt to find methods to reduce consumption of fluorspar. In addition, in some instances major consumers have become involved in exploration for fluorspar reserves. As yet no effective substitute for fluorspar, as a fluxing agent in steelmaking, has been found and indications are that the production of lump metallurgical grade material will, rather than increase, level out in the short term. Consequently, steelmakers may have to switch to higher-grade, higher-cost material, produced as flotation concentrates in pellet or briquette form. World consumption in the steel industry is forecast to increase from a current level of 1.7 million metric tons to 2.2 million metric tons in 1975. The following table demonstrates the increase in demand for metallurgical-grade fluorspar in steelmaking by selected countries. Metallurgical-grade fluorspar is also used as a flux in foundries and in the reduction of dolomite to magnesium.

TABLE 2

Canada, Fluorspar, Production, Trade and Consumption, 1961-70
(short tons)

	Production	Exports	Imports	Consumption
1961	78,600[2]	2,048	32,769	111,542
1962	77,700[2]	4	67,847	123,694
1963	85,000[2]	4	66,798	142,840
1964	96,000[2]	. .	69,986	155,828
1965	112,000[2]	. .	69,848	167,537
1966	79,000[1]	12	75,324	166,275
1967	72,752[1r]	. .	94,244	155,349
1968	105,000[1]	. .	115,465	178,901
1969	110,000[1]	. .	104,382	200,827
1970[p]	158,000	. .	94,682	. .

Source: Dominion Bureau of Statistics, except where otherwise indicated.
[1]Estimates reported by U.S. Bureau of Mines.
[2]Shipments reported in annual reports of Aluminum Limited.
[p]Preliminary; . . Not available. [r]Revised.

TABLE 3

Consumption of Fluorspar for Steelmaking 1970 and 1975* by Selected Countries
(1,000 metric tons)

Country	1970	1975	Increase
Canada	35.5	41.5	17%
U.S.A.	451.5	513.5	14%
Japan	430.7	570.5	32%
Australia	19.9	26.1	30%
Britain	95.3	138.2	45%
West Germany	176.2	214.9	22%
France	66.5	86.3	30%

Source: Industrial Minerals June 1970.

CERAMIC GRADE

Ceramic-grade fluorspar is used as an opacifer in enamels and opal glass. It is also used to a limited

Gold

J. J. HOGAN*

Gold production in Canada declined in 1970 for the tenth successive year and the decline is expected to continue in 1971.

Production in 1970 is estimated at 2,357,620 troy ounces** valued at $86,218,120, based on the average Royal Canadian Mint price for the year. In comparison, 1969 production was 2,545,109 ounces worth $95,925,158. The record Canadian gold production was attained in 1941 when 5,345,179 ounces valued at $205,789,392 were produced. The highest production since World War II was attained in 1960 when 4,628,911 ounces, worth $157,151,527 were produced.

The 1970 decrease in production, a drop of about 7.4 per cent from 1969, is mainly attributable to the closure of auriferous-quartz (lode) gold mines and to a production decline at most of the operating gold mines. In 1970 lode gold mines produced 1,848,601 ounces compared with 2,030,680 ounces in 1969. Three lode gold mines closed in 1970 and one mine came into production.

Ontario continued as the leading gold-producing province in 1970 with 48.5 per cent of the national total. Quebec was in second place with 29.0 per cent followed by the Northwest Territories with 13.6 per cent and British Columbia with 4.2 per cent.

World production in 1969 was estimated at 46.53 million ounces by the U.S. Bureau of Mines. In 1968 world production was 46.21 million ounces. About 67.2 per cent of the 1969 total, or 31.28 million ounces, was produced by the Republic of South Africa. The USSR produced an estimated 6.25 million ounces in 1969.

Canada has long been one of the world's leading producers of gold. Since production was first officially recorded in 1858, Canada has produced about 191.4 million ounces worth $6,234 million to the end of 1970. Although most provinces have been contributors to the total, Ontario, Quebec, British Columbia, the Yukon Territory and the Northwest Territories, in that order, are the leaders.

Since 1948, a large segment of the gold mining industry has received financial assistance from the Government of Canada under the provisions of the Emergency Gold Mining Assistance Act. An Amending Bill, which received first reading in the House of Commons on October 19, 1970 and which received Royal Assent on February 11, 1971, extended the operation of the Act for two and one half years to June 30, 1973 without change in level of assistance. Lode gold mines which were not in production on August 7, 1970 will not be eligible for assistance in the future. The operators of the lode gold mines are required, after December 31, 1970, to hire all employees at the mine through facilities administered by the Department of Manpower and Immigration. Operators are also required to give notice of the closure of a mine at least four months before the mine ceases production, except in cases where a mine ceases production prior to July 1, 1971; and to retain, immediately after the sending of the notice, the service of the Department of Manpower and Immigration to assist in finding employment for the released employees.

In 1970 a total of 31 lode gold mines were eligible for assistance. One gold mine was not eligible and sold its production on the free market.

A minor amount of gold was recovered in 1970 from placer operations, mainly in the Yukon Territory.

*Mineral Resources Branch.

**When used in this review, the term "ounce" refers to the "troy ounce".

TABLE 1

Canada, Production of Gold, 1969-70
(troy ounces)

	1969	1970p
NEWFOUNDLAND		
Base-metal mines	8,982	7,300
NOVA SCOTIA		
Auriferous quartz	13	–
NEW BRUNSWICK		
Base-metal mines	1,396	4,920
QUEBEC		
Auriferous quartz mines		
Bourlamaque-Louvicourt	188,645	184,623
Malartic	221,576	178,822
Chibougamau	22,977	–
Noranda	61,373	52,700
Total	494,571	416,145
Base-metal mines	266,799	268,655
Total Quebec	761,370	684,800
ONTARIO		
Auriferous quartz mines		
Kirkland Lake	82,187	81,809
Larder Lake	153,660	136,920
Porcupine	510,797	502,320
Red Lake and Patricia	335,497	312,827
Sudbury	28,320	10,050
Thunder Bay	44,197	29,050
Sault Ste. Marie	2,240	–
Total	1,156,898	1,072,976
Base-metal mines	72,768	70,944
Total Ontario	1,229,666	1,143,920
MANITOBA-SASKATCHEWAN		
Base-metal mines	67,573	77,450
ALBERTA		
Placer operations	133	70
BRITISH COLUMBIA		
Auriferous quartz mines	46,896	40,000
Base-metal mines	70,585	58,900
Placer operations	311	300
Total British Columbia	117,792	99,200
YUKON		
Auriferous quartz mines	3,905	–
Base-metal mines	17,496	15,400
Placer operations	8,281	5,000
Total Yukon	29,682	20,400

TABLE 1 (Cont'd)

	1969	1970p
NORTHWEST TERRITORIES		
Auriferous quartz mines	328,397	319,480
Base-metal mines	105	80
Total Northwest Territories	328,502	319,560
CANADA		
Auriferous quartz mines	2,030,680	1,848,601
Base-metal mines	505,704	503,649
Placer operations	8,725	5,370
Total	2,545,109	2,357,620
Total value	$95,925,158	$86,218,120
Average value per oz	$37.69	$36.57

Sources: Dominion Bureau of Statistics, basic data; breakdown by types of operations by Statistics Section, Mineral Resources Branch.
pPreliminary; – Nil.

OPERATIONS AT PRODUCING MINES

ATLANTIC PROVINCES

Gold production in Newfoundland, Nova Scotia and New Brunswick totalled 12,220 ounces in 1970 compared with 10,391 ounces in 1969. Production is derived mainly from base-metal mining in Newfoundland and New Brunswick. American Smelting and Refining Company (Buchans Unit) in Newfoundland, and Heath Steele Mines Limited in New Brunswick were the main producers. A very minor amount of gold is recovered occasionally from the auriferous-quartz deposits in Nova Scotia.

QUEBEC

Gold production in Quebec in 1970 amounted to 684,800 ounces, a decrease of 10.1 per cent compared with 1969. Nine lode gold mines operated in 1970.

One gold mine exhausted its ore reserves and suspended operations and one began production. Production decreased from lode gold mines and showed a slight increase from byproduct base-metal mines. The base-metal mines accounted for about 39.2 per cent of the provincial gold total as against 35 per cent in 1969. The principal producers of byproduct gold are the base-metal mines of the Chibougamau and Noranda districts.

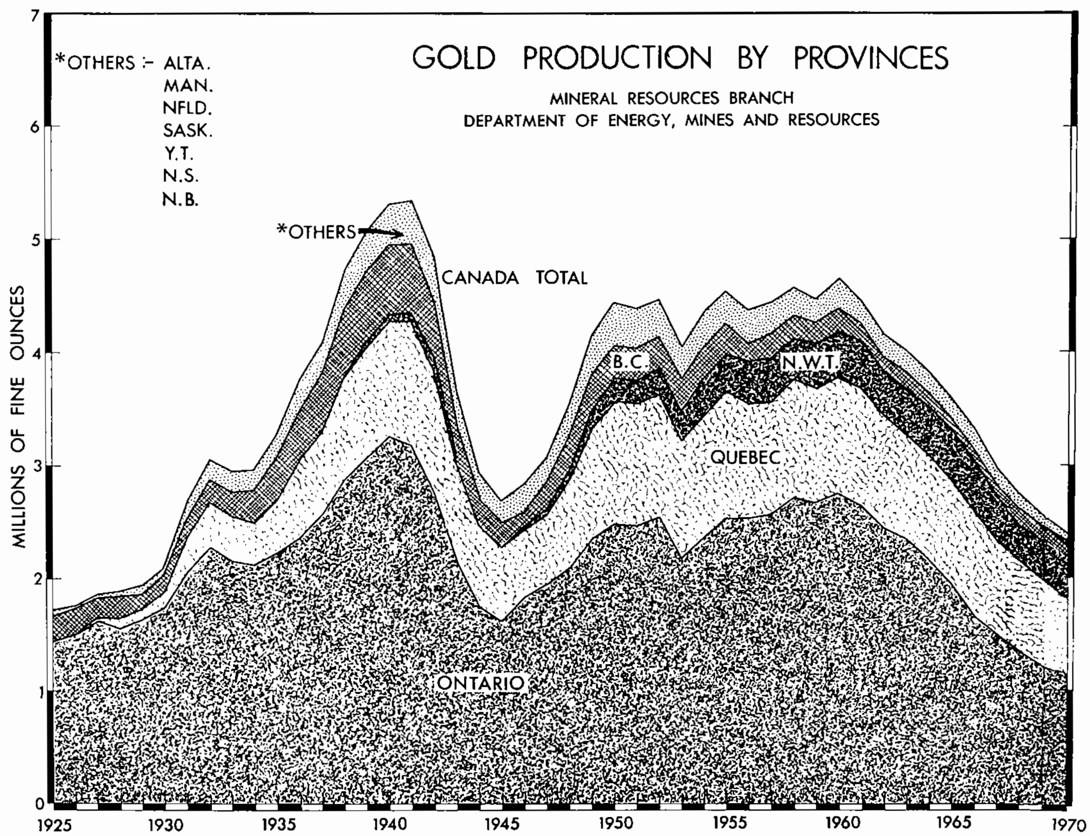
Auriferous-Quartz Mines

Bourlamaque-Louvicourt District. Two lode gold mines operated in the district in 1970. Production at Lamaque Mining Company Limited, the largest lode gold producer in the province decreased about 4.8 per cent in 1970 compared with 1969. Production at Sigma Mines (Quebec) Limited increased by approximately 4.8 per cent.

Malartic District. Four lode gold mines operated in the area in 1970. Production for the district decreased by 19.3 per cent in 1970 compared with 1969. Malartic Gold Fields (Quebec) Limited operated its custom mill in 1970 treating ore from Barnat Mines Ltd. and Marban Gold Mines Limited.

Barnat exhausted its ore reserves and closed at the end of March. Camflo Mines Limited had a small increase in production. The new 1,000-ton-a-day cyanide plant recorded its first full year of production. In 1971 the shaft will be deepened 450 feet to establish three new levels. Preliminary development work required to carry out this program was near completion at year-end. East Malartic Mines, Limited suffered a sharp decline in the ounces of gold produced. A strike of about thirty days duration was the main reason for lower production. Marban increased production in 1970 by a small amount. Ore reserves are near depletion and the mine is expected to suspend operations in 1971. At the end of 1970 Marban was the only mine shipping ore to the custom mill of Malartic Gold Fields.

Noranda District. Kerralda Mines Limited began shipping ore to the Quemont mill of Kerr Addison Mines Limited in June. The property adjoins Quemont Mines Limited and the ore is mined by Quemont through easterly extensions of its workings. A sharp reduction in the tons of ore treated by the combined operations of Wasamac Shaft Nos. 1 & 2 of Wright-Hargreaves Mines, Limited resulted in a decrease of about 15 per cent in the ounces of gold produced compared with 1969. On account of rising costs and low grade ore the property is scheduled for closure early in 1971.



ONTARIO

Seventeen lode gold mines operated in the province in 1970, the same number as in 1969. Two mines closed during the year. Gold produced from lode mines accounted for 93.8 per cent of the provinces' total gold output. Production declined by 7.3 per cent compared with 1969.

Auriferous-Quartz Mines

Kirkland Lake District. Two lode gold mines operated in this district in 1970. Production at Macassa Gold Mines Limited declined by about 8.8 per cent. The treatment of lower tonnage caused by a shortage of underground workers was responsible for the lower production. Through an agreement with Macassa which became effective the first of November 1970, Upper Canada Mines Limited took over the management control of Macassa. On December 31, 1970, Macassa was merged with Willroy Mines Limited. Production at Upper Canada increased in 1970.

Larder Lake District. Production at Kerr Addison Mines Limited declined by approximately 10.9 per cent.

Porcupine District. Six lode gold mines operated in the district in 1970. Production at Aunor Gold Mines Limited increased by a small margin compared with 1969. Dome Mines Limited, the largest lode gold producer in Canada in 1970, had a small increase in production. To combat increasing costs Aunor and Dome have introduced rubber tired load-haul-dump units for stope mucking. Production at Hallnor Mines, Limited, the Ross Mine of Hollinger Mines Limited, McIntyre Porcupine Mines Limited and Pamour Porcupine Mines, Limited decreased in 1970. For reasons of economy the operations of Pamour, Hallnor and Aunor, all controlled by Noranda Mines Limited, were integrated under one management.

Sudbury Mining Division. Renabie Mines Limited, the only lode gold producer in the area, depleted its ore reserve and closed in July 1970.

Thunder Bay Mining Division. The MacLeod Mosher Mine of Lake Shore Mines, Limited suspended mining operations at its property near Geraldton in July.

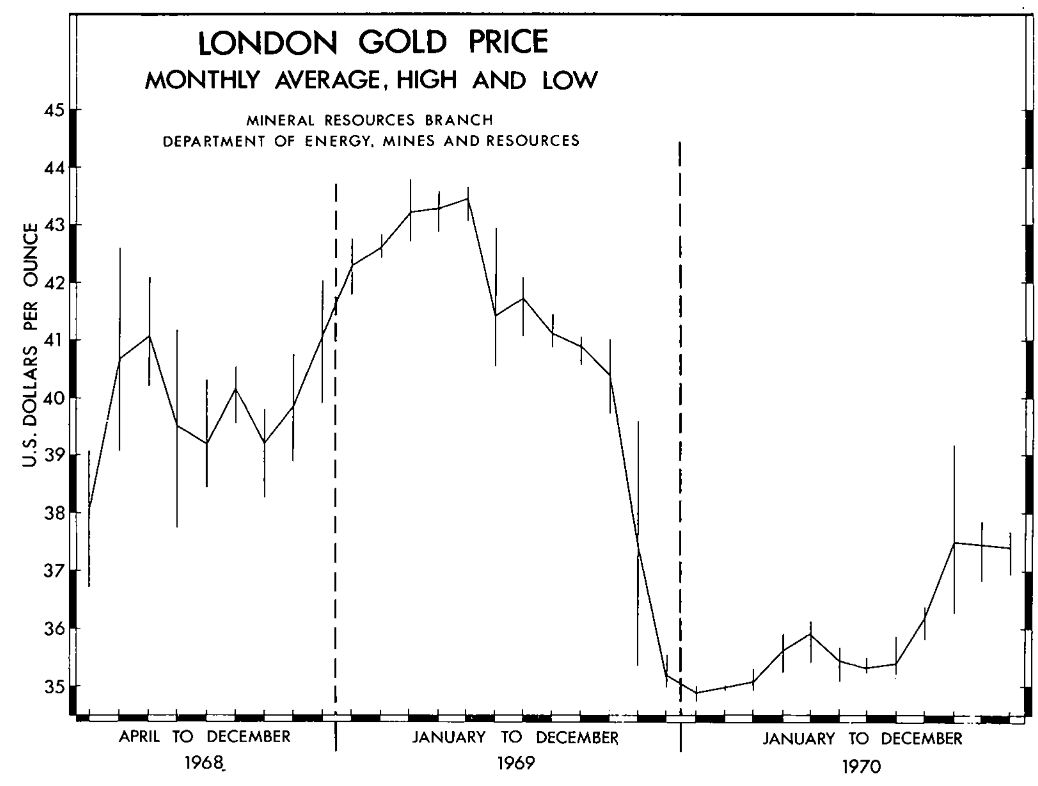
Red Lake Mining Division. Six lode gold mines operated in the district in 1970, the same number as in 1969. Production for the district declined by about 6.8 per cent compared with 1969. Ore from Annco Mines Limited and Wilmar Mines Limited is mined through the extensions of the underground workings of Cochenour Willans Gold Mines, Limited and is custom treated at the Cochenour mill. Production in 1970 at the Annco Mine was approximately the same as in 1969. Cochenour and Wilmar reported an increase in production. Production at Campbell Red Lake Mines Limited, the only lode gold mine in Canada in 1970 not receiving assistance under the provisions of the Emergency Gold Mining Assistance Act, increased by a small margin. Dickenson Mines Limited reported a decrease in production in 1970. Some gold was recovered by Dickenson from an underground development program on the adjoining property of Robin Red Lake Mines Limited. Production at Madsen Red Lake Gold Mines Limited in 1970 decreased substantially compared with 1969.

Base-Metal Mines

Byproduct gold was recovered from the nickel copper ores of the Sudbury area and the copper-zinc ores at Manitouwadge. McIntyre Porcupine Mines Limited at its property in Timmins and Upper Beaver Mines Limited, near Kirkland Lake, produced appreciable gold from copper-gold ores.

PRAIRIE PROVINCES

Virtually all gold produced in the Prairie Provinces is recovered as a byproduct from the mining of base-metal ores. Production in 1970 increased 14.5 per cent compared to 1969. Hudson Bay Mining and Smelting Co., Limited recovered byproduct gold from its operations in the Flin Flon and Snow Lake areas. Sherritt Gordon Mines, Limited recovered byproduct gold from its operations in the Lynn Lake district, Manitoba. The International Nickel Company of Canada, Limited produced some byproduct gold from nickel copper ores in the Thompson Lake area of



Manitoba. Anglo-Rouyn Mines Limited, near Lac La Ronge in Saskatchewan, recovered byproduct gold from its copper ore.

A small amount of gold is recovered by gravel-washing plants on the North Saskatchewan River near Edmonton, Alberta.

BRITISH COLUMBIA

Production in 1970 at Bralorne Can-Fer Resources Limited, the only remaining lode gold operation in British Columbia, decreased by about 14.7 per cent compared with 1969. Ore reserves are near depletion and the mine is expected to suspend operations in 1971.

A small amount of placer gold was produced chiefly in the Cariboo district.

Byproduct gold recovered from base-metal ores declined 16.6 per cent in 1970 and accounted for 59.4 per cent of the province's production compared with 59.9 per cent in 1969. The Phoenix Copper Division of The Grandby Mining Company Limited, Granisle Copper Limited, Western Mines Limited and Coast Copper Company, Limited were the four largest contributors to byproduct gold production in 1970 and all reported a decrease in production. Production at Wesfrob Mines Limited on Queen Charlotte Islands increased slightly.

YUKON TERRITORY

Gold production in the Yukon in 1970 decreased by 31.3 per cent compared with 1969. Lower gold production was recorded by the placer operations and by the base-metal mines. The silver-gold mine of Venus Mines Ltd., near Carcross, began operations in 1970. The base-metal mine of Anvil Mining Corporation Limited began production in 1970 and produced some gold.

Placer gold was produced by small operators in the Dawson, Mayo and Kluane Lake districts.

NORTHWEST TERRITORIES

Five gold mines, all located near the town of Yellowknife, operated in the Territories in 1970. Production declined by 2.7 per cent compared with 1969. The Con Mine of Cominco Ltd. completed sinking a new internal shaft to a depth of 750 feet below the 4,900-foot level. The Con Mine, Rycon Mines Limited and Giant Yellowknife Mines Limited suffered a decrease in gold production in 1970 compared with 1969. Lolor Mines Limited and Supercrest Mines Limited, both contiguous to and controlled by Giant increased gold production. The ore is mined through extensions of the underground workings of Giant and is custom treated at its mill.

TABLE 2

World Gold Production, 1968-69
(troy ounces)

	1968	1969[p]
NORTH AMERICA		
Canada	2,743,021	2,545,109
United States	1,478,292	1,733,176
Other countries	379,610	310,333
Total	4,600,923	4,588,618
SOUTH AMERICA		
Colombia	239,555	218,872
Brazil	176,628	176,938
Peru	105,118	127,722
Bolivia	68,266	51,000[e]
Chile	57,743	59,102
Other countries	43,148	34,753
Total	690,458	668,387
EUROPE		
U.S.S.R.[e]	5,900,000	6,250,000
Yugoslavia	70,314	76,068
France	55,000	48,000
Other countries	89,511	79,940
Total	6,114,825	6,454,008
ASIA		
Philippines	527,355	571,145
Japan	238,511	252,705
Korea	222,405	210,734
India	115,357	109,473
Other countries	85,284	88,657
Total	1,188,912	1,232,714
AFRICA		
Republic of South Africa	31,168,831	31,275,882
Ghana	727,122	706,621
Southern Rhodesia	499,943	480,000
Congo (Kinshasa)	169,975	175,804
Other countries	119,257	102,819
Total	32,685,128	32,741,126
OCEANIA		
Australia	787,358	716,089
Fiji	106,784	91,572
New Guinea	26,144	25,857
Other countries	8,626	10,717
Total	928,912	844,235
WORLD TOTAL	46,209,158	46,529,088

Sources: U.S. Bureau of Mines Minerals Yearbook Preprint 1969, and for Canada, Dominion Bureau of Statistics.
[p]Preliminary; [e]Estimated.

TABLE 3

Canada, Gold Production, 1961-1970

	Auriferous Quartz Mines		Placer Operations		Base-Metal Ores		Total	
	Troy Ounces	Per Cent	Troy Ounces	Per Cent	Troy Ounces	Per Cent	Troy Ounces	Per Cent
1961	3,774,522	84.4	69,240	1.5	629,937	14.1	4,473,699	100.0
1962	3,494,821	83.6	57,760	1.4	625,815	15.0	4,178,396	100.0
1963	3,324,907	83.1	57,905	1.4	620,315	15.5	4,003,127	100.0
1964	3,151,593	82.2	58,512	1.5	625,349	16.3	3,835,454	100.0
1965	2,958,874	82.1	44,598	1.2	602,559	16.7	3,606,031	100.0
1966	2,676,381	80.6	43,369	1.3	599,724	18.1	3,319,474	100.0
1967	2,426,137	81.2	9,411	0.3	550,720	18.5	2,986,268	100.0
1968	2,208,184	80.5	9,564	0.4	525,273	19.1	2,743,021	100.0
1969	2,030,680	79.8	8,725	0.3	505,704	19.9	2,545,109	100.0
1970p	1,848,601	78.4	5,370	0.2	503,649	21.4	2,357,620	100.0

Sources: Dominion Bureau of Statistics. Breakdown classification by Statistics Section, Mineral Resources Branch.
pPreliminary.

TABLE 4

Canada – Gold Production, Average Value per Ounce and Relationship to Total Value All Mineral Production, 1961-1970

	Total Production (troy ounces)	Total Value ($ Cdn.)	Average Value per Ounce ($ Cdn.)	Gold as a % of Total Value of Mineral Production
1961	4,473,699	158,637,366	35.46	6.1
1962	4,178,396	156,313,794	37.41	5.5
1963	4,003,127	151,118,045	37.75	5.0
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
1970p	2,357,620	86,218,120	36.57	1.5

Source: Dominion Bureau of Statistics.
pPreliminary.

NEW PROPERTY DEVELOPMENTS

QUEBEC

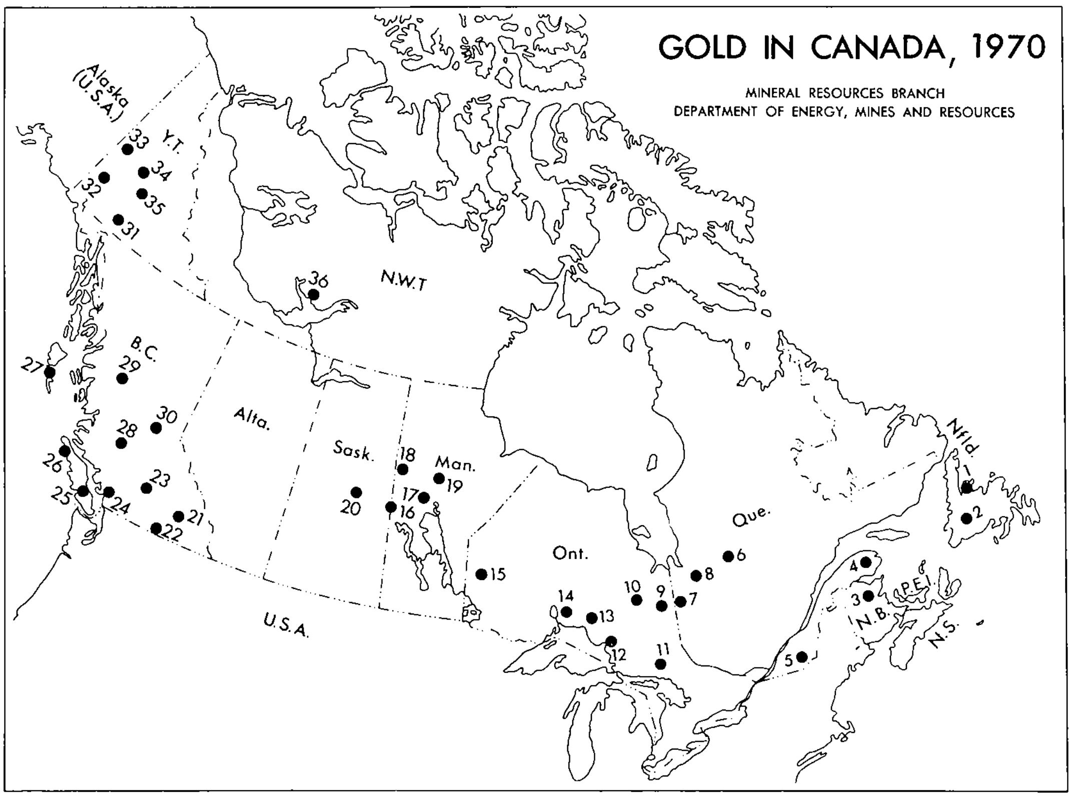
The gold property of Eagle Gold Mines Limited in Joutel Township, northwestern Quebec, is on a care and maintenance basis pending an improvement in the economic outlook for gold mining.

ONTARIO

The underground program of development by Robin Red Lake Mines Limited on its property in the Red Lake area continued in 1970. The work is being carried out by Dickenson Mines Limited through extension of the workings from its adjoining property. Dome Mines Limited and Noranda Mines Limited sold their interests in this property to Dickenson Mines. It is planned to bring the property into production in 1971.

NORTHWEST TERRITORIES

In the Yellowknife area, Cominco Ltd., under an agreement with Yellorex Mines Limited, continued an exploration program on the Yellorex property adjoining the Con Mine to the south. A drift has been advanced on the 2,300-foot level from the Con Mine into the Yellorex ground.



GOLD PRODUCERS, 1970

(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)
   Opemiska Copper Mines (Quebec) Limited (a)
   The Patino Mining Corporation (Copper Rand Mines Division) (a)
7. Noranda-Rouyn District
   Delbridge Mines Limited (a)
   Kerr Addison Mines Limited (Quemont) (a)
   Kerralda Mines Limited (b)
   Lake Dufault Mines Limited (a)
   Noranda Mines Limited (a)

Wright-Hargreaves Mines, Limited (Wasamac No. 1 and
No. 2 mines) (b)
Malartic District
Barnat Mines Ltd. (b)
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
Mattagami Lake Mines Limited (a)
Orchan Mines Limited (a)

ONTARIO
9. Larder-Lake District
Kerr Addison Mines Limited (b)
Kirkland Lake District
Macassa Gold Mines Limited (b)
Upper Beaver Mines Limited (a)
Upper Canada Mines, Limited (b)
10. Porcupine District
Aunor Gold Mines Limited (b)
Dome Mines Limited (b)
Hallnor Mines, Limited (b)
Hollinger Mines Limited (Ross) (b)
McIntyre Porcupine Mines Limited (a) (b)
Pamour Porcupine Mines, Limited (b)
11. Sudbury Mining Division
Falconbridge Nickel Mines Limited (a)
The International Nickel Company of Canada, Limited (a)
12. Renabie Mines Limited (b)
13. Thunder Bay Mining Division
Noranda Mines Limited (Geco Mine) (a)
14. Lake Shore Mines, Limited MacLeod Mosher Division (b)
15. Red Lake Mining Division
Annco Mines Limited (b)
Campbell Red Lake Mines Limited (b)
Cochenour Willans Gold Mines, Limited (b)
Dickenson Mines Limited (b)
Madsen Red Lake Gold Mines Limited (b)
Wilmar Mines Limited (b)

MANITOBA
16. Hudson Bay Mining and Smelting Co., Limited (a)
17. Hudson Bay Mining and Smelting Co., Limited (Snow Lake) (a)
18. Sherritt Gordon Mines, Limited (Fox Lake) (a)
19. The International Nickel Company of Canada, Limited (Thompson Mine) (a)

SASKATCHEWAN
16. Hudson Bay Mining and Smelting Co., Limited (a)
20. Anglo-Rouyn Mines Limited (a)

BRITISH COLUMBIA
21. Cominco Ltd. (a)
22. The Granby Mining Company Limited (Phoenix Copper Division) (a)
23. Bethlehem Copper Corporation Ltd. (a)
Brenda Mines Ltd. (a)
24. The Anaconda Company (Canada) Ltd., (Britannia Mine) (a)
Texada Mines Ltd. (a)
25. Western Mines Limited (a)
26. Coast Copper Company, Limited (a)
27. Wesfrob Mines Limited (a)
28. Bralorne Can-Fer Resources Limited (b)
29. Granisle Copper Limited (a)
30. Small placer operations (c)

YUKON TERRITORY
31. New Imperial Mines Ltd. (a)
Venus Mines Ltd. (d)
32. Small placer operations (c)
33. Small placer operations (c)
34. Small placer operations (c)
35. Anvil Mining Corporation Limited (a)

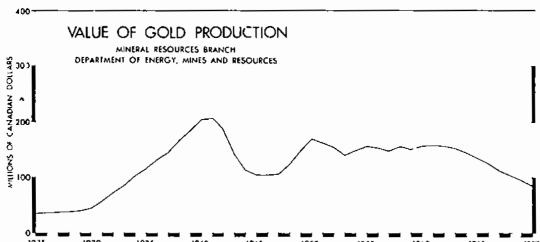
NORTHWEST TERRITORIES
36. Cominco Ltd. (Con and Rycon Mines) (b)
Giant Yellowknife Mines Limited (b)
Lolor Mines Limited (b)
Supercrest Mines Limited (b)

(a) Base-metal; (b) Auriferous quartz; (c) Placer; (d) Silver-gold

USES

Gold has been used traditionally as a monetary measure by governments and central banks in the settlement of international balances and it is still an important commodity for this purpose. In recent years the commercial demand for gold from industry and the arts has greatly increased. The International Monetary Fund estimated that gold consumed in the world for industrial and artistic purposes had increased from $745 million U.S. funds in 1966 to $930 million in 1969. Estimated consumption for the first quarter of 1970 was $235 million U.S.

Over 70 per cent of industrial gold is consumed by manufacturers of jewellery and objects of art. The electrical and electronic industry and dentistry are other major consumers of gold.



PRICES

The average price paid for gold by the Royal Canadian Mint in 1970 was $36.57 a fine ounce. This compares with $37.69 in 1969 and $37.71 in 1968. On account of the pressure on the Canadian dollar in the world money markets the Government of Canada on May 31, 1970 allowed the Canadian dollar to float in the international exchange markets. Since May, 1962, the value of the Canadian dollar had been fixed at $0.925 (US), with a permissible fluctuation of 1 per cent either way. The Mint gold price could range from $37.46 to $38.22 a fine ounce. During the period of the fixed value for the Canadian dollar the Mint buying price for gold fluctuated between a low of $37.54 and a high of $37.57 an ounce. After the unpegging of the Canadian dollar, the mint price varied from a high of $36.54 in June to a low of $35.38 at year-end.

In 1970 the price of gold on the London gold market varied from a low of $34.75 (US) a troy ounce in January to a high of $39.19 (US) in October.

Gypsum and Anhydrite

D. H. STONEHOUSE*

Gypsum is a hydrous calcium sulphate ($CaSO_4.2H_2O$) which, when calcined at temperatures ranging from 250°F 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 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.

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. Over 70 per cent of Canadian gypsum production is exported to the United States. The value of total construction in Canada in 1970 was estimated at $13.2 billion, about 30 per cent of which was credited to residential building construction. Despite high interest rates and serious work stoppages in the construction industry in 1970, dwelling starts were down only 9.3 per cent from the previous year at 190,528.

In 1970 crude gypsum production increased to 6,442,000 tons, exports remained relatively unchanged and imports decreased by over 52 per cent to 38,880 tons. Nearly all Nova Scotian production was exported to the United States while most of the output from other provinces was used regionally in Canada in the manufacture of gypsum products and portland cement.

Crude gypsum is crushed, pulverized and calcined to form stucco or plaster of paris 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 pre-determined lengths, dried, bundled and stacked for shipment. Production of gypsum wallboard, lath and sheathing decreased by 127,652,324 million square feet in 1970 and plaster production decreased by 50,930 tons.

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.

*Mineral Resources Branch.

TABLE 1

Canada – Gypsum – Production and Trade, 1969-70

	1969		1970P	
	Short Tons	$	Short Tons	$
Production (shipments)				
Crude gypsum				
Nova Scotia	4,754,642	10,691,940	4,856,000	10,800,000
Newfoundland	469,339	1,299,261	550,000	1,520,000
Ontario	622,058	1,597,938	553,000	1,371,000
British Columbia	280,894	764,032	265,000	730,000
Manitoba	165,258	506,976	149,000	418,000
New Brunswick	81,457	135,003	69,000	117,000
Total	6,373,648	14,995,150	6,442,000	14,956,000
Imports				
Crude gypsum				
Mexico	78,808	256,000	38,000	124,000
United States	2,959	34,000	868	19,000
Other countries	32	2,000	12	...
Total	81,799	292,000	38,880	143,000
Plaster of paris and wall plaster				
United States	8,579	589,000	8,367	549,000
Britain	278	12,000	431	19,000
Total	8,857	601,000	8,798	568,000
Gypsum lath, wallboard and basic products				
United States	3,412	201,000	25,093	740,000
Britain	73	7,000	34	3,000
Total	3,485	208,000	25,127	743,000
Total imports gypsum and gypsum products	94,141	1,101,000	72,805	1,454,000
Exports				
Crude gypsum				
United States	4,871,164	9,107,000	4,795,548	9,457,000
Bahamas	–	–	57,716	87,000
Britain	–	–	40	2,000
France	20	1,000	–	–
Total	4,871,184	9,108,000	4,853,304	9,546,000

Source: Dominion Bureau of Statistics.
PPreliminary; – Nil; . . . Less than $1,000.

CANADIAN INDUSTRY AND DEVELOPMENTS

ATLANTIC PROVINCES

During 1970 five companies produced 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, one gypsum wallboard manufacturing plant and one plant producing plaster of paris, together used an estimated 100,000 tons. Crude gypsum from Nova Scotia was 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, mined 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 was shipped to company-owned processing plants through the port of Hantsport, Nova Scotia.

National Gypsum (Canada) Ltd. produced gypsum from a quarry near Milford, Nova Scotia and exported 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 were used to haul gypsum from the quarry site to Dartmouth, a distance of 30 miles. Company-owned, self-unloading ore carriers of up to 30,000 tons capacity were loaded at rates up to 5,000 tons per hour through facilities on Bedford Basin. Shipments were 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 Division, mined gypsum from a quarry near River Denys, Inverness County, Nova Scotia. Crushed rock was transferred by rail to open storage at Point Tupper, 20 miles from the quarry, and loaded to chartered vessels through a conveyor and reclaim tunnel system. Shipments were exported mainly to the Georgia-Pacific plant at Wilmington, Delaware.

Little Narrows Gypsum Company Limited, another subsidiary of United States Gypsum Company, produced gypsum from a quarry at Little Narrows, Victoria County, Nova Scotia, for shipment to the United States, Quebec and Ontario through company ship-loading facilities near the plant site. This is a possible source of raw gypsum for a new wallboard plant begun during 1970 by Canadian Gypsum Company, Limited at St. Jerome, 27 miles northwest of Montreal, Quebec.

At Walton, Hants County, Nova Scotia, gypsum and anhydrite were produced for National Gypsum (Canada) Ltd. by B. A. Parsons under contract, shipments being made through the port of Walton to United States destinations.

Domtar Construction Materials Ltd. operated a calcining plant at Windsor, Nova Scotia, for the production of plaster of paris. Gypsum for the plant was 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 in Cape Breton Island.

Gypsum was 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 was 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 were 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 quarried gypsum during 1970. Canadian Gypsum Company, Limited, a subsidiary of United States Gypsum Company, produced gypsum for use in the manufacture of plaster and wallboard in the company-owned plant at Hillsborough. Canada Cement Lafarge Ltd. obtained 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 and on the Magdalen Islands in the Province of Quebec many gypsum outcrops occur.

ONTARIO

Two underground gypsum mines were operated in southwestern Ontario in 1970 to produce raw material for three gypsum products plants and a number of cement manufacturing plants. Domtar Construction Materials Ltd. mined gypsum at Caledonia, near Hamilton, from an 8-foot seam 75 feet below the surface. Crude gypsum was 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 was manufactured.

At Hagersville, southwest of Caledonia, Canadian Gypsum Company, Limited, a subsidiary of United States Gypsum Company, Chicago, produced crude gypsum by room and pillar mining methods from a 4-foot seam, reached through a 95-foot vertical shaft. Gypsum rock was shipped in crude form and was 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 of up 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 was produced from two underground mines and one surface operation in Manitoba and from one surface operation in British Columbia during 1970. Gypsum products plants, situated in areas exhibiting major development trends were supplied from Canadian producers of gypsum rock. Imports, mostly from Mexico, supplied a number of cement producers. BACM Industries Limited began construction of a gypsum products plant at Clover Bar, a suburb of Edmonton, Alberta, in 1969. The new facility went "on stream" in 1970.

Domtar Construction Materials Ltd. obtained crude gypsum from its quarry at Gypsumville, 150 miles northwest of Winnipeg, Manitoba. The company's gypsum products plants at Winnipeg and Calgary were supplied from this quarry.

Western Gypsum Limited mined gypsum from an underground deposit near Silver Plains, 30 miles south of Winnipeg, for use in its gypsum products plants at Winnipeg and Calgary. The deposit is 140 feet below the surface.

At Amaranth, Manitoba, BACM Industries Limited mined gypsum from a depth of 125 feet, through an inclined shaft, using room and pillar methods. Crude gypsum from this mine was used at the company's gypsum products plants at Saskatoon and Edmonton until mid-year, at which time the mine was permanently closed. Raw gypsum is now obtained from Western Gypsum Limited for these products plants.

Western Gypsum Mines Ltd., a subsidiary of Western Gypsum Limited operated an open-pit mine near Windermere in the southeastern part of British Columbia, supplying raw gypsum to its products plants at Calgary and Vancouver and to the Calgary and Vancouver plants of Domtar Construction Materials Ltd.

Gypsum occurs in Wood Buffalo National Park, in Jasper National Park, along the Peace River between 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.

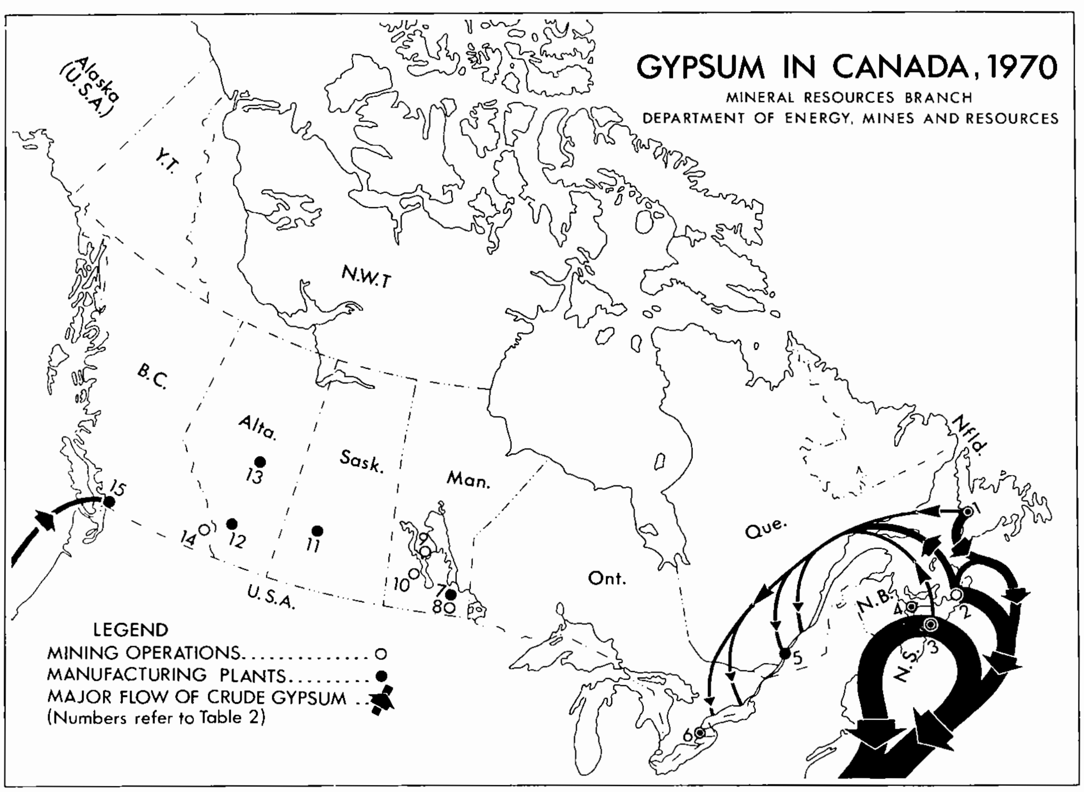


TABLE 2

Canada – Summary of Gypsum and Gypsum Products Operations, 1970
(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 manufactured.
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.
New Brunswick		
4. Canadian Gypsum Company, Limited	Hillsborough	Open-pit mining of gypsum. 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. Jerome	Gypsum products plant under construction.
Domtar Construction Materials Ltd.	Montreal	Gypsum products manufacture.
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.
Western Gypsum Limited	Clarkson	Gypsum products manufacture.
Manitoba		
7. Domtar Construction Materials Ltd.	Winnipeg	Gypsum products manufacture.
Western Gypsum Limited	Winnipeg	Gypsum products manufacture.
8. Western Gypsum Limited	Silver Plains	Underground mining of gypsum.
9. Domtar Construction Materials Ltd.	Gypsumville	Open-pit mining of gypsum.
10. BACM Industries Limited	Amaranth	Underground mining of gypsum.
Saskatchewan		
11. BACM Industries Limited	Saskatoon	Gypsum products manufacture.
Alberta		
12. Domtar Construction Materials Ltd.	Calgary	Gypsum products manufacture.
Western Gypsum Limited	Calgary	Gypsum products manufacture.
13. BACM Industries Limited	Edmonton	Gypsum products plant.
British Columbia		
14. Western Gypsum Mines Ltd.	Windermere	Open-pit mining of gypsum.
15. Western Gypsum Limited	Vancouver	Gypsum products manufacture.
Domtar Construction Materials Ltd.	Vancouver	Gypsum products manufacture.

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. World production was estimated at 55.4 million tons in 1970, over 50 per cent of which came from European countries. The major European producers in order of output were: France, Britain, USSR, Spain, Italy and West Germany.

The United States is the world's largest single producer and together with Canada brings North American production to 30 per cent of world output. Asian producers accounted for over 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 as companies explored the economics of producing wallboard and plaster from the waste gypsum that results during the manufacture of phosphoric acid from phosphate rock.

Production of sulphuric acid and co-product cement from gypsum and anhydrite has been practised in European countries for a number of years. A principal producer is Solway Chemicals Ltd., a subsidiary of Albright & Wilson Limited with a plant in England capable of producing 440,000 short tons of each product yearly.

A proposal to produce elemental sulphur from anhydrite in Cape Breton Island, Nova Scotia, was announced late in 1969, and a new company, Cape Anhydrite Process Company Limited, was incorporated as the operating company. No details of the proposed process were made available, but as sulphur supplies increased and prices deteriorated throughout 1970, plans for development were set aside.

Elcor Chemical Corporation, the only other known sulphur-from-gypsum facility, started up in April 1969 at Rock House, Texas, and produced bright yellow sulphur at a rate of 100 tpd. Because of design problems and construction delays the project was many months behind original schedules and in the fall of 1970 had produced only 403 long tons of sulphur on a 24-hour test run period, far short of the 1,000 tpd capacity anticipated.

TABLE 3

World Production of Gypsum 1969, 1970
(thousand short tons)

	1969	1970[e]
United States	9,905	9,900
Canada	6,374	6,442
France	5,622	5,600
Italy	3,638	3,600
Britain	5,291	5,300
Other Free World	16,208	16,300
Communist countries (except Yugoslavia)	7,763	7,800
World Total	54,801	54,942

Sources: U.S.B.M., Commodity Data Summaries, January, 1971, and for Canada, Dominion Bureau of Statistics.

[e]Estimated.

MARKETS, TRADE AND OUTLOOK

Gypsum and 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 in Canada. The long-established gypsum industry in Nova Scotia exists because efficient, large-volume, transportation facilities and favourable mining costs and conditions 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. On the basis of projected percentage increases in the gross national product of the United States, exports of gypsum from Nova Scotia are expected to reach 6.5 million tons by 1975 and 9.0 million tons by 1980. Cumulative United States domestic demand for crude gypsum from 1969 to 2000 has been estimated at 900 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 cement manufacture. Minor amounts of crude gypsum are shipped to the mid-United States for agricultural use.

Construction of homes, apartments, schools and offices will continue and the need for gypsum-based building products will rise steadily. Although new materials of construction 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

TABLE 4

Canada, Gypsum Production, Trade and Consumption, 1961-70

(short tons)

	Production[1]	Imports[2]	Exports[2]	Apparent Consumption[3]
1961	4,940,037	66,075	3,819,345	1,186,767
1962	5,332,809	69,947	4,162,997	1,239,759
1963	5,955,266	74,628	4,703,118	1,326,776
1964	6,360,685	80,940	5,057,253	1,384,372
1965	6,305,629	75,433	4,746,638	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[p]	6,442,000	38,880	4,853,304	1,627,576

Source: Dominion Bureau of Statistics.

[1] Producers' shipments, crude gypsum. [2] Includes crude and ground, but not calcined. [3] Production plus imports minus exports.

[p] Preliminary.

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. Canadian Standards Association standards A82.20 to A82.35 relate to gypsum and gypsum products.

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 1969 was 305,765 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.

TABLE 5

Canada, Production of Gypsum Products, 1969, 1970

Item		1969	1970
Wallboard	(square feet)	880,150,068	822,507,945
Lath	"	172,324,542	102,808,616
Sheathing	"	20,981,533	20,487,258
Plaster	(tons)	202,660	151,730

Source: Dominion Bureau of Statistics.

TARIFFS

CANADA Item No.		British Preferential	Most Favoured Nation	General
29200-1	Gypsum, crude	free	free	free
29300-1	Plaster of paris, or gypsum calcined, end prepared wall plaster, the weight of the package to be included in the weight for duty per 100 pounds	free	6¢	12½¢
29400-1	Gypsum, ground, not calcined	free	free	15%

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

TARIFFS (Cont'd)

UNITED STATES

Item No.			
512.21	Gypsum, crude	free	free
512.24	Gypsum, ground, calcined		
	on and after Jan. 1, 1970	83¢ per long ton	
	on and after Jan. 1, 1971	71¢ per long ton	
	on and after Jan. 1, 1972	59¢ per long ton	
245.70	Gypsum or plastic building boards and lath		
	on and after Jan. 1, 1970	8.5%	
	on and after Jan. 1, 1971	7%	
	on and after Jan. 1, 1972	6%	

Source: Tariff Schedules of the United States (Annotated) TC Publication 304.

Indium

D.B. FRASER *

Indium is produced as a byproduct of zinc and lead metallurgical operations carried out at Trail, British Columbia by Cominco Ltd. Output in 1970 was 900,000 troy ounces; in 1969, it was 323,000 troy ounces. The metal is recovered in very pure form from certain residues and slags in which indium becomes concentrated during the smelting of lead and zinc. Only a few of the world's smelters produce indium. Cominco Ltd. is one of the largest producers.

Statistics on the output and consumption of indium are not generally available. It is produced in a number of countries including Japan, United States, Peru, USSR, and West Germany as well as Canada. Indium occurs in minute quantities in certain ores of zinc, lead, iron and copper, and is associated in particular with sphalerite, the principal zinc mineral.

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 the following year, 437 ounces were produced by laboratory methods. After several years 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, or 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 grades (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 and a variety of fabricated forms such as disks, wire, ribbon, foil and sheet, powder, and spherical pellets.

PROPERTIES AND USES

Indium is a silvery-white, soft metal that resembles tin in its physical and chemical properties. Its chief characteristics are its extreme softness, its 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

*Mineral Resources Branch.

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. Indium is used also in low-melting-point alloys containing bismuth, lead, tin and cadmium, 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.

A newer use of indium, probably the most extensive now, is found 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 1934, indium and its compounds are relatively new materials whose potential applications are still being explored. Uses have been found in intermetallic semiconductors, electrical contacts, resistors, thermistors and photoconductors. Indium can be used as an indicator in atomic reactors since artificial radioactivity is easily induced in indium by neutrons of low energy. Indium compounds added to lubricants have been found to have a beneficial anticorrosive effect. Indium is used in certain very small lightweight batteries.

FOREIGN TRADE

Statistics on foreign trade are not generally available for indium. United States imports in 1969 totalled 283,275 troy ounces, obtained as follows: 165,095 ounces from Canada, 55,388 from Japan, 21,051 from Peru, 13,088 from the USSR, 12,908 from West Germany, 8,368 from Belgium, 6,861 from Britain, and 516 ounces from the Netherlands.

PRICES

Prices of indium as quoted in *Metals Week* remained unchanged during 1970 from those established September 19, 1968.

Prices were as follows:

	September 19, 1968 to Year-end 1970
Sticks, 30-90 troy oz	$2.50 a troy oz
Ingot, 100 troy oz	$2.05 a troy oz
10,000+ troy oz	$1.75 a troy oz

Iron Ore

P. LAFLEUR*

Canadian iron ore shipments totalled 47.5 million tons** valued at $589 million in 1970 surpassing the previous record of 42.4 million tons established in 1968 and well above the 35.8 million tons shipped in 1969. Domestic shipments at 8.8 million tons (difference between total shipments and total exports in Table 1; 9.4 million tons in Table 3) and exports at 38.7 million tons were each up sharply from 1968. During 1969 the Canadian iron ore industry was unable to produce and deliver as a result of widespread iron ore industry strikes; during 1970 it operated at near capacity. Shipments exceeded production by an estimated 1.5 million tons and stock at mines and ports, estimated to contain 10.3 million tons at the end of 1969, went down accordingly.

Increased demand from western Europe was mainly responsible for the new high in exports and record Canadian steel production accounted for the all-time high in domestic shipments. Crude steel production totalled 12.3 million net tons surpassing the previous high of 11.3 million net tons established in 1968. Domestic consumption of iron ore was 11.5 million tons (Table 3) of which an estimated 9.4 million tons were of domestic origin and the remainder imports; iron and steel plant stocks were up slightly by 0.1 million tons from 1969 to 4.1 million tons. The trend toward lower imports continued in 1970 as they declined slightly from 2.3 million tons in 1969 to 2.1 million tons (Table 1).

The Canadian iron ore industry, which began a period of slow growth in 1969, added only 0.07 million tons to production capacity in 1970 and a total of only 0.42 million tons is anticipated for 1971. Annual iron ore production capacity at the end of 1970 was 46.48 million tons, which included 24.83 million tons of pellet capacity.

Three major projects for Quebec-Labrador were announced in mid-1970: a 12.0-million-ton-a-year expansion of Iron Ore Company of Canada's Labrador City concentrator; a new 6.0-million-ton-a-year concentrator and pellet plant at Sept-Îles, Quebec, by the same company; and a 16-million-ton-a-year concentrator at Mt. Wright, Quebec, by Quebec Cartier Mining Company.

At least 20 companies were active in 1970 in the geological, metallurgical and economic evaluation of iron ore deposits and/or in the seeking of markets and financing.

World production of iron ore was an estimated 741 million tons in 1970, up 34 million tons from 1969. This parallels the rise in world steel production which was up an estimated 18 million net tons from 1969 to 653 million net tons. The startup of the Robe River project was the outstanding event in the world iron ore industry in 1970. World iron ore pellet capacity at the end of 1970 totalled an estimated 106.73 million tons including 52.55 million tons in the United States and 24.83 million tons in Canada. Total world trade was an estimated 303 million tons, up 21 million tons from 1969.

A general rise in international iron ore prices in 1970 and in early 1971 indicates that prices of world ores may be on an upward trend.

*Mineral Resources Branch.

**The long ton or gross ton (2,240 pounds) is used throughout unless otherwise stated.

TABLE 1

Canada, Iron Ore Production and Trade, 1969-70

	1969		1970p	
	Long Tons	$	Long Tons	$
Production (shipments)				
Newfoundland	13,139,477	194,971,157	22,219,018	296,734,000
Quebec	11,410,197	111,198,774	13,079,286	131,319,000
Ontario	9,389,987	128,166,423	10,492,946	144,279,000
British Columbia	1,823,084	19,739,264	1,717,500	16,794,000
Total	35,762,745	454,075,618	47,508,750	589,126,000
Byproduct iron ore*	968,000	..	876,000e	..
Imports				
United States	1,999,059	27,037,000	1,973,793	26,806,000
Brazil	174,615	1,533,000	143,754	1,301,000
Australia	–	–	8,000	120,000
West Germany	–	–	48	1,000
Chile	40,168	341,000	–	–
Mauritania	27,162	291,000	–	–
Venezuela	19,352	248,000	–	–
Total	2,260,356	29,450,000	2,125,595	28,228,000
Exports				
Iron ore, direct shipping				
United States	3,078,122	29,674,000	5,141,544	49,380,000
Britain	718,766	6,863,000	1,372,590	12,795,000
Italy	394,161	2,507,000	507,003	3,965,000
Netherlands	44,560	670,000	342,177	3,293,000
Belgium and Luxembourg	77,547	753,000	286,601	2,591,000
France	–	–	39,245	390,000
Japan	–	–	20,135	189,000
Total	4,313,156	40,467,000	7,709,295	72,603,000
Iron ore, concentrates				
United States	5,565,815	56,174,000	6,289,788	68,856,000
Japan	2,084,315	20,354,000	1,950,581	18,025,000
Britain	1,149,650	7,959,000	1,886,110	14,484,000
West Germany	742,014	5,228,000	1,630,949	12,448,000
Netherlands	1,090,660	7,297,000	1,418,268	11,136,000
Belgium and Luxembourg	–	–	125,684	948,000
Finland	90,629	648,000	84,646	622,000
France	–	–	78,274	574,000
Bahamas	4,999	48,000	6,001	63,000
Italy	65,549	459,000	–	–
Total	10,793,631	98,167,000	13,470,301	127,156,000

TABLE 1 (Cont'd)

	1969		1970p	
	Long Tons	$	Long Tons	$
Iron ore, agglomerated				
United States	8,917,644	135,466,000	12,339,154	193,427,000
Britain	991,097	15,045,000	1,659,374	26,441,000
Netherlands	1,013,658	15,247,000	1,347,731	21,260,000
Italy	581,786	8,417,000	1,095,144	17,530,000
West Germany	478,249	7,195,000	370,945	5,839,000
Japan	106,561	1,601,000	223,644	3,426,000
France	29,670	446,000	177,341	2,727,000
Belgium and Luxembourg	83,100	1,249,000	133,200	2,122,000
Spain	–	–	129,101	2,053,000
Total	12,201,765	184,666,000	17,475,634	274,825,000
Iron ore, not elsewhere specified				
United States	597,556	9,830,000	71,368	1,160,000
Japan	–	–	5	...
Total	597,556	9,830,000	71,373	1,160,000
Total export all classes				
United States	18,159,137	231,144,000	23,841,854	312,823,000
Britain	2,859,513	29,867,000	4,918,074	53,720,000
Netherlands	2,148,878	23,214,000	3,108,176	35,689,000
Japan	2,190,876	21,955,000	2,194,365	21,640,000
West Germany	1,220,263	12,423,000	2,001,894	18,287,000
Italy	1,041,496	11,383,000	1,602,147	21,495,000
Belgium and Luxembourg	160,647	2,002,000	545,485	5,661,000
France	29,670	446,000	294,860	3,691,000
Spain	–	–	129,101	2,053,000
Finland	90,629	648,000	84,646	622,000
Bahamas	4,999	48,000	6,001	63,000
Total	27,906,108	333,130,000	38,726,603	475,744,000

Source: Dominion Bureau of Statistics.
*Total shipments of byproduct iron ore compiled by Mineral Resources Branch from data supplied by companies. Total iron ore shipments include shipments of byproduct iron ore.
pPreliminary; .. Not available; – Nil; eEstimated; ... Less than $1,000.

In 1971, Canadian shipments are expected to decline by some 1.5 million tons to equal the expected production of 46.0 million tons, 0.5 million tons less than production capacity. It is reasonable to anticipate exports of about 36.3 million tons and domestic shipments of 9.7 million tons; imports will probably remain at about the 1970 level of 2.1 million tons.

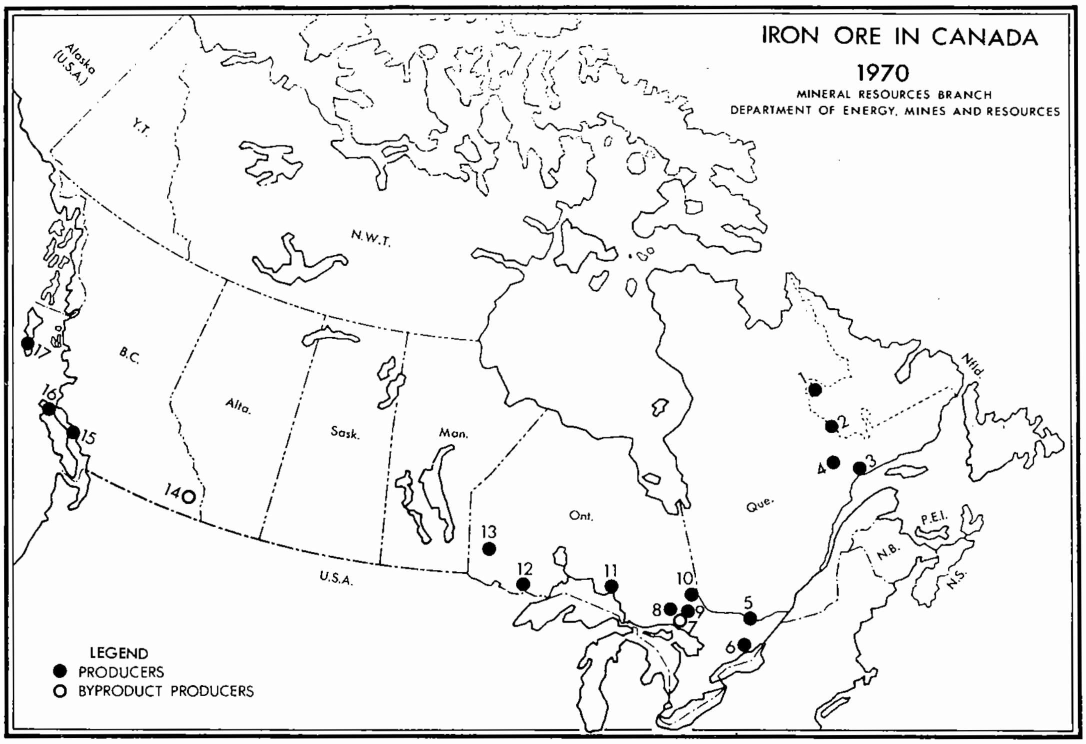
PRODUCTION, TRADE AND CONSUMPTION

PRODUCTION

A total of 18 companies with 19 operations produced an estimated 46.0 million tons iron ore and byproduct iron ore in 1970. Ten operations were in Ontario, four in British Columbia, two in Quebec, two in Newfoundland (Labrador) and one in Quebec-Labrador. Coast Copper Company, Limited closed its iron ore recovery plant at its copper mine on Vancouver Island, British Columbia, in mid-1970 because ore feed from its new orebody, which was too high in pyrrhotite, resulted in a magnetic concentrate high in deleterious sulphur.

Newfoundland and Ontario of the four producing provinces had record shipments of iron ore in 1970. The leading province was Newfoundland (Labrador) with 22.2 million tons, a 4.6 million-ton increase over the previous high in 1968, followed by Quebec with 13.1 million tons, Ontario with 10.5 million tons and British Columbia with 1.7 million tons.

In Quebec and Labrador, shipments from Iron Ore Company of Canada (IOC) totalled 20.1 million tons comprised of 10.5 million tons of pellets, 7.6 million tons of direct-shipping ore and 2.0 million tons of concentrate. Quebec Cartier Mining Company's production was above capacity and some 8.9 million tons were shipped. At Quebec Cartier's Lac Jeannine Mine a new electric tramway system to enable diesel-electric trucks to negotiate steeper-than-normal grades was put into operation. The method could well find application elsewhere in either the design of new open pits or in prolonging the life of deep-pit mines currently operating. Wabush Mines shipments, at an estimated 5.4 million tons, were some 0.6 million tons less than capacity and reflected extensive modifications to its pellet plant regrind mills



PRODUCERS

(numbers refer to numbers on map)

1. Iron Ore Company of Canada (Schefferville)
2. Iron Ore Company of Canada (Labrador City) Wabush Mines (Wabush Lake)
3. Wabush Mines, Pointe Noire (Pointe Noire)
4. Quebec Cartier Mining Company (Gagnon)
5. Hilton Mines (Shawville)
6. Marmoraton Mining Company, Division of Bethlehem Chile Iron Mines Company (Marmora)
8. National Steel Corporation of Canada, Limited (Capreol)
9. Sherman Mine (Temagami)
10. Adams Mine of Jones & Laughlin Mining Company, Ltd. (Kirkland Lake)
11. Algoma Ore Division of The Algoma Steel Corporation, Limited (Wawa)
12. Caland Ore Company Limited (Steep Rock Lake) Steep Rock Iron Mines Limited (Steep Rock Lake)
13. Griffith Mine, The (Bruce Lake)
15. Texada Mines Ltd. (Texada Is.)
16. Coast Copper Company, Limited (Benson Lake)
17. Wesfrob Mines Limited (Moresby Is.)

BYPRODUCT PRODUCERS

7. Falconbridge Nickel Mines Limited (Falconbridge)
   The International Nickel Company of Canada, Limited (Copper Cliff)
14. Cominco Ltd. (Trail)

from wet to dry. Capacity production is expected in 1971. Shipments from The Hilton Mines, at an estimated 1.0 million tons, exceeded production capacity by 0.1 million tons because of shipments from stockpile.

In Ontario, The Griffith Mine approached capacity production and shipments totalled an estimated 1.5 million tons. The Sherman Mine experienced gear difficulties with its three wet autogenous mills and, as a result of lower production, shipments were down from 1969 by 0.2 million tons to 0.9 million tons. Two pellet-line modifications were completed in late 1970 at The International Nickel Company of Canada, Limited's pellet plant, thus raising capacity from 0.9 million tons to 1.05 million tons, but effective capacity remains at 0.9 million tons until such time as magnetite feed becomes available. The company expects to produce 950,000 tons in 1971 and at maximum capacity by mid-1972 . Tune-up operations began in late 1970 at Falconbridge Nickel Mines Limited's new 300,000-ton-a-year reduced iron-nickel plant. The iron-nickel pellets, containing 92 per cent iron and 1.5 per cent nickel, will be used as feed in electric furnaces making alloy steels. Elemental sulphur will also be produced. Normal production capacity rate was attained at all other mines in Ontario. National Steel Corporation of Canada, Limited was testing a 500-cu-ft flotation cell, the largest ever made, that is to be used for the flotation of silica at IOC's pellet plant at Sept-Îles. The Adams Mine and the Sherman Mine have installed fine ore screening to improve the efficiency of silica flotation.

In British Columbia, Coast Copper Company, Limited closed its iron ore recovery plant at its copper mine on Vancouver Island because feed from its new orebody was too high in pyrrhotitic sulphur. Two mining operations remain in British Columbia–Texada Mines Ltd., an underground operation, and Wesfrob Mines Limited, an open-pit operation; both produce copper concentrate and magnetite concentrate. Wesfrob Mines, which began production in 1967, attained capacity production for the first time in 1970.

TRADE : EXPORTS

Exports of iron ore, at 38.7 million tons, surpassed the record of 36.0 million tons established in 1968 and was considerably more than the 28.0 million tons shipped in 1969. The weakness of exports in 1969 was because of the inability to produce and deliver brought on by labour strikes during the spring and summer when operations reach their highest rates. Lower demand from the United States was more than offset by record demand from Britain and all European Coal and Steel Community (ECSC) countries. Prospects for Canadian exports in the next decade appear excellent.

Of 38.7 million tons exported, the United States took 23.8 million tons (26.7 million tons in 1968), followed by Britain with 4.9 million tons (3.4 million tons), West Germany with 3.9 million tons including about 1.9 million tons transshipped from the Netherlands (2.1 million tons including about 0.7 million tons transshipped from the Netherlands), Japan with 2.2 million tons (1.9 million tons), Italy with 1.6 million tons (1.3 million tons) and the Netherlands with 1.2 million tons excluding about 1.9 million tons transshipped to West Germany (0.4 million tons excluding about 0.7 million tons transshipped to West Germany). Exports to Belgium and Luxembourg as well as to Finland were both higher than in 1968. Shipments to France, which began in 1969, were up sharply to 295,000 tons. Spain became an importer of Canadian iron ore for the first time with 129,000 tons.

TABLE 2

Production and Capacity of Pig Iron and Crude Steel at Canadian Iron and Steel Plants, 1969-70
(short tons)

	1969	1970p
Pig iron		
Production	7,461,219	9,085,955
Capacity at December 31	9,580,000	11,335,000
Steel ingots and castings		
Production	10,306,552	12,346,132
Capacity at December 31	13,241,375	14,083,375

Source: Dominion Bureau of Statistics, Primary Iron and Steel.
pPreliminary.

TABLE 3

Receipts, Consumption and Stocks of Iron Ore at Canadian Iron and Steel Plants, 1969-70
(long tons)

	1969	1970p
Receipts imported	2,193,270	2,091,862
Receipts from domestic sources	7,402,291	9,438,631
Total receipts at iron and steel plants	9,595,561	11,530,493
Consumption of iron ore	9,302,792	11,473,953
Stocks of ore at iron and steel plants, December 31	4,060,747	4,140,629
Change from previous year	+387,478	+79,882

Source: American Iron Ore Association, compiled from company submissions.

TRADE : IMPORTS

The trend toward lower imports continued in 1969 as they declined 0.2 million tons from 1969 to 2.1 million tons. One of the anomalies of the industry is that despite Canada's position as a major producer of iron ore a significant part of the ore consumed is imported. The peak in imports was reached in 1963 but large-scale participation by Canadian steel companies in the development of domestic iron ore sources, the most recent being The Griffith Mine and the Sherman Mine, has reduced reliance on foreign sources. Imports will continue because some Canadian steel companies have interests in United States mines.

United States provided the bulk of imports in 1970 with 2.0 million tons, or 93 per cent (87 per cent in 1969), followed by Brazil with 144,000 tons. Some 8,000 tons of Australian ore were imported for experimental purposes. Chile, Mauritania and Venezuela, exporters to Canada in 1969, did not record any shipments. All the United States ore was consigned to Ontario steel plants, while the Brazilian ore went to the Sydney Steel Corporation. Increased shipments from Labrador-Quebec to that steel company have largely supplanted foreign ores in that market.

CONSUMPTION

Consumption of iron ore in Canadian iron and steel plants rose in 1970, roughly in proportion to higher iron and steel production. Crude steel production totalled an estimated 12.3 million net tons in 1970, including an estimated 200,000 tons of steel castings, up nearly 20 per cent from 1969, and about 9 per cent from 1968, the previous record year. Consumption of iron ore totalled 11.5 million tons (Table 3) of which an estimated 9.4 million tons came from domestic sources and the remainder from imports; iron and steel plants and iron ore stocks were up slightly by 0.1 million tons from 1969 to 4.1 million tons.

DEVELOPMENTS 1970-71*

PRODUCING MINES

The Canadian iron ore industry, which began a period of slow growth in 1969, added only 0.07 million tons in 1970 when Chesbar Iron Powder Limited began production at its concentrator in northwestern Quebec. New capacity anticipated for 1971 includes a 300,000-ton-a-year reduced iron ore plant of Falconbridge Nickel Mines Limited and a 120,000-ton expansion of the Sherman Mine. Although the 250,000-ton expansion of The International Nickel Company of Canada, Limited's pellet plant was completed in 1970, the effective capacity of the plant remains at 0.9 million tons until such time as additional magnetite feed becomes available. Annual iron ore production capacity at the end of 1970 was 46.48 million tons, which included 24.83 million tons of pellet capacity.

Three major projects, two by Iron Ore Company of Canada and one by Quebec Cartier Mining Company, were announced in September 1970 after favourable mine tax announcements were made by the federal government.

Iron Ore Company of Canada's 12.0 million-ton-a-year expansion of its Labrador City concentrator, now at 11.0 million tons of which 10 million tons will continue to be pelletized, is expected to be completed by 1973 and a 6.0 million-ton-a-year concentrator and pellet plant at Sept-Îles, Quebec, on January 1, 1973. The Sept-Îles concentrator will utilize a flotation system developed by the company to upgrade friable ore grading 50-52 per cent iron from the Schefferville area. IOC has said that direct-shipping ore shipments, currently from 7.0 million tons to 8.0 million tons a year, may decrease to about 5.0 million tons a year by 1974 because of the possible lack of demand for this type of ore. The costs of the expansion of operations at Labrador City and of the concentrator and pellet plant at Sept-Îles will be $150 million and $140 million; together the projects will create 3,000 construction jobs and 800 permanent jobs.

Quebec Cartier Mining Company's 16-million-ton-a-year concentrator at Mt. Wright, Quebec, 75 miles northeast of Gagnon and 25 miles southwest of Labrador City, is expected to be completed by 1975. A railroad spur, starting near Gagnon and extending 88 miles to Mt. Wright is expected to be finished by 1973. Work on the railroad right-of-way was under way in late 1970 as was construction of a 35-mile long road from Labrador City to Mt. Wright. When the road is completed, men and materials brought in by the Quebec North Shore and Labrador Railway from Sept-Îles will be trucked to the site in the early phase of the project. The Mt. Wright project will cost over $300 million and will create 5,000 construction and 2,000 permanent jobs. By early 1976, ore from the Lac Jeannine Mine at Gagnon is expected to be depleted and the company has stated that feed for the concentrator could come from the Fire Lake Mine, when it is developed, some 35 miles northeast and near the new Mt. Wright spur line. However, production capacity of the concentrator would be reduced to 5.0 million tons from 8.5 million tons because of the finer grind required for the new ore.

EXPLORATION AND DEVELOPMENT COMPANIES

At least 20 companies were active in 1970 in the geological, metallurgical and economic evaluation of iron ore deposits and/or in the seeking of markets and financing. As in the past few years, most activities were centred in Quebec-Labrador and Ontario. Little exploration activity was reported by companies with

*To March 31, 1971.

TABLE 4

Canada, Iron Ore Producers*, 1969 and 1970

Company and Property Location	Material Mined and/or Treated (% Fe natural)	Product Shipped (% Fe dry)	Shipments (000 tons) 1969	1970	Developments in 1970 and to March 31, 1971
Algoma Ore Division of The Algoma Steel Corp. Ltd.; mines and sinter plant near Wawa, Ont.	Siderite from open-pit and underground mines(33)	Sinter from siderite (51)	1,109	1,529	Ruth and Lucy open-pit mine ceased production in 1970 for an indefinite period; all production now comes from George W. MacLeod underground mine. Limestone used in sintering in 1970 to produce a superflux sinter assaying 47.84% Fe natural, 2.49% Mn and 4.29% CaO. Company stated that the performance of this type of sinter was most rewarding in its blast furnaces.
Brynnor Mines Ltd.[1], wholly-owned subsidiary of Noranda Mines Ltd.; near Ucluelet, Vancouver Is., B.C.	Magnetite from open-pit mine (54)	Magnetite concentrate (63)	39	44	Ceased mine operations December 1967; continued to mill 1967-68; ceased all production June 1968; shipments continued from stockpile in 1969; stockpiled ore exhausted January 1970.
Caland Ore Co. Ltd., wholly-owned subsidiary of Inland Steel Co.; E. arm of Steep Rock Lake, near Atikokan, Ont.	Hematite and goethite from open-pit mine (55)	Pellets (63) Concentrates (58-60) (screened ore slightly concentrated)	896 886	1,086 1,057	
Carol Pellet Company, owned by U.S. participants in IOC; adjacent to IOC's concentrator, Labrador City, Labrador	Company's plant operated by IOC, to process IOC hematite and magnetite concentrate (39)	Pellets (65) Concentrate (66)	8,096 328	10,535 1,970	See "Iron Ore Company of Canada" in this table for details of expansion of the adjacent concentrator. The assets of Carol Pellet Company, established to pelletize concentrates produced by IOC, were acquired by IOC on December 31, 1970.
Coast Copper Co. Ltd.[1]; Benson L., northern Vancouver Is., B.C.	Chalcopyrite and magnetite from underground mine (31)	Byproduct magnetite concentrate (65)	75	77	Iron ore recovery plant shut down in 1970 because of difficulties in achieving a suitable grade of concentrate due mainly to changes in sulphur content in the ore and mineralogical changes.
Griffith Mine, The, wholly-owned subsidiary of The Steel Co. of Canada, Ltd. (Pickands Mather & Co. is the managing agent); 35 miles south of Red Lake, Ont.	Magnetite from open-pit mine (26)	Pellets (66)	921	1,503	A possible application of fine ore screening is being investigated.

TABLE 4 (Cont'd)

Company and Property Location	Material Mined and/or Treated (% Fe natural)	Product Shipped (% Fe dry)	Shipments (000 tons) 1969	1970	Developments in 1970 and to March 31, 1971
Hilton Mines, The[2]; near Shawville, Que.; 40 miles NW of Ottawa	Magnetite from open-pit mine (31)	Pellets (66)	1,020	1,030	Fine ore screening equipped with a pneumatic rapper device installed in all ball mill lines in 1970.
Iron Ore Company of Canada (IOC)[3]; Schefferville, Que.	Hematite-goethite-limonite from open-pit mines (54)	Direct shipping (60)	4,231	7,604	In 1970, a new dock to handle 200,000-ton-vessels at low tide and dredging of ship basin to take 150,000 ton ships were completed at a cost of $15 million. In 1971, the new dock will be lengthened and the basin dredged further to take vessels of up to 260,000 tons (high tide). Announcement September 10, 1970 of plans to: 1. Expand concentrator at Labrador City from 11 to 23 million tons a year at a cost of $150 million with completion expected in 1973. 2. Construct a concentrator and pellet plant of 6-million-ton annual capacity at Sept-Îles to up-grade and pelletize low-grade hematite ores from Schefferville, Quebec area. Pellet plant and expanded shipping facilities to cost $140 million. Two grate-kiln systems to cost a total of $16 million have been ordered for the pellet plant. A total of 15 locomotives to cost $6 million will be delivered in 1971.
Jones & Laughlin Mining Co., Ltd. (Adams Mine); near Kirkland Lake, Ont.	Magnetite from open-pit mines (20)	Pellets (65)	1,083	1,173	Started production from northeast orebodies in 1970.
Marmoraton Mining Company, Division of Bethlehem Chile Iron Mines Company; near Marmora, Ont.	Magnetite from open-pit mine (21e)	Pellets (65)	513	465	

TABLE 4 (Cont'd)

Company and Property Location	Material Mined and/or Treated (% Fe natural)	Product Shipped (% Fe dry)	Shipments (000 tons) 1969	1970	Developments in 1970 and to March 31, 1971
National Steel Corporation of of Canada, Ltd. (Moose Mountain Mine); Sudbury area, 20 miles north of Capreol, Ont.	Magnetite from open-pit mine (34)	Pellets (64)	664	663	Testing a 500-cu-ft flotation cell, the largest ever made, to be used for silica flotation at IOC's new pellet plant at Sept-Îles, Que.
Quebec Cartier Mining Company, wholly-owned subsidiary of United States Steel Corp.; Gagnon, Que.	Specular hematite from open-pit mine (34)	Specular hematite concentrate (66)	7,736	8,870	Announcement September 4, 1970 of plans to: 1. Construct a 16-million-ton-a-year concentrator at Mt. Wright, Quebec, some 75 miles northeast of present facilities at Gagnon, Que. and some 25 miles southwest of Labrador City, Labrador. 2. Extend the railroad from Gagnon to Port Cartier (shipping point) 88 miles to Mt. Wright. 3. Possible development of Fire Lake orebody, 35 miles northeast of Gagnon and near the new railroad, to provide raw hematite ore to Gagnon concentrator after 1976 when Lac Jeannine Mine is expected to be exhausted.
Sherman Mine[4]; near Temagami, Ont.	Magnetite from open-pit mines (24)	Pellets (65)	1,058	914	Fine ore screening installed in 1970 and other modifications to raise annual capacity from 1.0 to 1.12 million tons. Experienced gear difficulties with its three autogenous mills resulting in below-capacity production in 1970.
Steep Rock Iron Mines Ltd.; Steep Rock Lake, north of Atikokan, Ont.	Hematite-goethite from open-pit (51e)	Concentrate (58) Pellets (63)	159 1,413	47 1,435	Review of ore reserves in 1969 was continued in 1970.
Texada Mines Ltd.[5]; Texada Island, B.C.	Magnetite and chalcopyrite from underground mines (34)	Magnetite concentrate (65)	581	467	Transition from conventional slusher and rail haulage to trackless mining completed at year-end 1969. New regrind mill and additional flotation capacity were being added to concentrator circuit to improve grade and recovery of both copper and magnetite concentrates.

TABLE 4 (Cont'd)

Company and Property Location	Material Mined and/or Treated (% Fe natural)	Product Shipped (% Fe dry)	Shipments (000 Tons) 1969	1970	Developments in 1970 and to March 31, 1971
Wabush Mines[6]; Scully Mine includes mine and concentrator at Wabush, Labrador; Pointe Noire Division includes pelletizing plant at Pointe Noire, Que.	Specular hematite and some magnetite from open-pit mine (34)	Pellets (66)	3,321	5,478	Modifications of entire grinding circuit from wet to dry at Pointe Noire pellet plant, started in 1968, was completed in 1970. Program included installation of 9th mill to achieve necessary grinding capacity.
Wesfrob Mines Limited, wholly-owned subsidiary of Falconbridge Nickel Mines Ltd.; Moresby Is., Queen Charlotte Island, B.C.	Magnetite and chalcopyrite from open-pit mines (36)	Magnetite pellet-feed (70) and sinter-feed concentrate (61)	928	974	Capacity production reached for first time in 1970. Switched pellet feed portion of contract with Japan to Oregon Steel Mills, Seattle, in early 1970. Ore will be shipped by the Marconaflo system. A development exploration adit started in 1970 to delineate a probable underground orebody west of present open pits. Drilling will also be carried out from the adit to test favourable ground southwest of pits.
Zeballos Iron Mines Ltd.[1]; near Zeballos, Vancouver Is., B.C.	Magnetite from underground mine (48)	Magnetite concentrate (63)	76	–	Ore production ceased June 1969; all stockpiled ore shipped.
BYPRODUCT PRODUCERS					
Cominco Ltd., Kimberley, B.C.	Pyrrhotite flotation concentrates roasted for acid production; calcine sintered	Iron oxide sinter (64) processed into pig iron at plant	149	146	
Falconbridge Nickel Mines Ltd.; Falconbridge, Ont.	Pyrrhotite flotation concentrates treated	Iron oxide calcine (67)	44	63	Pyrrhotite plant operated routinely with production of 81,000 tons of calcine. Production in excess of shipments stockpiled at the mine. Tune-up operations at the new nickel-iron refinery began in late 1970. Capacity is some 300,000 tons per year of reduced iron pellets containing about 1.5% nickel and 92% Fe.

TABLE 4 (Cont'd)

Company and Property Location	Material Mined and/or Treated (% Fe natural)	Product Shipped (% Fe dry)	Shipments (000 tons) 1969	1970	Developments in 1970 and March 31, 1971
International Nickel Co. of Canada, Ltd. The,; Copper Cliff, Ont.	Pyrrhotite flotation concentrates treated	Pellets (67)	775[e]	667[e]	Two pellet line modifications completed in late 1970 to raise capacity from 0.9 million tons to 1.05 million tons but effective capacity remains at 0.9 million tons until such time as magnetic feed becomes available.
Quebec Iron and Titanium Corp.; mine at Lac Tio, Que.; electric smelter at Sorel, Que.	Ilmenite-hematite (40% Fe, 35% TiO_2) from open-pit mine at Lac Tio, beneficiated and calcined at Sorel	Ilmenite-hematite calcine is electric smelted to TiO_2 slag and various grades of desulphurized pig iron (remelt iron)	1,381[7]	1,571[7]	Computerization of smelting furnaces continued.

Sources: Company reports, personal communication and others for shipments and detail.

*Exclusive of Craigmont Mines Limited which shipped in 1970 some 18,114 tons of magnetite concentrate to Western Canada coal preparation plants, and Chesbar Iron Powder Limited which began production of its 70,000-ton-a-year concentration in the latter part of 1970.

[1]No longer operating. [2]Owned by The Steel Co. of Canada, Ltd., 50%; Jones & Laughlin Steel Corp., 25%; Pickands Mather & Co. (Managing agent), 25% [3]Owned by Labrador Mining and Exploration Co. Ltd.; Hollinger Mines Limited; The Hanna Mining Co. (Managing agent); Armco Steel Corp.; Bethlehem Steel Corp.; National Steel Corp.; Republic Steel Corp.; Wheeling-Pittsburgh Steel Corp.; and Youngstown Sheet and Tube Co., Carol Pellet Company, formerly owned by the U.S. participants in IOC, was merged into IOC on December 31, 1970. [4]Owned by Dominion Foundries and Steel, Ltd., 90%, and the Cleveland-Cliffs Iron Company (managing agent), 10%. [5]Wholly-owned subsidiary of Kaiser Aluminum & Chemical Corp. [6]Owned by The Steel Co. of Canada, Ltd.; Dominion Foundries and Steel, Ltd.; Youngstown Sheet and Tube Co.; Inland Steel Co.; Interlake, Inc.; Wheeling-Pittsburgh Steel Corp.; Finsider of Italy; and Pickands Mather & Co. (Managing agent). [7]Ilmenite smelted to pig iron and titania slag.

[e]Estimated; – Nil.

properties in British Columbia. There are several factors responsible for the decreased activity in this province including the prevalence of small orebodies with a short life that can only be mined at high unit cost and intense competition from foreign ores. The viability of British Columbia's only two producers depends on the added income from byproduct copper concentrate.

In Labrador-Quebec, Canadian Javelin Limited was very active in searching for markets and financing. The company plans to construct two concentrators, one for the Julian Lake deposit north of Wabush, Labrador, and the other for the O'Keefe-Star Lake properties about 20 miles southwest of Mt. Wright, Quebec. A pipeline is being planned rather than conventional railway to carry the concentrates to a proposed 12-million-ton-a-year pellet plant at Pointe Marmite on the north shore of the St. Lawrence River. The Julian Lake deposit including the Lakewood Extension owned by Labrador Mining and Exploration Company Limited is reported to contain about 1 billion tons grading over 36 per cent iron. The O'Keefe Lake west property contains 27 million tons grading 35 per cent iron and the Star Lake property, 152 million tons grading 33 per cent iron.

Other companies active in Quebec and in the Quebec-Labrador Trough area during 1970 included Albanel Minerals Limited, Armore Mines Ltd., Chesbar Iron Powder Limited, Kallio Iron Mines Limited, Expo Iron Limited, Mount Wright Iron Mines Company Limited, Labrador Mining and Exploration Company Limited, Quebec Cobalt and Exploration Limited, Ungava Iron Ores Company and Wrightbar Mines Limited.

In Ontario, Algoma Ore Division of The Algoma Steel Corporation, Limited continued to be actively engaged in both exploration and feasibility studies on properties it either owns or has under long-term lease. Algoma's exploration activities were concentrated in the Lake St. Joseph and Geraldton areas of northwestern Ontario. The Geraldton iron deposit, part owned by Algoma and part optioned from Little Long Lac Mines Limited, contains both hematite and magnetite in a taconite formation. The main emphasis was on the selection and testing of a metallurgical flowsheet for this property. Material for pilot plant testing was obtained and at year-end 1970 testing began. Others active in Ontario during 1970 included Steep Rock Iron Mines Limited,The Steel Company of Canada, Limited, Lake St. Joseph Iron Ltd., and Canada Costa Rica Mines Limited.

In British Columbia, Imperial Metals and Power Ltd. initiated a diamond-drilling program to enlarge upon its iron and coal reserves. On the Melville Peninsula in the Northwest Territories, Borealis Exploration Limited has been conducting since 1968 an extensive exploration program on its three permits totalling 350,000 acres. The westernmost deposits were reported to contain 2.6 billion tons with grades ranging from 35 per cent to 40 per cent iron, and the eastern deposits, 1.1 billion tons with grade between 25 per cent and 30 per cent iron Baffinland Iron Mines Limited has been conducting additional feasibility studies on its Baffinland Island, Northwest Territories, deposit. Reserves are reported to be in excess of 131 million tons grading 68 per cent iron.

WORLD REVIEW

World production of iron ore was an estimated 741 million tons in 1970, up 34 million tons from 1969 (*Metal Bulletin*; April 8, 1971). This parallels the rise in world steel production which was up an estimated 18 million net tons from 1969 to 653 million net tons (*Metal Bulletin*; April 2, 1971). The USSR ranked first among world iron ore producers with an estimated 192 million tons (compared to 183 million tons in 1969), followed by United States with 89 million tons (88 million tons), France with about 56 million tons (55 million tons), Canada with 48 million tons (36 million tons), and Australia with about 45 million tons (38 million tons). Canada regained fourth position from Australia in 1970. Australia had displaced Canada in this position in 1969 because of a tremendous rise in shipments by Australia to supply burgeoning Japanese demand against lower shipments by Canada as a result of labour disputes.

All obstacles to development having finally been surmounted, construction of the $300-million Robe River iron venture in Western Australia was started in late 1970. Cliffs Western Australia Mining Co. Pty. Ltd., the operating company, has contracted to supply a total of 87 million tons of pellets and 71 million tons of prepared sinter fines to a group of Japanese steel mills. Under this contract, the largest single mineral agreement ever made, deliveries must start with 4 million tons of pellets and fines in 1972, increasing to more than 9 million tons in 1973, and to 10.3 million tons in 1975. The project's main constituents are the establishment of a mine, industrial area and modern town for about 1,000 people at Mount Enid; harbour, loading pier, pellet plant, town for 2,000 people, power station and industrial area at Cape Lambert; and a 100-mile railway to link mine and port. At Cape Lambert the port will accommodate bulk carriers of up to 250,000 tons. The pellet plant with an annual capacity of 4 million tons will be the largest in the world outside North America. One vital factor differentiates this project from the other large iron ore developments in Western Australia–Robe River will mine lower grade limonitic ores and will require a pellet plant as a necessary condition of production.

World iron ore pellet capacity at the end of 1970 totalled an estimated 106.73 million tons including 52.55 million tons in the United States and 24.83 million tons in Canada. The remaining capacity was mainly in Sweden (6.50 million tons), Australia (5.8 million tons) and Peru (3.5 million tons). Other pellet-producing countries include Belgium, Finland, France, India, Italy, Japan, Liberia, Mexico, Netherlands, Norway, Philippines and the USSR.

The growth in world pellet capacity has been uneven. While the growth was dramatic in 1968 when some 15.75 million tons of capacity was added it was only 4.2 million tons in 1969 and 4.5 million tons in 1970. According to current construction and firm commitments, some 6.25 million tons of capacity are expected to be added in 1971, 17.8 million tons in 1972, none in 1973 and 11.0 million tons in 1974. New plants in 1970 included the Grangesberg Co. plant of 1.2 million tons, the Swedish LKAB plant of 1.8 million tons and the Mexican Hojalata y Lamina plant of 1.1 million tons. The Grangesberg plant uses a unique pelletizing process in that bonding is achieved with 10 per cent gypsum-free, portland cement rather than with conventional bentonite and hardening is done in silos at room temperature rather than by firing at high temperatures. Expected to start production in 1971 are the Cia. Vâle do Rio Doce, Kobe Steel Works Ltd., and Bong Mining Co. pellet plants, each of 2.0 million tons annual capacity.

Iron Ore Company of Canada announced in mid-1970 that it would construct a 6-million-ton-a-year pellet plant at Sept-Îles, Quebec with completion expected January 1, 1973.

The trend toward increasing international trade in iron ore continued in 1970 because most major steel-producing countries are also new major importers of ore. Total trade was an estimated 303 million tons, up 21 million tons from 1969. Japan was the major contributor to the increase when its imports rose by 17 million tons from 1969 to 100 million tons. Imports to the ECSC countries were up an estimated 2.5 million tons to 95 million tons and to eastern European countries an estimated 2.0 million tons to 36.5 million tons. Imports by the United States were down from 1969 by 1 million tons to 40 million tons. Increases in export trade was recorded by Canada, up 11 million tons to 38.7 million tons, by Australia, up an estimated 7 million tons to 33 million tons, by Brazil and Venezuela, up each by about 2 million tons to 23 million tons and 21 million tons, respectively, and by African countries, up about 4 million tons to 50 million tons. A decrease in export trade was recorded by Sweden, Chile and Malaysia.

PRICES

A general rise in international iron ore prices in 1970 and in early 1971 indicated that prices of world ores may be on an upward trend. Between 1957-58 and 1968 iron ore prices fell owing to the increasing availability of iron ore through the opening up of new mines with large capacities, through improved shipping facilities and because of lower growth of steel production in some of the major iron ore importing countries. This downward trend was arrested in 1969 when a combination of factors tended to stabilize iron ore prices at about the 1968 level.

The buoyant state of the world steel industry combined with the shortfall created by strikes in Canada during 1969 and at Swedish iron mines in late 1969 and early 1970 together resulted in higher prices on the European market for 1970. The Lake Erie base price was also higher in 1970 reflecting increased transportation and labour costs. F.o.b. prices of world ores contracted by Japan, that had levelled off from a downward trend in 1969, appeared to have stabilized and even to have increased slightly in 1970. However, the average c.i.f. price of Japanese imports increased over that of 1969, the first time in a decade.

In 1971, Lake Erie base prices advanced by as much as 5 per cent. European prices based on negotiations concluded in mid-February between Swedish iron ore producers and Ruhr steel producers as well as the British Steel Corporation are expected to be about 10 per cent higher than in 1970. F.o.b. prices of world ores contracted for the Japanese market may be up fractionally in 1971 according to short-term contracts signed in the latter part of 1970 and early 1971 with Australian producers.

NORTH AMERICA

Prices received by most iron ore producers in Ontario, Quebec, Quebec-Labrador, and in the United States Great Lakes area for North American sales are a reflection of the Lake Erie base price, which is the price paid for a long ton unit of iron in iron ore

TABLE 5

Lake Erie Base Prices of Selected Ores, 1964-71

	$ U.S./long ton[1]		
	1964-69	1970	1971
Mesabi Non-Bessemer	10.55	10.80	11.32
Mesabi Bessemer (+ phos. premium)	10.70	10.95	11.17
Old Range Non-Bessemer	10.80	11.05	11.42
Old Range Bessemer	10.95	11.20	11.57
High Phosphorous	10.55	10.80	10.80
Pellets (per ton nat. unit[2])	0.252[3]	0.266	0.280

[1]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. [2]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. [3]Price applicable for years from 1962 to 1969.

delivered at rail of vessel at Lake Erie ports. The Lake Erie base price for selected ores from 1964 to 1969, which remained stable in this period, and increased prices in 1970 and 1971 are listed in Table 5. It should be noted that these increases cover only open market ore, and this market does not represent the bulk of ore consumption by the steel mills which are supplied mainly by captive sources. However, the higher transportation and production costs which are said to be partly responsible for the upward trend are also applicable for "captive" ores. Thus, steel mills face higher iron ore costs regardless of ore source.

Lake Erie base prices were revised upwards in 1970 to reflect increased production and transportation costs. Prices for natural ore including lump rose by 25¢ a ton while the price for pellets rose 1.4¢ an iron unit, equivalent to about 90¢ a ton. This was the first change in the base price for pellets since 1962 when pellet prices were first quoted and for natural iron ore since 1964 when the price of natural ore had declined 10¢ in a buyer's market. The increase in freight rates of about 2½ per cent in mid-summer were absorbed by the iron ore producer because Lake Erie base prices once set are applicable for the whole year.

The Lake Erie base price increased for the second consecutive year in 1971. Prices for natural ore rose by as much as 52¢ a ton and for pellets by 1.4¢ an iron unit. However, as in 1970, these gains by the iron ore producer are expected to be offset somewhat by a general rise in lake freight rates and increased production costs. Pellet producers that use fuel oil for pelletization can surely expect higher costs in 1971 through 1975 because of the continuous rise in the world price of crude oil expected in those years. The Interlake Steamship Co. division of Pickands Mather & Co., the largest independent United States fleet operator on the Great Lakes, announced, in early March 1971, increases in freight rates of about 4½ per cent effective with opening of the 1971 navigating season. It was reported that Wilson Marine Transit and Oglebay Norton Company had followed suit with a similar rate increase. An accompanying table lists posted lake freight rates in 1970-71.

TABLE 6

Posted Lake Freight Rates, 1970-71
$ U.S./long ton

	1970* (April 15)	1971 (March 10)
Head of the lakes to		
Lower Lakes	2.05	2.25
Marquette, Mich. to		
Lower Lakes	1.84	2.02
Escanaba, Mich. to:		
Lake Erie and Detroit	1.54	1.69
Lower Lake Michigan	1.23	1.35
Sept-Îles to Lower Lakes	1.65**	1.65**
Thunder Bay, Ont. to		
Lower Lakes	1.78-1/8	1.78-1/8

*Rates increased by about 2½ per cent in mid-summer.

**Rate subject to additional cost for St. Lawrence Seaway tolls of about $0.45 a long ton.

EUROPE

European prices for iron ore increased in 1970 and in 1971 to reflect both short-term demand and higher shipping costs. Generally, Europe's steel producers, unlike those in the United States and Japan, have relatively unprotected forward positions in that about half of their ore is obtained by annual contracts, usually in the preceding December. In contrast, United States consumers obtain most of their ore from captive mines and Japanese steel producers obtain their ore from suppliers under large-tonnage, long-term contracts; as a consequence, ore prices in the United States and Japan are not affected by strong short-term demand.

A labour strike at the Swedish LKAB mines in December 1969 and early 1970 aggravated an already tightened supply situation brought on by peak European steel production and decreased supplies from Canada. As a result, considerable ore was bought in late 1969 and early 1970 on a spot basis from other sources and c.i.f. prices advanced to U.S. 23¢ a unit compared with 18¢-19¢ previously. Shipping rates, which were already under upward pressure from accelerated worldwide Japanese traffic in bulk materials, rose sharply to account for some of the price rise.

The LKAB strike may have helped to strengthen the bargaining position of most world suppliers to Europe who were reported to have obtained price increases for 1970 delivery ranging from 10 to 15 per cent. Some world suppliers, especially those that may have been in a poor bargaining position, were reported to have settled for increases ranging from 5 to 8½ per cent on previous contract prices. However, since about half of European imports are either covered by long-term contracts or come from captive sources and since most ore is shipped on the time charter basis, the average price on the European market did not rise appreciably, especially for Canadian ore.

The mid-1970 f.o.b. price for Kiruna D ore (60 per cent Fe, 1.8 per cent P) was U.S. $8.03 a long ton (Annales des Mines: 40.75 krona/metric ton). The price for Kiruna D ore, c.i.f. Rotterdam, which is indicative of the European market, was U.S. $8.70 a metric ton in 1968-69 after having fallen almost every year from its 1957 peak of over $15. The mid-1970 f.o.b. mine price, 32 per cent iron base, for French ore was 13.3 francs (Annales des Mines; equivalent to about U.S. $2.45 a ton) in mid-1970 compared with 12.58 francs in the fourth quarter of 1969, 11.57

francs in the first quarter of 1969, 11.86 francs in 1968 and 12.66 francs in 1967.

The statistical f.o.b. mean price a metric ton for Swedish iron ore products rose from 38 krona (U.S. \$7.48/long ton) in 1969 to 42 krona (U.S. \$8.27/long ton) in mid-1970. The increase in price not only reflects increased demand but also the rising output of higher-grade products, the share of pellets and sinter in the exported ore amounting to 14.4 per cent (11.1 per cent in 1969). The mid-1970 price for Malmberget pellets (60 per cent Fe dry basis) was \$12.25 U.S. a long ton, f.o.b. Lulea and for Kiruna-Svappaara pellets, \$12.80 U.S. a long ton (21.3¢ a unit), f.o.b. Narvik (Annales des Mines). The f.o.b. price for Carol Lake pellets selling in the European market was 23.4¢ an Fe unit (Annales des Mines).

It is interesting to note the f.o.b. price of certain Swedish ores selling in the Japanese market in 1970 (Source: The Text Report 1970).

Kiruna pellets – U.S. \$12.29 a long ton (63 per cent Fe basis) or 19.5¢ a unit

Kiruna-C (Fines) – U.S. 13.2¢ f.o.b. a dry long ton unit and U.S. 20.0¢ c.&f. a dry long ton unit

Grancold pellet – U.S. \$12.56 a long ton (Fe 60 per cent base, CaO 20 per cent base)

European prices in 1971 based on negotiations concluded in mid-February between Swedish iron ore producers and Ruhr steel producers as well as the British Steel Corporation are expected to be about 10 per cent higher than in 1970. However, it is expected that these gains by the iron ore producers will be offset somewhat by a rise in iron ore production costs and rising freight rates during the year. Though Swedish exporters are also faced with the increased production costs, they should benefit from the fact that the increased freight rates will hit competitors from other continents harder. In early 1971, it was reported (Japanese Commerce Daily, March 18, 1971) that The Hanna Mining Company (managing agent for the Iron Ore Company of Canada) had reached an agreement with European steel mills on an upward revision of the Carol Lake pellet price for 1971 delivery. The new price was reportedly fixed at U.S. 24.2¢ a dry long ton iron unit (65.3 per cent Fe basis) f.o.b. Sept-Îles, up 5 per cent from that of the preceding year.

JAPAN

The average c.i.f. price of Japanese imports increased over that in 1969, the first time in nearly a decade. The average c.i.f. price a metric ton rose steadily throughout the year to reach U.S. \$12.24 in October, the average for the year being U.S. \$11.83 which compares with U.S. \$11.64 in 1969 and U.S. \$12.23 in 1968. Shipping innovations, such as larger ships, O.B.O. vessels and favourable large long-term contracts, had been mainly responsible for keeping the average price down despite longer average seaborne distance (6,210 miles in 1970 compared to 5,460 miles in 1965). The higher average c.i.f. price in 1970 can be attributed to higher ship-building and bunker fuel costs increases in insurance rates, shortfall of bottoms that has tended to push voyage charter rates up, and increased iron ore prices for spot sales.

The c.i.f. price of imports from Australia and India, Japan's principal suppliers, averaged U.S. \$11.32 and U.S. \$11.25, respectively, for the first seven months of 1970. The c.i.f. price for Australian ores usually sets the pattern for prices of other ores entering the Japanese market because of their high-grade, high-quality and closeness to Japan. With all else being equal, it is the producer who is closer to his markets that will have the competitive edge in a buyer's market. F.o.b. prices of world ores contracted by Japan that had levelled off from a downward trend in 1969 appeared to have stabilized and even to have increased slightly in 1970 (Table 7).

Two contracts of Iron Ore Company of Canada both call for a price of U.S. 16.4¢/DLT unit on a special c.&f. basis with freight rates U.S. \$3.775 for one contract (using 165,000-ton vessels) and U.S. \$3.155 for the other (using 250,000-ton vessels). A Quebec Cartier Mining Company contract for 6 million tons (1.2 million tons for five years) calls for a price of U.S. 16.5¢/DLT unit. The low freight rates for 15,200 miles are made possible by the transportation in large Oil-Bulk-Oil (OBO) carriers that can backhaul oil from Kuwait. In 1969, Quebec Cartier deepened its harbour to take vessels of up to 150,000 tons and in January 1970 IOC completed a new dock and high-speed loading facilities capable of handling vessels of up to 200,000 tons (250,000 tons at high tide).

Prices received by British Columbia mines on ore sales to Japan are negotiated between producers and consumers. Prices have weakened in recent years, and specifications have become more stringent to meet competition from world iron ore producers, particularly Australian. This downward trend continued in 1969 when Texada Mines Ltd. agreed in a new contract to lower the c.&f. price by 40¢ to U.S. \$11.62 a dry metric ton, equivalent to about 18¢ a unit, and the f.o.b. price by 5¢ to U.S. \$9.12 a dry metric ton. The current contract of Wesfrob Mines Limited calls for a price of U.S. \$8.85 a dry metric ton for its sinter feed with a freight rate of U.S. \$2.70/DLT using 55,000-ton-carriers. The pellet feed portion of the Wesfrob contract with Japan has been transferred to Oregon Steel Mills, Portland, Oregon.

The Japanese market for iron ore to 1975 is uncertain. Japanese steel production, previously forecast to 160 million metric tons in 1975, was recently revised downwards to 130 million metric tons. The lower iron ore requirements, an estimated 150 million metric tons compared with 184 million metric tons forecast previously, are covered by already-contracted supplies of some 153 million tons (*The Tex Report 1970*, published by The Tex Report Ltd. of Tokyo). Thus, it will not be surprising to see few iron ore

TABLE 7

Representative Australian Iron Ore Contracts, 1966-71
(U.S. $/dry long ton, 64 per cent Fe basis)

	Hamersley		Goldsworthy		Mt. Newman	
	Lump	Fines	Lump	Fines	Lump	Fines
1966-67	9.92	7.68	9.86	7.25 (62% Fe)	Nil	Nil
1968	9.37	7.68	9.37	7.68	9.37	7.13 (62% Fe)
1969	9.37	7.63	9.37	7.68	–	–
1970	9.58	7.23 (62% Fe)	9.86	7.95	9.58	7.23 (62% Fe)
1971	9.58	7.95	–	–	–	–

– No record.

contracts signed for delivery before 1975 except on a spot basis unless, of course, there is renewed growth in steel demand.

Japanese requirements are only partially covered by long-term contracts after 1975, and a large market should exist for good quality competitive ores. Although Australia is taking an ever-increasing share of the burgeoning Japanese market (20 per cent in 1968, 28 per cent in 1969, and 38 per cent in fiscal 1970), it is probable that Japan will limit Australia's share to about 45 per cent. Australian iron ore accounts for 47 per cent of the 153 million metric tons contracted for 1975.

The balanced supply-demand relationship that may exist in the Japanese market to 1975 and the possibility of increased sales by Australian iron ore producers in other markets may have a stabilizing effect on iron ore prices to 1975. Delivered (c.i.f.) prices are expected to rise to cover higher shipping costs despite increasing economies of scale in production and transportation; there may be a reduction in f.o.b. prices to competitive markets to compensate for higher transportation costs from many sources of good quality iron ore.

OUTLOOK AND FORECAST

In 1971, shipments are expected to decline by some 1.5 million tons to equal the expected production of 46.0 million tons, 0.5 million tons less than production capacity. It is reasonable to anticipate exports of about 36.3 million tons and domestic shipments of 9.7 million tons; imports will probably remain at the 1970 level of 2.1 million tons.

Exports of iron ore to Britain and the ECSC countries, which were at record highs in 1970, are expected to decline slightly in response to slackening production but these will be offset by increased exports to Japan. Exports to the United States are expected to remain at the 1970 level of 23.8 million

TABLE 8

Canada, Iron Ore Capacity, Production and Shipments, and Raw Steel Output, 1970, Forecast to 1980
(long tons)

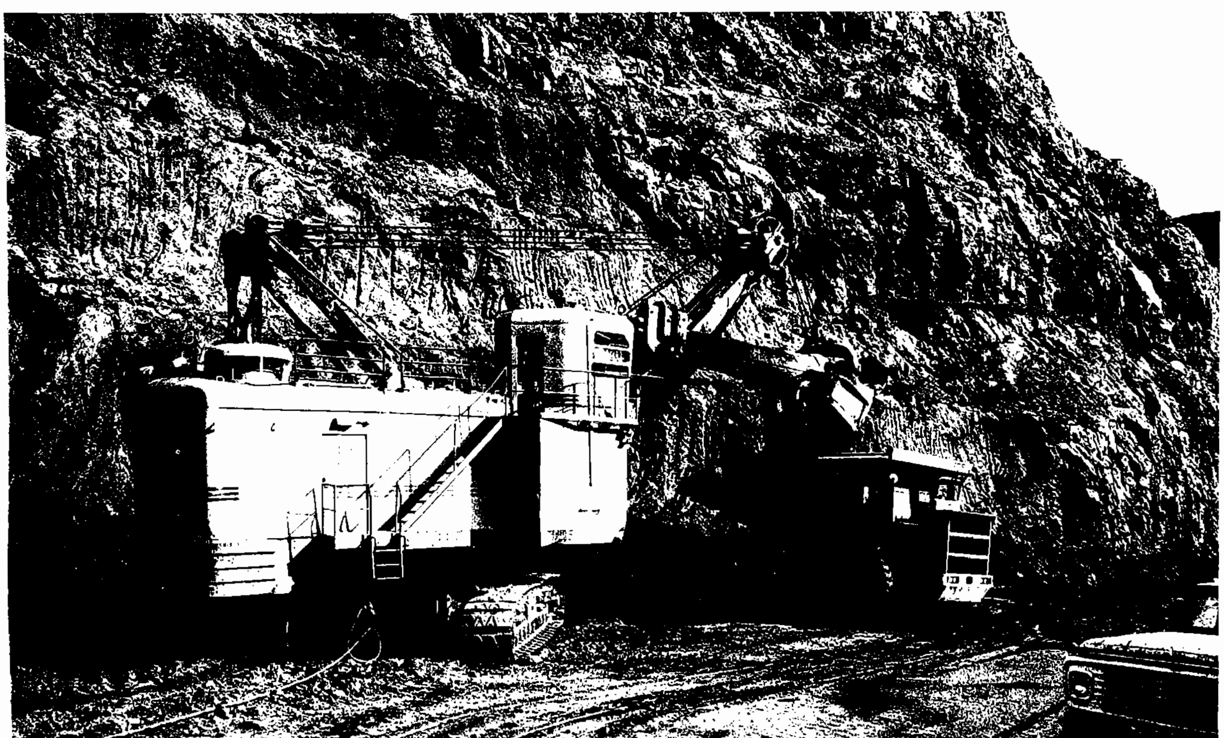
	Iron Ore Capacity (at Dec. 31)	Iron Ore Production	Shipments		Imports	Raw Steel Output (net tons)
			Exports	Domestic		
1970	46.5	46.0	38.7	8.8	2.1	12.3
1971	46.9	46.0	36.3	9.7	2.1	12.7
1972	47.2	46.5	36.2	10.3	2.0	13.2
1973	65.2	49.0	38.1	10.9	2.0	13.9
1974	65.2	58.0	46.4	11.6	2.0	14.7
1975	73.2	65.0	52.8	12.2	2.0	15.3
1976	77.7	68.0	55.0	13.0	2.0	16.2
1977	86.5	72.0	58.2	13.8	2.0	17.1
1978	88.0	76.0	61.4	14.6	2.0	18.0
1979	96.0	80.0	64.6	15.4	2.0	18.9
1980	106.0	90.0	73.6	16.4	2.0	20.0

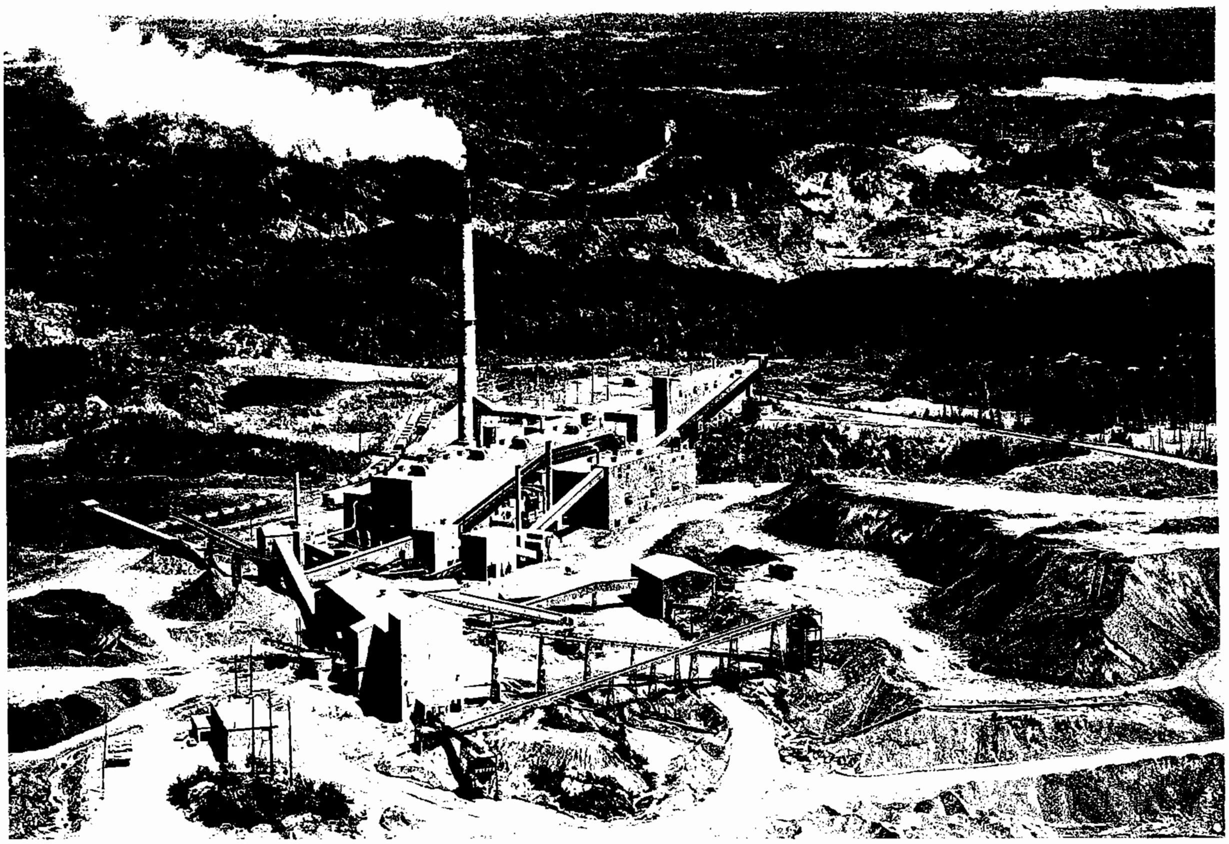
tons despite anticipated higher-than-normal rate of shipments in the first half of the year. United States steel production is expected to go up in the first half to build up consumer inventories as a hedge against a possible steel labour strike in August. Canadian crude steel production is likely to reach 12.7 million net tons in 1971, up 0.4 million net tons, in response to a probable upswing in the Canadian economy coupled with an increase in steel exports to the United States because of the aforementioned strike hedge. Iron ore consumption is therefore estimated at 11.9 million tons of which 9.8 million tons will be probably supplied from domestic sources and 2.1 million tons from imports providing stocks at the steel plants remain at the 1970 level.

Iron ore shipments in 1975 are expected to reach 65 million tons composed of 52.8 million tons of exports and 12.2 million tons of domestic shipments. The export estimate will be realized if Canada increases its share of the market in the United States, Britain and western Europe and begins major shipments to Japan from new or expanded facilities in Quebec and Labrador. Iron ore plants under construction or planned as of 1970 will add some 34.67 million tons of production capacity by 1976. On the negative side, annual production capacity is expected to decrease at several mines. New requirements for domestic consumption by 1975 could well be met by developments in several areas of which the most important might be expansion of Wabush Mines, which is 42 per cent owned by Stelco and Dofasco.

An annual production of 90 million tons comprised of 74 million tons of exports and 16 million tons of domestic shipments are anticipated for 1980. The estimate for exports may appear high but the 74 million tons as a share of the total world market, or 15 per cent, is only slightly above the estimated 13 per cent recorded in 1970 when Canadian exports reached their peak. The principal factors that could account for this growth include the inability of new and traditional world sources to meet the increasing demand for beneficiated high-grade ore, the proximity of Canada's large beneficiating-grade iron ore deposits to the United States and Europe, the existence of deepwater ports on the St. Lawrence River to enable concentrates and pellets to compete in major markets, particularly Japan, the existence of mine infrastructure that facilitates expansion or new building, and Canada's continuing favourable political and fiscal policies. The United States will continue to be the largest market with 32 million tons, followed by Japan with 20 million tons, the ECSC with 13 million tons, and Britain with 9 million tons; the domestic market should absorb about 16.4 million tons. It is expected that total annual capacity will be about 106 million tons by the end of 1980.

Nine cubic yard electric shovel loading 100-ton truck in South Roberts open pit. (Photo by Hunter)





Steep Rock Iron Mines pellet plant; Caland operations
in background. (Photo by Hunter)

Iron and Steel

V. B. SCHNEIDER*

Crude** steel production in Canada totalled 12.35 million tons† in 1970 (Table 4), including 191,720 tons of steel castings, up 19.9 per cent from the previous year and surpassing the previous record of 11.20 million tons in 1968. Through 1967 the value of Canadian imports always exceeded the value of exports but this long-time imbalance was broken in 1968 when the value of exports exceeded the value of imports by a modest $26 million. The labour strike in the Canadian steel industry in 1969 resulted in the value of imports exceeding the value of exports by some $142.6 million. In 1970, the Canadian steel industry, for the second time, experienced a favourable trade balance in the value of iron and steel products. However, imports at 2.2 million tons were high and indicative of a softening world demand that made foreign material available to compete in the domestic market.

Apparent domestic consumption of steel products at 12.2 million tons, on a crude steel basis, was at an all-time high. Apparent consumption calculations do not take into account inventory changes and it is believed that steel inventories, which were reduced during the labour strike in the Canadian steel industry in 1969, were again built up in 1970. That being so, real consumption was probably closer to 12 million tons.

Steel prices rose in virtually every steelmaking country in the world in 1969 and continued to rise in many countries for selected products during 1970. In Canada, a report by the Prices and Incomes Commission, issued in March, found that steel producers had kept their increases in line with rising costs. Subsequently, in November, Canadian prices increased from 3.3 per cent to 5.3 per cent for some products but many products were excluded from the increases. In the United States, price increases were selective as domestic mills faced stiff competition from imports. Some price increases, up to $10 a ton, were announced in February and March for sheet piling and structural shapes; there was also an increase of $10 a ton on the base price of reinforcing bars in June. European continental steel prices declined during the year from $118 to $106 a metric ton for merchant bars, and from $155 to $131 a metric ton for plates.

Corporate profits varied from company to company, but in general the year was a satisfactory one for the Canadian steel industry. The aggregate of the three largest producers, who account for about 80 per cent of Canadian production, shows that profits as a percentage of sales were 9.3 per cent in 1970 compared with 7.8 per cent in 1969 and 11.6 per cent in 1968.

WORLD PRODUCTION

Steel production rose in most countries in 1970 with total production reaching an estimated 653 million tons compared with 630 million tons in 1969, an increase of some 4 per cent, which was slightly lower than the rise in recent years. Japan accounted for half of the absolute rise with an increase of 12.3 million tons. The outlook for 1971 is cautiously optimistic for a modest 4¾-per-cent increase to 685 million tons. Reasons for the modest growth expectations in 1971 are the high cost of capital for plant expansion in the steel industry and for capital to finance large steel-consuming industries together with anti-inflationary

*Mineral Resources Branch.
**Crude steel includes ingots, continuous cast sections and steel castings.
†The short, or net, ton of 2,000 pounds is used throughout.

measures being instituted by the governments of many of the larger steel producer-consumer countries, including some of the Common Market countries, Japan and the United States.

In Europe, among the major steel producers, only Britain and Italy are expecting the consumption and production of steel to rise significantly in 1971 from that of 1970. Production in the United States could be adversely affected by a labour strike before a new contract is negotiated between the workers and the major steel companies. Canada continued to be the world's twelfth largest steel producer. Probably the most noteworthy development in 1970 related to the world's steel industry was the realization that Japan will have to scale back its growth rate. The country's announced plans had called for a productive capacity of 178 million tons in 1975 but this was later scaled back to about 140 million tons and production of about 130 million tons.

TABLE 1

Canada–General Statistics
of the Domestic Primary Iron and Steel Industry, 1968-70

	Unit	1968	1969	1970p
Production				
Volume Indexes				
Total Industrial Production	1961 = 100	159.8	166.6	170.4
Iron and Steel Mills[1]	"	169.7	156.9	174.1
Value of Shipments, Iron and Steel Mills[1]	$ millions	1,333.8	1,415.6	1,678.5
Value of unfilled orders, year-end, Iron and Steel Mills[1]	"	156.2	299.4	355.5
Value of Inventory owned, year-end, Iron and Steel Mills[1]	"	270.7	153.7	173.7
Employment – Iron and Steel Mills[1]				
Administrative	number	8,310	8,811	7,053
Hourly rated	"	36,324	34,700	40,444
Total	"	44,634	43,511	47,497
Employment index, all employees	1961 = 100	130.7	126.1	137.6
Average hours per week, hourly rated	hours	40.3	40.1	40.2
Average earnings per week, hourly rated	$	132.11	139.81	159.03
Average salaries and wages per week, all employees	$	139.08	147.94	163.23
Expenditures – Iron and Steel Mills[1]				
Capital: on construction	$ million	11.7r	15.9	24.6
on machinery	"	53.7r	92.5	156.3
Total	"	65.4r	108.4	180.9
Repair: on construction	"	9.1r	9.2	9.4
on machinery	"	144.4r	132.0	162.9
Total	"	153.5r	141.2	172.3
Total Capital and Repair		218.9r	249.6	353.2
Trade – Primary Iron and Steel[2]				
Exports ($ millions)	$ millions	310.9	267.8	382.4
Imports ($ millions)	$ millions	284.9	410.4	362.0

Source: Dominion Bureau of Statistics.

[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. Excludes sponge iron, iron castings and cast iron pipe – compilation by Mineral Resources Branch.

pPreliminary; rRevised.

TABLE 2

World Production of Crude Steel, 1968-70

(thousands of net tons)

	1968	1969[r]	1970[p]
North America, total	146,304	155,392	148,512
Canada	11,251	10,307	12,346
Mexico	3,591	3,823	4,066
United States	131,462	141,282	132,100
South America, total	8,593	8,467	10,914
Western Europe, total	159,250	169,581	175,108
Belgium and Luxembourg	18,079	20,226	19,899
France	22,491	24,807	26,189
West Germany	45,366	49,937	49,636
Italy	18,694	18,104	19,030
Netherlands	4,081	5,194	5,549
Total ECSC	108,711	118,268	120,303
Britain	28,965	29,583	30,735
Other	21,574	21,730	24,070
Eastern Europe, total	155,463	164,767	172,926
Czechoslovakia	11,676	11,923	12,640
Poland	12,133	12,443	12,739
USSR	117,064	121,536	126,730
Other	14,590	18,866	20,817
Africa and Middle East, total	5,095	5,714	5,813
Far East, total	98,347	118,551	131,758
China	15,000	17,778	18,734
India	6,953	7,226	6,965
Japan	73,730	90,547	102,846
Other	2,664	3,000	3,213
Oceania, total	7,330	7,931	7,707
Australia	7,160	7,731	7.527
Other	170	200	180
World, total	580,382	630,404	652,738

Sources: Dominion Bureau of Statistics; Annual Statistical Report, American Iron and Steel Institute; Metal Bulletin, April 2, 1971; Monthly Report of the Iron & Steel Statistics, January 1971, Vol. 14, No. 2, The Japan Iron & Steel Federation; and Bulletin de la Chambre Syndicale de la Siderurgie Française, December 1970, No. 275.

[p]Preliminary; [r]Revised.

CANADIAN PRIMARY IRON AND STEEL INDUSTRY*

Pig iron is made at seven plants in Canada and raw steel is made at 18 plants. Five of these produce both primary (pig) iron and steel. There are also three plants that have rolling mills but no iron or steel furnaces. The four largest integrated plants – two at Hamilton, Ontario, and one each at Sault Ste. Marie, Ontario, and at Sydney, Nova Scotia – accounted for about 84 per cent of both pig iron and crude steel production in 1970.

PIG IRON

Production of pig iron rose 21 per cent in 1970 to 9.1 million tons (Table 3). Production was adversely affected in 1969 by a strike at plants of The Steel Company of Canada, Limited (Stelco) and The Algoma Steel Corporation, Limited.

Most pig iron is further processed into steel at the same plants but the three smaller producers sell some or all of their output. Canada is one of the world's leading pig iron exporters and exports in 1970 were only slightly below those of 1969. Only minor tonnages are imported. Construction of a new blast furnace at Dominion Foundries and Steel, Limited (Dofasco) was almost completed at year's end and another is planned at Algoma with construction scheduled to begin early in 1973.

CRUDE STEEL

Production of crude steel rose 19.9 per cent in 1970 to 12.35 million tons (Table 4). Castings production rose 12.4 per cent to 191,720 tons. Open-hearth furnaces produced 54 per cent of total crude steel, oxygen furnaces accounted for 29 per cent, and electric furnaces produced 17 per cent of the total in 1970. Production of steel in both basic oxygen and electric furnaces, especially the former, is expected to displace that in open-hearths, which are being replaced particularly by basic oxygen furnaces. Open-hearth plants will be dismantled with perhaps some being retained on a standby basis.

Total crude steel capacity in Canada was 14.1 million tons at the end of 1970 and investment projects underway or planned will raise annual capacity to 15.5 million tons by early 1973.

*A complete listing of Canadian primary iron and steel plants including steel foundries is in the booklet "Operators List 1, Part 1: Primary Iron and Steel" (75 cents). A more comprehensive description of the industry with detailed supporting statistics, is contained in MR 92, Primary Iron and Steel in Canada (116 pages, $2.00) by G. E. Wittur and MR 113, Canadian Primary Iron and Steel Statistics to 1969 (75 cents) by V. B. Schneider. All three are available from the Mineral Resources Branch or Information Canada.

STEEL PIPE AND TUBE

The annual production capacity of the steel pipe and tube industry in 1970 was 2.61 million tons, up 65,000 tons from 1969. Ontario and Quebec were the only producing provinces in 1952 when annual capacity was 414,000 tons. Annual capacity rose rapidly in the mid-1950's when new plants were established in the three westernmost provinces. However, most of the increase in capacity occurred in Ontario. Three large pipe plants were built in Alberta in the early 1960's, mainly to service the petroleum and natural gas industries. Several mills have also been installed in the 1960's in various parts of Canada to produce tubing and specialty products including spiral-weld pipe.

With the acquisition of Page-Hersey Tubes, Limited in 1964, The Steel Company of Canada, Limited became the largest manufacturer of steel pipe and tube in Canada. Stelco now operates 13 pipe and tube mills at five locations and accounts for nearly half of Canada's steel pipe and tube capacity. In 1955, Welland Tubes Limited was formed jointly by Page-Hersey and Stelco to produce large diameter pipe at Welland, Ontario; in 1959, Camrose Tubes Limited was similarly formed at Camrose, Alberta. With the acquisition of Page-Hersey, full ownership of Welland Tubes and Camrose Tubes accrued to Stelco. In

TABLE 3

Canada, Pig Iron Production, Shipments, Trade and Consumption, 1968-70

(net tons)

	1968	1969	1970^p
Furnace capacity, December 31			
Blast furnaces	8,701,000	9,005,000	10,625,000
Electric furnaces	575,000	575,000	710,000
Total	9,276,000	9,580,000	11,335,000
Production			
Basic iron	7,517,292^r	6,556,964	8,275,191
Foundry iron	561,468^r	628,689^r	810,764
Malleable iron	242,786^r	275,517^r	*
Total	8,321,546^r	7,461,170^r	9,085,955
Shipments			
Basic iron	62,855	70,332	51,511
Foundry iron	601,366	641,304^r	803,637
Malleable iron	198,397	173,327	*
Total	862,618	884,963^r	855,148
Imports–net tons	36,777	22,944	96
–value ($000)	1,812	1,104	9,000
Exports–net tons	548,643	721,644	642,797
–value ($000)	26,967	35,815	35,320
Consumption of pig iron			
Steel furnaces	7,457,200	6,296,304	8,063,315
Iron foundries	315,658	282,591	289,939
Consumption of iron and steel scrap			
Steel furnaces	5,372,201	5,134,762	5,940,659
Iron foundries	978,797	1,063,769	869,441

Source: Dominion Bureau of Statistics, 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; ^r Revised.

TABLE 4

Canada, Crude Steel Production, Shipments, Trade and Consumption, 1968-70

(net tons)

	1968	1969	1970[p]
Furnace capacity, December 31			
Steel ingot			
Basic open-hearth	6,970,000	6,970,000	6,970,000
Basic oxygen converter	3,800,000	3,800,000	4,400,000
Electric	1,923,650	2,055,450	2,294,450
Total	12,693,650	12,825,450	13,664,440
Steel castings	420,725	415,925	418,925
Total	13,114,375	13,241,375	14,083,375
Production			
Steel ingot			
Basic open-hearth	6,189,450	5,292,069	6,906,491
Basic oxygen[e]	3,509,038	3,275,297	3,617,986
Electric	1,410,119	1,584,480	1,629,935
Total	11,108,607	10,151,846	12,154,412
of which continuously cast	1,068,282	1,212,813	1,398,463
Steel castings*	142,389	154,706	191,720
Total steel production	11,250,996	10,306,552	12,346,132
Alloy steel in total	804,659	844,086[r]	1,088,909
Shipments from plant			
Steel ingots	393,339	472,377	507,413
Steel castings	138,187	153,959	181,952
Rolled steel products	8,211,358	7,984,481	9,084,605
Total	8,742,884	8,611,177	9,773,970
Exports† – equivalent steel ingots	2,078,962	1,423,353	2,299,397
Imports† – equivalent steel ingots	1,884,983	2,934,414	2,189,320
Indicated consumption† – equivalent steel ingots	11,057,017	11,817,614	12,236,055

Source: Dominion Bureau of Statistics.

*Includes electric and basic open-hearth. †Computed by Mineral Resources Branch.

[r]Revised; [e]Estimated; [p]Preliminary.

addition, Stelco acquired Page-Hersey's remaining extensive pipe and tube making facilities at Welland, Ontario, and Page-Hersey's wholly-owned western plant at Camrose.

Canadian Phoenix Steel & Pipe Ltd. is Canada's second largest producer, accounting for a fifth of total capacity, with plants at Edmonton and Calgary, Alberta, and Port Moody, British Columbia. Total annual capacity is now 618,000 tons with the acquisition of Driam Pipe (Canada) Limited in 1968. Mannesmann Tube Company, Ltd. is the third largest with an annual capacity of 225,000 tons and Interprovincial Steel and Pipe Corporation Ltd. is fourth with 210,000 tons.

Production of steel pipe and tubing in 1970 amounted to a near record 1,065,397 tons, only slightly less than the high of 1,065,774-ton record set in 1968. Some 1,000 miles of big-inch pipe line are scheduled for construction in Canada in 1971, which is almost double the 508 miles of 1970. Total, big-inch and little-inch mileage, projects for 1971 indicate that some 6,800 miles will be constructed during 1971 in Canada compared with 6,300 miles in 1970.

The weight of steel per foot, based upon specified wall thickness, may be calculated by the following formula:

$$W = 10.68 (D-t)t$$

where W = Weight (lb per ft)

D = Specified outside diameter in inches

t = specified minimum wall thickness in inches

This formula is based on a steel density of 490 pounds per cubic foot. Therefore the weight of a mile of 48-inch pipe with a minimum wall thickness of 0.5 inch would be 669.64 tons.

OUTLOOK AND FORECAST

Prospects for the Canadian steel industry in 1971 are considered good with production expected to slightly exceed the record of 1970. An increase in consumer inventories is expected to occur during the first half of the year as a hedge against a labour strike in the United States steel industry. Export possibilities are favourable, though the world-wide demand for steel that existed through 1969 and part of 1970 is slackening. Prospects for the long term remain optimistic with a consensus of informed persons suggesting that by 1975 and 1980 domestic production capacity should reach 17.8 million and 24 million tons in terms of crude steel equivalent.

If there is a note of caution to be considered in forecasting steel production over the medium term the problems of pollution and the cost of eliminating pollution must be carefully considered. This applies not only to the capital costs under consideration by the steel industry but also to the costs of pollution control devices for some of its major customers. In some areas it is suspected that regulatory controls under consideration are ahead of the technology necessary to assure compliance. Should this prove correct, growth forecasts now predicted for the 1970's may well have to be stretched out to the mid-1980's. The steel industry of Canada is spending large sums of money on its anti-pollution controls. Dominion Foundries and Steel Limited (Dofasco) spent more than $20 million since 1950 on pollution abatement installations and has scheduled projects through 1975 amounting to some $26.5 million. The Steel Company of Canada, Limited (Stelco) spent over $23 million in the last 10 years on air and water quality control equipment and additional, equally large expenditures are expected during the next five or six years. The remainder of the Canadian steel industry has also spent, or will spend, large amounts according to the size and capacity of plants. These expenditures, though absolutely essential, are placing a burden on the capital structure of the industry; some of the steel industry's major customers face even greater challenges.

The forecast for 1971 Canadian investment expenditures are higher than those for 1970. A survey conducted by the Department of Industry Trade and Commerce among 200 major companies in manufacturing, mining, oil and gas, electric utilities, and transportation and communications shows that investment expenditures should be up some 11 per cent from those of 1970. This compares with an increase in capital outlays in 1970 of about $18,000 million which in turn was an increase of about 8 per cent over those of 1969 when they were $16,600 million. Considering the foregoing indicators and the ability of the Canadian steel industry to meet most domestic demands, Canadian steel production may approach 12.5 million tons in 1971.

A consensus of expert opinion suggests that world demand for raw materials will cause steelmakers to accelerate their development of sources of raw materials, particularly for iron ore and coal. It is most likely that joint international ventures, under long-term sales contracts with a world market orientation, will continue to be the preferred form of raw material development. With this trend, many low-grade, high-cost sources of iron ore and to a lesser extent coal, that have been kept operative just because they represent a domestic supply, will be phased out.

TRADE

Canada achieved a favourable balance of trade in primary steel products plus castings, forgings, pipe and wire in 1970. For most products, the quantity and value of exports exceeded imports, the notable exception being structurals, where imports continue to trouble the domestic industry. In this category imports at 293,000 tons were more than double the exports at 140,000 tons. However, this was a considerable improvement over the two previous years when the ratio of imports to exports was in the order of 5:1 and 4:1 (Table 8). Imports of plates also continue to exceed exports but this imbalance will probably be corrected in 1971 or 1972 when Algoma has its new 160-inch plate mill in operation. On a value comparison basis, Canadian imports of hot-rolled products exceeded the value of exports; in cold-rolled products exports and imports were in balance; and for castings, forgings and ingots the value of exports exceeded the value of imports (Table 9).

The United States continued to be Canada's most important steel trading partner for both imports and exports. Trade with Britain and the European Coal and Steel Community (ECSC) countries remained fairly constant with imports into Canada exceeding exports, usually by a wide margin. However, exports to other European countries including the USSR, which represented only 9,200 tons and 15,700 tons in 1968 and 1969, increased to 109,100 tons in 1970. The greatest imbalance between imports and exports occurs in Canadian trade with Japan where imports in 1970 amounted to 391,300 tons compared with exports that amounted to 300 tons.

RAW MATERIALS

Consumption of raw materials in the Canadian steel industry increased to meet the increase in iron and steel production. Higher quality steel products, to meet higher standards and specifications of today's advanced technology, have resulted in increased consumption of ferroalloys and other additives used by the steel industry. Not only has the total consumption of these additives increased but so has their consumption based on pounds per ton of steel produced. Their increased prices have also been a reflection of the increase in demand for steel additives.

Domestic iron ore consumption increased in total and as a percentage of total iron ore consumed, a trend that continued during the last decade as the domestic steel producers have integrated backwards into the iron ore producing industries. Most of the ore imported from the United States results from corporate ownership in mines there by Canadian steel companies.

Iron and steel scrap prices increased during the latter part of the year, particularly in the Toronto-Hamilton area. This was partly due to the increased cost and shortage of good quality coking coal in both Canada and the United States. The brokers' price for No. 1 heavy melting scrap, as quoted in the *American*

TABLE 5

Canada, Production, Trade and Apparent Consumption of Crude Steel, 1961-70
(000 net tons equivalent ingots)

	Crude Steel Production	Imports[1]	Exports[1]	Indicated Consumption[2]
1961	6,488	1,096	841	6,743
1962	7,173	1,046	990	7,229
1963	8,190	1,295	1,369	8,116
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[r]	1,884[r]	2,079	11,003[r]
1969	10,307	2,934	1,423	11,818
1970[p]	12,346	2,189	2,299	12,236

Source: Dominion Bureau of Statistics.
[1]From Trade of Canada adjusted to equivalent crude steel by Mineral Resources Branch. [2]Production plus imports, less exports with no account taken for stocks.
[p]Preliminary; [r]Revised.

TABLE 6

Canada, Net Shipments of Rolled Steel Products by Type, 1968-70
(net tons)

	1968	1969	1970
Hot-rolled products			
Semis	544,023	379,300	503,817
Rails	231,178	308,266	353,225
Wire rods	529,252	464,745	568,569
Structurals			
Heavy	459,285	464,641	618,858
Light	126,838	139,906	137,293
Bars, concrete reinforcing	646,787	699,910	730,755
Bars, other hot-rolled	754,358	744,536	807,834
Tie plate and track material	54,931	84,555	91,765
Sheet and strip	1,605,365	1,544,156	1,717,006
Plates	1,086,996	967,794	1,255,400
Total	6,039,013	5,797,809	6,784,522
Cold-rolled products			
Bars	71,962	81,831	67,391
Sheet, tin mill black-plate and tin-plate	1,510,704	1,499,340	1,602,132
Galvanized sheet	589,679	605,861	630,560
Total	2,172,345	2,187,032	2,300,083
Total shipments	8,211,358	7,984,841	9,084,605
Alloy steel in total shipments	459,374	422,414	561,336

Source: Dominion Bureau of Statistics, Primary Iron and Steel (monthly).

TABLE 7

Canada, Shipments of Rolled Steel Products (Carbon and Alloy) to Consuming Industries, 1968-70
(net tons)

	1968	1969	1970
Automotive and aircraft	826,077	847,669	855,793
Agricultural equipment manufacturers	156,612	155,105	140,565
Construction	1,442,361	1,464,012	1,577,876
Containers	483,588	497,979	515,604
Machinery and tools	269,586	287,589	297,963
Wire, wire products and fasteners	598,735	536,259	559,735
Resources and extraction	198,258	163,910	210,295
Appliances, utensils, stamping, pressing	544,099	603,212	591,053
Railway operating	255,737	325,991	405,677
Railway cars and locomotives	58,866	95,281	124,080
Shipbuilding	45,486	49,916	59,544
Pipes and tubes	1,123,585	947,116	1,121,276
Wholesalers and warehouses	969,003	1,146,923	1,232,869
Miscellaneous	81,892	86,874	64,581
Total	7,053,885	7,207,836	7,756,911
Direct exports*	1,157,473	777,005	1,327,694
Total	8,211,358	7,984,841	9,084,605

Source: Dominion Bureau of Statistics, Primary Iron and Steel (monthly).
*Does not include exports by nonproducers, nor ingots and castings.

Metal Market, rose to $32.50 a ton late in 1970 compared with $24.50 late in 1969. However, some transactions were completed in the $40-$45-a-ton range. Coking coal, which came into tight supply in 1969, became an even more serious problem in 1970. This is a world-wide problem for the steel industry and all indications are that it will persist until at least 1980. The Canadian steel industry has, in the past, relied almost entirely on coking coal sources in the United States in which the Canadian steel industry has corporate mine ownership or participation. However, indications are that western Canada coking coal may loom much larger as a source of supply for the steel mills in Ontario.

IRON AND STEEL PRICES

Steel prices rose in virtually every steelmaking country in 1969 and continued to rise in many countries for selected products during 1970. In Canada, a report by the Prices and Incomes Commission, issued in March, reported that domestic steel producers had kept their increases in line with rising costs. Subsequently, in November, Stelco announced a range of price increases from 3.3 per cent to 5.3 per cent for some products but many products were excluded from the increases. Other Canadian steel manufacturers followed Stelco's lead but, like Stelco, the increases were applied to specific products rather than across the board. In the United States, price increases were selective as domestic mills faced stiff competition from imports; they were also affected by the labour strike against General Motors. Some price increases, up to $10 a ton, were announced in February and March for sheet piling and structural shapes; there was also an increase of $10 a ton on the base price of reinforcing bars in June. According to the *American Metal Market*, November 10, 1970, European continental steel prices per metric ton, f.o.b. Antwerp, declined from $118 in January to $113 in September for wire rod, from $118 to $106 for merchant bars, and from $155 to $131 for plates.

SHIPMENTS OF STEEL PRODUCTS

The total tonnage of hot- and cold-rolled products shipped to domestic consumers in 1970 was up for almost all types of products and industries. Particularly surprising was the fact that shipments of rolled steel products to the automotive industry were slightly ahead of those for 1969 in spite of a prolonged strike at the Canadian plants of General Motors Corporation. Shipments to such industries as manufacturers of railway equipment, pipe and tube manufacturers, and resources extraction were all well ahead of those for the previous years.

During 1970 important capital investment increases occurred in the mining, manufacturing and utility groupings, which was reflected by the increased

TABLE 8

Canada, Trade in Steel Castings, Ingots and Rolled Products, 1968-70
(000 net tons)

	Imports			Exports		
	1968	1969	1970p	1968	1969	1970p
Steel castings	6.1	7.8	8.8	23.5	28.9	29.1
Steel forgings	11.9	11.1	10.7	28.6	37.8	34.0
Steel ingots	1.0	23.0	44.0	84.1	80.2	76.5
Hot-rolled products						
Semis	8.8	278.2	206.5	214.1	91.6	89.4
Rails	6.0	6.2	7.6	64.0	57.7	81.9
Wire rods	152.6	225.0	161.2	48.3	54.1	127.0
Structurals	319.4	395.9	292.9	77.5	77.9	139.7
Bars	172.8	236.7	110.0	69.5	75.4	176.1
Track material	1.7	3.2	4.2	3.2	3.5	3.5
Plates	190.8	282.4	193.3	101.6	52.9	122.8
Sheet and strip	95.4	201.4	145.9	238.1	89.7	200.1
Total, hot-rolled	947.5	1,629.0	1,121.6	816.3	502.8	940.5
Cold-rolled and other products						
Bars	11.0	20.0	16.2	11.6	11.6	14.2
Sheet and strip						
Cold-rolled	25.5	71.0	40.0	161.2	86.9	191.1
Galvanized	7.3	16.5	17.4	88.0	74.3	90.4
Other*	110.8	133.8	105.0	124.8	109.4	142.3
Pipe	188.9	209.5	207.6	283.3	170.5	236.4
Wire	67.6	92.7	76.6	18.2	15.3	18.7
Total, cold-rolled and other	411.1	543.5	462.8	687.1	468.0	693.1
Total, rolled products	1,358.6	2,172.5	1,584.4	1,503.4	970.8	1,633.6
Total, steel	1,377.6	2,214.4	1,647.9	1,639.6	1,117.7	1,773.2

Source: Dominion Bureau of Statistics, Trade of Canada. Compilation by Mineral Resources Branch.
*Includes hot-rolled stainless sheet and strip.
pPreliminary.

demand for steel. Mining investments exceeded those of 1969 by 13 per cent with gas processing plants, coal, asbestos and nickel-copper mines well above those made in 1969 and 1968. The increase in the demand for steel by the construction industry, at only 8 per cent, was disappointing and was attributable probably to the high cost of borrowing money for construction projects.

INVESTMENT AND CORPORATE DEVELOPMENTS

Capital expenditures on new iron and steel facilities in 1970 amounted to $180.9 million, which was lower than forecasts but nonetheless the third highest in the industry's history. The high cost of money, particularly during the first half of the year, influenced some companies to postpone or stretch-out capital expenditures. Anti-pollution devices are increasing the cost of new iron and steelmaking equipment up to 10 per cent. This adds little or nothing to productivity but is a necessary commitment on the part of the steel industry. A survey of the steel industry's intentions late in 1970 suggested that capital and repair expenditures for 1971 will be about $213.2 million and $185.9 million. Should these expenditures be realized, 1971 will become the peak investment year of the Canadian steel industry.

THE ALGOMA STEEL CORPORATION, LIMITED

Capital and mine development expenditures totalled $31 million compared with $40 million and $23 million in 1969 and 1968. Major items completed include relocation of a coil conveyor in the 106-inch

TABLE 9

Canada, Value of Trade in Steel Castings, Ingots and Rolled Products, 1968-70
($000)

	Imports			Exports		
	1968	1969	1970^p	1968	1969	1970^p
Steel castings	5,120	7,106	6,967	8,037	11,471	11,836
Steel forgings	14,671	11,020	11,899	14,772	19,758	18,910
Steel ingots	241	1,806	3,594	6,870	9,411	8,240
Rolled products						
Hot-rolled	123,216	211,944	176,812	107,786	83,655	149,980
Cold-rolled and others	139,824	177,399	162,692	146,517	107,681	158,142
Total	263,040	389,343	339,504	254,303	191,336	308,122
Total steel	283,072	409,275	364,964	283,982	231,976	347,108

Source: Dominion Bureau of Statistics, Trade of Canada.
Note: The values in this table relate to the tonnages shown in Table 8.
^{p}Preliminary.

TABLE 10

Canada, Trade in Steel by Country, 1968-70
(thousand net tons)

	Imports From			Exports To		
	1968	1969	1970^p	1968	1969	1970^p
United States	379.4	1,019.1	799.7	1,273.7	869.6	1,222.5
Britain	175.4	162.9	143.4	93.2	41.8	80.2
ECSC* Countries	459.4	418.6	194.2	58.2	16.6	84.2
Other Europe†	139.6	173.7	107.9	9.2	15.7	109.1
Africa	0.3	2.7	0.9	4.1	4.6	10.5
Japan	211.6	404.6	391.3	0.2	11.3	0.3
Other Asia	0.2	0.9	2.3	11.2	9.6	27.1
Latin America	–	–	0.2	167.2	121.1	190.8
Middle East	0.6	–	–	3.5	9.8	10.1
Oceania	11.1	31.9	8.0	19.1	17.6	38.4
Total	1,377.6	2,214.4	1,647.9	1,639.6	1,117.7	1,773.2

Source: Dominion Bureau of Statistics, Trade of Canada. Tabulation by Mineral Resources Branch.
Note: Products included are those listed in Table 8.
*European Coal and Steel Community (ECSC). †Includes the USSR.
^{p}Preliminary; – Nil.

wide hot strip mill to facilitate installation of the 160-inch plate mill; construction of a new ingot mould yard to improve the quality of steel and facilitate production of higher grade steels; and the construction of a railway car repair shop to replace a shop destroyed by fire.

Almost completed at year-end was the new 160-inch plate mill and it was expected to be "dry run" tested in March 1971. The 160-inch mill eventually will also act as a roughing mill for the 106-inch wide hot strip mill. The rated capacity of the mill is envisaged as approximately 408,000 tons a year of plate plus 2.4 million tons a year of coiled strip.

Other major projects either under way or announced for startup in 1971 included the relining of No. 5 blast furnace; construction of a second L-D oxy-

TABLE 11

Canada–Steel, Iron, Coke and Sinter Capacity and Production at Integrated Plants[1], 1970
(net tons)

	Algoma							
	Sault Ste. Marie	Port Colborne	Cominco Kimberley	Dofasco Hamilton	Sysco Sydney	(QIT) Tracy (Sorel)	Stelco[2] Hamilton	National Total
Crude Steel								
Facilities, Dec. 31								
Open-hearth								
Number	6	–	–	–	5	–	14	25
Capacity	1,150,000	–	–	–	1,025,000	–	4,750,000	6,970,000*
Basic Oxygen								
Number	3	–	1	3	–	–	–	7
Capacity	1,450,000	–	75,000	2,320,000	–	–	–	4,400,000*
Electric								
Number	–	–	–	5	1	–	–	..
Capacity	–	–	–	50,850	30,000	–	–	2,713,375
Total Capacity	2,600,000	–	75,000	2,370,850	1,055,000	–	4,750,000	14,083,375
Production	2,300,608	–	57,435	2,321,860	1,003,682	–	4,687,936	12,346,132
Pig Iron								
Facilities, Dec. 31								
Blast Furnaces								
Number	4	1	–	3	2	–	5	15
Capacity	2,335,000	240,000	–	1,730,000	875,000	–	4,000,000	10,625,000
Electric Furnaces								
Number	–	–	2	–	–	9	–	11
Capacity	–	–	110,000	–	–	637,000	–	710,000
Total Capacity	2,335,000	240,000	110,000	1,730,000	875,000	637,000	4,000,000	11,335,000
Production	2,216,022	223,885	107,839	1,940,617	771,252	616,000	3,339,116	9,085,955
Coke from Coal								
Facilities								
No. of Ovens	260	–	–	158	[3]	–	264	..
Capacity	1,670,000	–	–	950,000	[3]	–	1,940,000	..
Production	1,618,931	–	–	960,000	[3]	–	1,874,000	5,668,219

TABLE 11 (Cont'd)

	Algoma							
	Sault Ste. Marie	Port Colborne	Cominco Kimberley	Dofasco Hamilton	Sysco Sydney	(QIT) Tracy (Sorel)	Stelco[2] Hamilton	National Total
Sinter								
Facilities								
No. of Strands	1	–	1	–	1	–	1	8[4]
Capacity	725,000	–	300,000	–	273,000	–	900,000	. .
Production	458,916	–	171,441	–	136,569	–	742,129	5,668,219

Source: Company data supplied to Mineral Resources Branch; National total from Dominion Bureau of Statistics.

*Totals do not agree with those of D.B.S. because D.B.S. has included increases in production scheduled to come into effect early in 1971.

[1]The seven plants listed accounted for all the pig iron and 84 per cent of the crude steel produced in 1970. [2]Stelco has an electric furnace plant (132,000 tons a year capacity) at Edmonton. [3]Coke ovens formerly owned by Sysco were sold to Cape Breton Development Corp. (Devco) in 1968. Devco has 114 ovens with an annual capacity of 612,000 tons of coke and produced 586,000 tons in 1970. [4]Includes four strands at Algoma Ore Properties Division, Wawa, Ontario.

– Nil; . . Not available.

TABLE 12

Canada, Consumption of Raw Materials at Pig Iron and Integrated Steel Plants[1], 1970
(net tons)

		In Iron and Steel Furnaces		
	In Sinter Plants	Pig Iron Furnaces[2]	Steel Furnaces	Total in Furnaces
Iron Ore				
Crude and concentrate	469,415	306,092[3]	98,465	404,557
Pellets	169,993	9,964,825	275,887	10,240,712
Sinter	148,836	2,916,928	1,114	2,918,042
Total iron ore	788,244	13,187,845	375,466	13,563,311
Contained iron	459,867	8,074,295	253,958	8,328,253
Other Iron-Bearing Materials				
Flue dust	158,038	–	–	–
Scale, sponge-iron, etc.	423,143	121,897	8,203	130,100
Total	581,181	121,897	8,203	130,100
Contained iron	359,020	74,358	4,922	79,280
Other Materials				
Ferromanganese	–	130	92,690	92,820
Pig iron	–	n.a.	8,037,588	8,037,588
Scrap: own make	48,677	69,016	2,970,150	3,039,166
purchased	8,991	145,521	841,175	986,696
Total	57,668	214,537	3,811,325	4,025,862
Coke	30,764	4,605,125	615	4,605,740
Stone: Limestone	169,694	625,414	197,367	822,781
Dolomite	218,911	476,053	109,187	585,240
Total	388,605	1,101,467	306,554	1,408,021
Burnt stone: Lime	–	–	318,948	318,948
Dolomite	–	–	122,101	122,101
Total			441,049	441,049

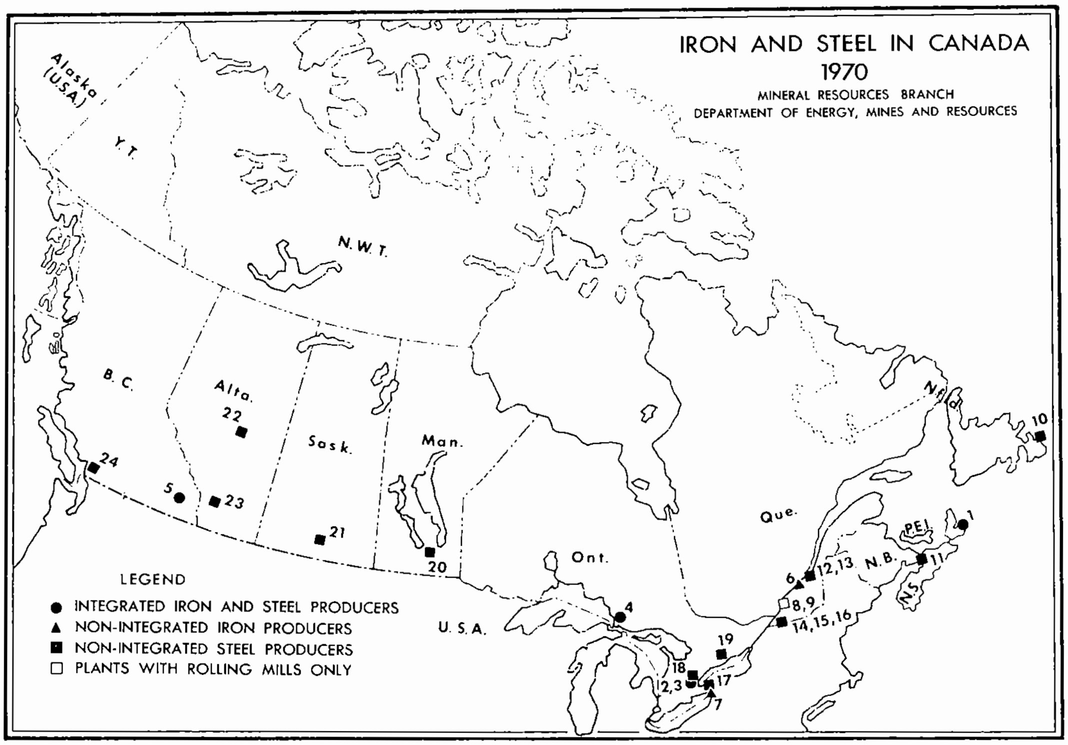
Source: Company data supplied directly to Mineral Resources Branch.
[1]Includes plants listed in Table 11 except QIT. [2]Blast and electric furnaces. [3]Excludes 1,759,794 net tons of ilmenite iron which 594,944 net tons of iron was recovered.
– Nil; n.a.– Not available.

gen steel plant that along with other major facilities will increase annual raw steel capacity to 4 million tons a year by mid-1975; installation of a second lime kiln to produce burnt lime for the second L-D oxygen steel plant, and pollution abatement devices to reduce, and eliminate where possible, impurities being discharged into the air and the St. Mary's River. Construction of a new No. 7 blast furnace having a capacity of over 5,000 tons of pig iron a day is scheduled to begin early in 1973 for completion in the fall of 1974 at a capital cost of $45 million.

Algoma announced that it is negotiating to lease the seamless tube plant of Mannesmann Tube Company, Ltd. that is adjacent to the company's Sault Ste. Marie plant. If negotiations are successful, the tube plant will be operated as a Division of Algoma.

ATLAS STEELS DIVISION OF RIO ALGOM MINES LIMITED

The Company's major long-term program to modernize its Welland, Ontario, plant continued through 1970. New major bar finishing units were put into operation and a major rehabilitation and re-arrangement of the conditioning department and billet stock area began; six modern machine grinders are being installed, a new outdoor billet stock area is in operation and a new building for the staging and the



INDEX FOR MAP

IRON AND STEEL IN CANADA, 1970

INTEGRATED IRON AND STEEL PRODUCERS •

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. Cominco Ltd. (Kimberley)

NON-INTEGRATED IRON PRODUCERS ▲

6. Quebec Iron and Titanium Corporation (Sorel)
7. Canadian Furnace Division of Algoma (Port Colborne)

PLANTS WITH ROLLING MILLS ONLY □

8. Dominion Steel and Coal Corporation, Limited (Contrecoeur)
9. The Steel Company of Canada, Limited (Contrecoeur)

NON-INTEGRATED STEEL PRODUCERS (a partial listing)

10. Newfoundland Steel (1968) Company Limited (Octagon Pond)
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. Dominion Steel and Coal Corporation, 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)

TABLE 13

Canada, Energy and Reductant Consumption at Major Integrated Steel Plants*, 1970

	Coal (net tons)	Coke (net tons)	Coke Oven Gas (mill. cu. ft.)	Tar and Pitch (000 Imp. gal.)	Nat. Gas (mill. cu. ft.)	Fuel Oil (000 Imp. gal.)	Oxygen (mill. cu. ft.)	Electricity (mill. kwh)
In coke ovens**	7,457,304	–	21,007	–	–	–	–	56.6
In sinter plants	. .	30,764	398	–	–	–	–	24.3
In iron furnaces	. .	4,576,303	3,948	. .	. .	48,895	23	408.4
In steel furnaces	–	. .	4,736	. .	. .	65,562	14,696	355.9
In other uses	117,393	33,949	43,556	. .	. .	72,666	1,158	1,815.7
Total Consumption	7,574,697	4,641,016	73,645	12,067	16,538	187,123	15,877	2,660.9

Source: Data supplied by companies to Mineral Resources Branch.
*Includes all plants listed in Table 11 except QIT.
**Includes coal used by Devco which took over Sysco coke ovens, May 1, 1968.
– Nil; . . Included in total, publication would disclose individual company data.

preparation of billets for rolling has been completed. The capability of the plant's melt shop laboratory was improved by the addition of new spectrometer and x-ray units. These units together with a computerized in-process analytical system is expected to increase the total plant efficiency.

Research and development programs directed toward reducing the cost of operations included research into the possibilities of using a higher proportion of low-grade ferrochromium; vacuum decarburization of stainless steel, also under investigation, is expected to result in cost reductions at the company's Tracy, Quebec, plant. The company announced that electro-slag refining of steel is reaching production status, with proven advantages for the company's high-quality steel grades and that a powder metallurgy program, which uses new techniques, is ahead of schedule.

CANADIAN PHOENIX STEEL & PIPE LTD.

Canadian Phoenix, which operates plants at Toronto, Calgary, Edmonton and Port Moody, added a OEW Spiral Weld mill to its Edmonton works. This mill can produce spiral weld pipe with diameters from 16 inches to 80 inches and has an annual capacity of 48,000 tons. The company also modified its Calgary plant so that it can now produce pipe up to 42 inches in diameter. Previously, 36 inch was the maximum capability of the Calgary plant. Canadian Phoenix is continuing to study the feasibility of integrating backwards to the production of steel in Alberta.

DOMINION FOUNDRIES AND STEEL, LIMITED

Capital expenditures in 1970 by Dofasco amounted to $73 million and are expected to amount to $85 million in 1971. The bulk of these expenditures were for installations scheduled for completion in 1971. Among these are included a fourth blast furnace and a fifth battery of coke ovens to increase Dofasco's ironmaking and cokemaking capacities by 50 and 30 per cent. The expansion of the steelmaking division will increase capacity by more than 25 per cent. Included in this project is the installation of a flux system for more efficient handling and accurate measurement of materials charged into the steelmaking furnaces. Hot-rolling capacity will be increased by 20 per cent by the addition of a 2-high slabbing mill, six soaking pits, and a downcoiler.

Production capacity is being increased in the cold-rolling division by the addition of increased annealing facilities, the installation of an additional 56-inch cold mill, and the construction of a third electrolytic tinning line.

DOMINION STEEL AND COAL CORPORATION, LIMITED

Through DOSCO, Sidbec operates four plants in Canada–three in Quebec and one in Ontario. These plants have a combined potential capacity of over 700,000 tons of finished products. They include steelmaking and rolling facilities in Montreal, a rolling mill for bars and sheet at Contrecoeur, Quebec, and fabricating or finishing plants in the Montreal area and at Toronto, Ontario. Steelmaking capacity at the Montreal Works was increased in 1970 by 200,000 tons a year to 365,000 tons a year by the installation of a 50-ton, 30,000 kva furnace.

Sidbec announced a five-year plan to build a steelmaking complex at Contrecoeur and expand the Montreal Works. The estimated cost of the program is $128 million, with $80 million to be invested in additional steelmaking capacity and $48 million to expand the present rolling and finishing facilities.

The steelmaking facilities will include two 100-ton 50,000 kva electric furnaces with a combined annual capacity of 500,000 tons of steel. The project also includes a 6-strand casting machine capable of casting 3½-inch and 7½-inch square billets.

INTERPROVINCIAL STEEL AND PIPE CORPORATION LTD. (IPSCO)

IPSCO started production from a second spiral-weld mill at its Regina plant in 1970. The new facility has doubled the company's capacity to produce large diameter pipe from 48,000 tons a year to 96,000 tons a year. Installation of IPSCO's third electric furnace in May 1970 boosted ingot production capacity to 210,000 tons a year and the completion of two additional soaking pits in February 1971 will further increase the rate to 250,000 ingot tons a year. The expansion program of 1970 cost some $2.5 million and IPSCO has indicated that its expansion program for 1971-72 will cost $2.9 million and will boost ingot capacity to 350,000 tons a year, extend the range of coiled skelp width from 62 inch to 72 inch and further expand capacities in the pipe mills.

THE STEEL COMPANY OF CANADA, LIMITED

The Steel Company of Canada, Limited announced expenditures totalling some $200 million to raise the production and processing capacity of its Hilton Works from 4.75 million tons to 6 million tons of crude steel a year. Capital expenditures in 1970 amounted to $89.5 million compared with $33.3 million in 1969.

New installations included a third, $16-million, electrolytic tinning line; a new battery of 83 coke ovens; many pollution abatement projects; blast furnace modifications which, when completed, will increase output by some 200,000 to 400,000 tons a year; and the development of a new coal property in West Virginia. Work on the basic oxygen steelmaking furnace is progressing on schedule; the first heat is expected by mid-1971. However, the Lake Erie complex, which had been scheduled to get under way early in 1970, was deferred indefinitely and will have to await completion of the current expansion at the Hilton Works that will be completed in 1972.

SYDNEY STEEL CORPORATION

Sydney Steel Corporation (Sysco), the Nova Scotia Crown Corporation that operates Dosco's former Sydney Works, announced a $94-million modernization program that will take 2½ years to complete from its beginning late in 1970. The program includes basic oxygen steelmaking units to replace the open-hearth furnaces now in use, facilities to produce continuous cast blooms and billets, and facilities to produce vacuum-degassed steel. Approximately one sixth of the cost of the new program will be provided by the federal government as development incentive grants.

TABLE 14

Canada – Tariffs on Selected Iron and Steel Materials.

Tariff Item			British Preferential	Most Favoured Nation	General
32905-1	Iron ore		free	free	free
37301-1 37302-1 37303-1	Iron and steel scrap		free	free	free
37400-1	Pig iron, n.o.p.	per ton	free	free	$2.50
37600-1	Sponge iron		free	free	free
37700-1	Ingots of iron or steel, n.o.p.	per ton	free	free	$5.00
37800-1	Iron or steel, semi-finished, namely: blooms, slabs, billets or sheet bars		free	5%	10%
37900-1	Bars or rods, hot-rolled		5%	10%	20%
37905-1	Bars or rods, cold-rolled		5%	12½%	25%
37915-1	Rods for wire manufacture	per ton	free	$3.00	$5.00
37920-1	Rods for fencing wire manufacture (expires 31 October, 1971)	per ton	free	free	$5.00

Table 14 (Cont'd)

Tariff Item			British Preferential	Most Favoured Nation	General
37950-1	Shapes or sections, n.o.p., not further manufactured than extruded or drawn		10%	12½%	35%
	Shapes or sections of iron or steel, not further manufactured than hot- or cold-rolled				
38001-1	Angles, beams, channels, tees, zees, and other shapes		5%	10%	20%
38002-1	Large sections–not made in Canada	per ton	free	$5.00	$20.00
38100-1	Plate, hot- or cold-rolled		5%	10%	20%
38105-1	Plate, flanged or dished		5%	15%	30%
38110-1	Plate of iron or steel, n.o.p.		5%	12½%	25%
	Sheet or Strip				
38201-1	Sheet or strip, hot-rolled		5%	10%	20%
38202-1	Sheet or strip, cold-rolled		5%	12½%	25%
38203-1	Sheet or strip, coated with tin or enamel		10%	12½%	25%
38204-1	Sheet or strip, coated with zinc		7½%	12½%	25%
38205-1	Sheet or strip, n.o.p.		7½%	12½%	20%
38400-1	Skelp (plate, sheet, strip, hot- or cold-rolled for mfg. pipe, tubes)		free	7½%	15%
38700-1	Rails		5%	10%	20%
39000-1	Castings, rough, n.o.p.		15%	15%	27½%
39005-1	Piston ring castings, rough		free	free	27½%
39101-1	Ingot moulds for steel production		free	free	free
39102-1	Ingot moulds, n.o.p.		free	7½%	10%
39200-1	Forgings		15%	17½%	30%
39900-1	Pipes, large diameter		10%	15%	30%
40101-1	Wire, round, n.o.p.		2½%	7½%	20%
40102-1	Wire, other, n.o.p.		5%	10%	20%
40103-1	Wire, coated or covered, n.o.p.		5%	10%	20%

Source: Canada
The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Further details and specific variations may be obtained from the above authority.

n.o.p. – Not otherwise provided.

Lead

J.G. GEORGE*

Canada's recoverable production of lead increased to 383,208 short tons** in 1970, about 20 per cent more than in 1969 and the highest on record. Much higher production by Anvil Mining Corporation Limited, in the Yukon Territory, that completed its first full year's operation accounted for most of the increase. The remainder of the increase came largely from greater output by the Sullivan mine of Cominco Ltd. in British Columbia and by Heath Steele Mines Limited in New Brunswick. Also contributing to the increase was initial output by five new silver-lead-zinc mines; one in Quebec, three in British Columbia and one in the Yukon Territory. Further details are given later in the text. In March and August operations were suspended at the properties of Utica Mines Ltd. and Canadian Exploration, Limited, respectively; both in southeastern British Columbia. Because of greater output, the value of Canadian lead mine production was some $24.5 million higher than that of 1969.

Primary refined lead output totalled 204,630 tons compared with 187,143 tons in 1969. Cominco Ltd. operated its smelter and refinery at Trail, British Columbia, at slightly less than capacity of 190,000 tons annually. The lead refinery of East Coast Smelting and Chemical Company Limited at Belledune, New Brunswick with annual capacity of 30,000 tons, remained Canada's only other producer of primary lead metal.

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 that portion of the output of Brunswick Mining and Smelting Corporation Limited smelted at the East Coast plant, were shipped to Trail, British Columbia and smelters in the United States and Europe.

Exports of ores and concentrates were over 18 per cent higher than in 1969, with more than 70 per cent of them going to Japan and the United States. Metal exports in 1970 were almost 43 per cent higher than in 1969, with the United States and Britain continuing to be the major customers. Imports of refined lead metal were 2,199 tons compared with 131 tons in 1969.

Statistics are not available for Canadian consumption of lead metal in 1970, but in 1969 reported consumption of primary and secondary lead was 72,152 and 35,118 tons, respectively.

UNITED STATES IMPORTS AND STOCKPILES

United States imports of lead metal and lead in ores and concentrates totalled 355,800 tons in 1970, about 8 per cent less than those in 1969. Virtually all of the reduction occurred in metal imports since there was very little change in imports of lead in ores and concentrates. The decrease resulted mainly from a domestic oversupply of lead which developed largely as a result of the economic slowdown in the United States economy.

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*Mineral Resources Branch.

**Wherever used in this review, the term "ton" refers to the short ton of 2,000 pounds avoirdupois, unless otherwise stated.

TABLE 1

Canada, Lead Production, Trade and Consumption, 1969-70

	1969		1970p	
	Short Tons	$	Short Tons	$
Production				
All forms[1]				
Northwest Territories	106,457	32,299,014	110,000	34,804,000
British Columbia	105,036	31,868,008	107,917	34,145,100
Yukon Territory	14,028	4,256,183	68,737	21,748,500
New Brunswick	51,092	15,501,384	62,130	19,658,000
Newfoundland	22,207	6,737,575	20,215	6,395,900
Ontario	12,097	3,670,117	10,260	3,246,200
Quebec	1,558	472,565	2,109	667,100
Nova Scotia	2,735	829,752	1,299	411,000
Manitoba	560	169,961	541	171,100
Saskatchewan	2,862	868,310	–	–
Total	318,632	96,672,869	383,208	121,246,900
Mine output[2]	332,903		394,548	
Refined[3]	187,143		204,630	
Exports				
Lead contained in ores and concentrates				
Japan	37,808	7,078,000	77,080	17,072,000
United States	62,211	10,865,000	41,020	8,118,000
West Germany	18,070	2,995,000	22,347	4,037,000
Belgium and Luxembourg	12,194	2,216,000	20,456	3,614,000
Britain	7,860	1,381,000	2,833	492,000
Other countries	2,032	295,000	2,176	360,000
Total	140,175	24,830,000	165,912	33,693,000
Lead in pigs, blocks and shot				
United States	45,593	12,225,000	56,965	16,444,000
Britain	42,243	10,100,000	56,217	15,010,000
India	3,734	900,000	18,909	5,088,000
Netherlands	3,169	759,000	5,302	1,363,000
West Germany	7,107	1,745,000	3,975	1,114,000
Italy	–	–	2,848	791,000
Yugoslavia	–	–	1,987	459,000
Pakistan	–	–	1,959	603,000
Argentina	–	–	1,538	451,000
Iran	–	–	1,102	249,000
Other countries	5,244	1,273,000	2,019	572,000
Total	107,090	27,002,000	152,821	42,144,000
Lead and lead-alloy scrap (gross weight)				
United States	5,189	1,152,000	1,901	592,000
South Africa	–	–	1,527	250,000
Belgium and Luxembourg	524	34,000	1,113	237,000
West Germany	49	10,000	751	157,000
Other countries	550	153,000	450	131,000
Total	6,312	1,349,000	5,742	1,367,000

TABLE 1 (Cont'd)

	1969		1970p	
	Short Tons	$	Short Tons	$
Exports (Cont'd)				
Lead fabricated materials, not elsewhere specified				
United States	3,564	1,291,000	6,582	3,316,000
Australia	8	4,000	20	11,000
Denmark	–	–	20	12,000
Other countries	120	96,000	4	5,000
Total	3,692	1,391,000	6,626	3,344,000
Imports				
Lead pigs, blocks and shot	131	56,000	2,199	668,000
Lead oxide; litharge, red lead, mineral orange	3,261	967,000	1,878	672,000
Lead fabricated materials, not elsewhere specified	408	324,000	382	334,000
Total	3,800	1,347,000	4,459	1,674,000

	1969			1970p		
	Primary	Secondary[4]	Total	Primary	Secondary[4]	Total
	(Short Tons)			(Short Tons)		
Consumption						
Lead used for, or in the production of:						
Antimonial lead	2,180	*	*	1,412	*	*
Battery and battery oxides	28,597	19,887	48,484	20,273	20,199	40,472
Cable covering	2,812	*	*	2,296	*	*
Chemical uses:						
white lead, red lead, litharge, tetraethyl lead, etc.	21,795	*	*	22,112	*	*
Copper alloys: brass, bronze, etc.	380	*	*	318	*	*
Lead alloys–solders	3,041	2,914	5,955	2,527	2,977	5,504
–other (including babbitt, type metal, etc.)	249	2,059	2,308	268	2,875	3,143
Semi-finished products:						
pipe, sheet, traps, bends, blocks for caulking, ammunition, foil, collapsible tubes, etc.	11,215	829	12,044	8,570	479	9,049
Other	1,812	2,665	4,477	2,367	1,599	3,966
Total**	72,081	33,834	105,915	60,143	33,294	93,437

Source: Dominion Bureau of Statistics.

[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] 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.

* Not available for publication; ** Total includes figures for all categories.

p Preliminary; – Nil.

In July 1969, the United States government authorized the release of 100,000 tons of lead from the government's national stockpiles. All sales were to be made by General Services Administration (GSA) and were for domestic consumption only. Up to the end of 1970 some 22,700 tons were sold (of which only 22 tons were disposed of in 1970), leaving an unsold balance of 77,300 tons. Of a prior stockpile release of 50,000 tons for government use only, authorized in April 1965, about 18,700 tons had been sold by the end of December 1970. The lead inventory in the stockpile at the end of 1970 amounted to some 1.14 million tons, of which 0.61 million tons were considered to be surplus to conventional and nuclear war requirements. The stockpile objective remained at 530,000 tons.

Of the total industrial stocks of 242,400 tons on hand at the end of 1970, 117,600 tons were in the hands of consumers with the remainder held by producers. Corresponding figures at the end of 1969 were 197,500 and 150,900 tons, respectively.

Early in 1970, officials of the United States government administration and representatives of the lead industry began closed discussions of a proposal for the industry to dispose of the excess inventory of lead in the government stockpile, then amounting to 623,000 tons. The plans, which were eventually shelved, called for flexible quarterly sales quotas and envisaged a long-range disposal program, possibly over a period of 10 years or more.

In February 1970, Bills HR15834 and S3447 to dispose of 498,000 tons of lead, were introduced in Congress. Hearings were conducted on these Bills but no final action was taken. It was expected that the Bills would be reintroduced in the new Congress which convened in January 1971.

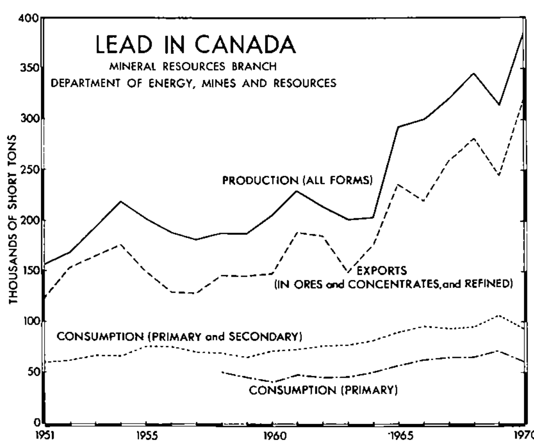
On May 20, 1970, President Nixon announced his intention to request Congress to enact an environmental control tax on lead additives used in motor fuels. The primary announced purpose of the tax was to provide an incentive for the rapid development of gasoline with a low and eventually lead-free content. The proposed tax was to be effective July 1, 1970 and was to take the form of an excise tax at the rate of $4.25 per pound of lead contained in gasoline additives. The tax would have been equivalent to about 2.3 cents per gallon on regular automobile gasoline if no reduction were made in the lead additive content. The tax bill, introduced later, was referred to as the "Clean Air Tax Act of 1970". On September 9, 1970, the Bill came before a hearing of the House Ways and Means Committee but was not approved.

The lead industry has adamantly opposed the proposed tax on lead in gasoline. Its grave concern is determined by the fact that about 270,000 tons of lead is used annually in the United States in gasoline anti-knock compounds. This quantity represents approximately 20 per cent of total consumption, including secondary and imported lead; and in 1969 it was equivalent to more than 50 per cent of the newly mined lead production in the United States.

WORLD PRODUCTION AND CONSUMPTION

Non-communist world mine production of lead, according to statistics published by the International Lead and Zinc Study Group, was 2.80 million tons in 1970, or almost 5 per cent higher than in 1969. Substantial increases in output in the United States and Canada, together with greater production in Peru, Yugoslavia and Mexico, more than offset declines in Australia, the Republic of South Africa, Italy and some other countries. Canada remained the non-communist world's third largest producer following the United States and Australia. Non-communist world production of refined lead was an estimated 3.63 million tons, or some 69,100 tons more than in 1969. Britain, Japan, Canada and France, reported the largest increases in refined lead production.

Mine production of lead in the United States rose significantly from 530,211 tons in 1969 to 603,184 tons in 1970. Increased output from mines in the New Missouri Lead Belt in southeast Missouri accounted for most of the increase. Output from the State of Missouri represented 75 per cent of United States production. Primary refined lead output in the United States totalled 674,366 tons in 1970 compared with 643,621 tons in 1969.



Consumption of lead in the non-communist world rose in 1970 to a new record high of 3.54 million tons, an increase of almost 3 per cent from 1969. The United States remained the world's largest consumer, using 1.24 million tons or some 32,200 tons less than in 1969. An increase in the requirements of lead for gasoline anti-knock additives was more than offset by declines in almost all other uses for lead in the United States, including that for storage batteries.

TABLE 2

Canada, Lead Production, Trade and Consumption, 1961-70
(short tons)

	Production		Exports				
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total	Imports Refined[3]	Consumption[4]
1961	230,435	171,833	70,967	117,637	188,604	1,121	73,418
1962	215,329	152,217	59,495	125,802	185,297	578	77,286
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
1970p	383,208	204,630	165,912	152,821	318,733	2,119	93,437

Source: Dominion Bureau of Statistics.

[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.

In reviewing the statistical position and outlook for lead at its November 1970 meeting in Geneva, Switzerland, the International Lead and Zinc Study Group noted that after an exceptional expansion of consumption of lead in 1968 and 1969, there had been a set-back in the growth in consumption in 1970, particularly in the United States and other countries where measures had been taken to curb inflation. For 1971, the Study Group forecast increases in both mine and metal production, but consumption was forecast to resume a more normal rate of growth.

Because of the lower demand resulting from a slowdown in the general economy, rather than from any specific problem in the lead industry itself, several companies in Canada, the United States and Japan announced, in the second half of 1970, voluntary curtailments in refined lead production. These cutbacks generally amounted to about 10 per cent of output and in some cases applied to both mine and metal production.

There was no significant change in lead smelter capacity in 1970. An Imperial Smelting Furnace (ISF) plant, with annual capacity of 44,000 tons of refined lead, was scheduled to open in Italy, and it was planned to increase productive capacity at a conventional smelter in Japan from 32,000 to 40,000 tons a year. Another ISF plant, with annual capacity of 33,000 tons, was planned for installation in Yugoslavia with operations due to start in 1973. The lead smelter and refinery at Selby, California, was to be closed down early in 1971. This custom smelter, which had been in continuous operation since 1885, had for several years been operating at only 50 to 60 per cent of capacity. A combination of rising cost and changing patterns in world trade finally made it economically obsolete.

Although five large lead mines were opened in 1968-69 in the New Missouri Lead Belt district of southeastern Missouri, it was not until 1970 that these mines reached normal operating conditions, because of labour shortages, strikes and some specific technical operating problems. No new significant-size lead mines were brought into production in the non-communist world in 1970. Three new lead-producing mines were scheduled to begin operations in 1971; one in Nicaragua, the second in the United States and the third in Morocco. Expansion of output was planned for a mine in Australia, one in Japan and another in Peru. Two new lead-producing mines were expected to begin operations in 1972; one in Peru and the other a zinc-copper-lead-silver property in the Sturgeon Lake area of northwestern Ontario to be operated by Mattabi Mines Limited. Expansion of existing facilities was planned for another lead-producing mine in Yugoslavia. Another lead-producing mine was scheduled to begin operations in the United States in 1973 and other such mines in Spain in 1975.

OUTLOOK

Canada's mine production of lead in 1971 is forecast to be some 430,000 tons, and during the period

1972-76 it could range between 425,000 and 475,000 tons annually.

Although a reasonably good demand is expected to prevail for lead over the next few years, the long-term outlook is somewhat indefinite because of the threatened elimination of lead additives from gasoline. The use of lead anti-knock compounds to raise the octane rating of gasoline accounts for about 20 per cent of consumption in the United States, the world's largest consumer of lead. Should governments decide to legislate the removal of lead from gasoline, a market weakness could develop if tetraethyl lead is to be withdrawn on short notice and reduced growth in lead consumption could be expected over the near term. If lead is phased out over a long period, the market may be able to absorb the loss through substantial growth in alternative uses of lead and expanded markets in the developing countries. It is also possible that the use of lead anti-knock additives in gasoline may continue. Devices have been developed to reduce the lead content of exhaust gases to permissible levels. The applicability of these devices, the degree of air pollution properly attributable to lead compounds, and the problems of operating motor vehicles on non-leaded gasoline, leave the market outlook for lead in this important industrial use uncertain.

Serious difficulty is not anticipated in selling in foreign markets the substantial portion of Canadian output of both refined lead metal and lead contained in ores and concentrates that will be surplus to domestic requirements. However, because of the substantial increases expected in United States lead output resulting from rising production in the New Missouri lead belt area, a greater portion of Canada's exports might have to find markets in other foreign countries.

CANADIAN DEVELOPMENTS

YUKON TERRITORY

A sharp increase in lead output in 1970 in the Yukon Territory resulted from much greater production at the lead-zinc-silver property of Anvil Mining Corporation Limited which completed its first full year of operations. Also contributing to the Territory's increase was initial output by Venus Mines Ltd. which began tune-up operations at the 300-ton-a-day mill at its gold-silver-lead-zinc property about 18 miles south of Carcross.

Hart River Mines Ltd. was considering bringing into production, in late 1970 or early 1971, its silver-base-metals property in the Yukon Territory some 85 air miles northeast of Dawson City. Hudson Bay Mining and Smelting Co., Limited continued development work at its silver-lead-zinc "Tom" claims on the Canol Road near the Yukon-Northwest Territories border. An adit was advanced 1,700 feet into the mountain as a part of a planned program that will include some 5,000-6,000 feet of underground development work and about 20,000 feet of diamond drilling. Matt Berry Mines Limited completed an agreement with Canadian Nickel Company Limited (a subsidiary of The International Nickel Company of Canada, Limited) and Metallgesellschaft Canada Limited for a continuing program of exploration, which will include some drilling, on its silver-base-metals property in the Frances Lake area. Previous diamond drilling indicated a deposit containing 415,000 tons with grade averaging 9.12 per cent lead, 6.25 per cent zinc, and 4.33 ounces silver a ton.

TABLE 3

Non-Communist World Mine Production of Lead, 1969-70

(short tons)

	1969	1970P
United States	530,200	603,200
Australia	484,600	477,900
Canada	330,700	388,200
Mexico	183,400	189,100
Peru	170,900	180,800
Yugoslavia	122,700	130,200
Morocco	85,500	..
Sweden	84,200	81,100
Republic of South Africa	83,400	77,700
Spain	76,600	76,400
Japan	70,000	71,000
Ireland	64,700	65,400
West Germany	48,000	47,100
Italy	40,800	38,400
Other countries	293,900	372,500
Total	2,669,600	2,799,000*

Source: International Lead and Zinc Study Group, monthly bulletin May 1971.
*Total includes estimates for those countries for which figures are not available.
P Preliminary; .. Not available.

NORTHWEST TERRITORIES

Pine Point Mines Limited, 69 per cent owned by Cominco Ltd. was again Canada's largest single mine producer of lead. Lead output, at its lead-zinc property near Pine Point on the south shore of Great Slave Lake, was considerably higher than in 1969. Cadillac Explorations Ltd. concluded an agreement with Penarroya Canada Limited whereby the latter agreed to spend up to $3 million for exploration and development work at Cadillac's Prairie Creek silver-lead-zinc property in the Nahanni Mining District some 110 miles due west of Fort Simpson. Diamond drilling and drifting have reportedly indicated reserves averaging

11.48 per cent lead, 13.65 per cent zinc, 0.3 per cent copper and 5.81 ounces silver a ton. Under an agreement with Bathurst Norsemines Ltd., Cominco Ltd. did diamond drilling and other exploration work on the Norsemines silver-base-metals prospect in the Hackett River area about 300 miles northeast of Yellowknife, Northwest Territories. Cominco Ltd. conducted detailed field examinations in 1970 preparatory to the formulation of a diamond drilling program for 1971 at the lead-zinc prospect of Bankeno Mines Limited on Little Cornwallis Island. Cominco operates the property and holds a 75 per cent interest in it.

BRITISH COLUMBIA

Cominco Ltd. operated two lead-zinc mines in the southeastern part of the province - the Sullivan and Bluebell. Concentrates from these mines, from Pine Point Mines Limited, and from custom suppliers were treated at Cominco's metallurgical works at Trail which include a lead smelter and refinery. On August 1, 1970, the Jersey lead-zinc mine of Canadian Exploration, Limited near Salmo ceased operations because of exhaustion of ore reserves. The mine had been in almost continuous operation since March 1949, but during the past year production was derived mainly from ore remnants and pillar recovery. The Company is a wholly-owned subsidiary of Placer Development Limited. On March 31, 1970 milling operations ceased at the silver-lead-zinc property of Utica Mines Ltd. near Keremeos. The plant had been in continuous operation since August 1967 and produced a relatively small byproduct output of lead.

Mill tune-up operations began in August 1970 at the Ruth-Vermont lead-zinc-silver property of Copperline Mines Ltd. in the East Kootenay district near Golden. Mill capacity is 600 tons a day. Copperline holds a 60 per cent interest in the property with the remaining 40 per cent held by Columbia River Mines Ltd. Proven ore reserves were estimated at some 650,000 tons grading 3.21 per cent lead, 3.95 per cent zinc, and 4.55 ounces silver a ton. Operations also began in August 1970 at the silver-lead-zinc property of Silmonac Mines Limited near New Denver in the Slocan district of southeastern British Columbia. The ore is custom-milled at a nearby concentrator. Initial mill rate was 130 tons a day and it was expected that the rate would soon be increased to 150 tons daily. Probable ore reserves have been estimated at 230,000 tons grading about 15 ounces silver a ton, 5 per cent lead and 8 per cent zinc. The operation is financed and managed by a syndicate headed by Kam-Kotia Mines Limited. Underground exploration and development work continued at the copper-lead-zinc-silver property of Nadina Explorations Limited near Owen Lake, about 30 miles southwest of Housten in central British Columbia.

MANITOBA-SASKATCHEWAN

Byproduct lead was again produced in Manitoba at copper-zinc mines, in the Flin Flon and Snow Lake areas, operated by Hudson Bay Mining and Smelting Co., Limited. The lead was recovered in a lead concentrate produced at the company's central mill at Flin Flon, Manitoba. No output of lead was recorded for Saskatchewan in 1970 because of the cessation of operations in July 1969 at the zinc-lead-copper-silver mine of Western Nuclear Mines, Ltd. at Hansen Lake in northern Saskatchewan.

ONTARIO

Production of lead in Ontario in 1970 was somewhat lower than that of 1969, mainly because of reduced byproduct output at the Kidd Creek silver-base-metal mine of Ecstall Mining Limited near Timmins. The decrease at this particular mine is thought to have been caused by lower lead content of the millheads.

A new company, Mattabi Mines Limited, owned 60 per cent by Mattagami Lake Mines Limited and 40 per cent by Abitibi Paper Company Ltd., was incorporated late in 1970 to acquire the mineral lands containing the major ore deposit discovered by Mattagami on Abitibi's timber limit Block 7 in the Sturgeon Lake area northwest of Lake Superior. The mine is now being developed for production at an anticipated rate of 3,000 tons a day, with operations expected to begin about mid-1972. Ore reserves have been estimated at some 13 million tons grading 7.6 per cent zinc, 0.91 per cent copper, 0.84 per cent lead, and 3.13 ounces of silver and 0.007 ounce of gold a ton. In October 1970, Falconbridge Nickel Mines Limited made an important discovery when drilling an anomaly on property optioned from New Brunswick Uranium Metals & Mining Limited and which adjoins the Mattagami Lake claims on the east, in the Sturgeon Lake area. Falconbridge planned to do considerably more follow-up drilling to further probe the anomaly containing copper-zinc-lead-silver mineralization.

QUEBEC

Lead production in Quebec remained small with the two principal producers being the Solbec and Cupra Divisions of Sullivan Mining Group Ltd. at Stratford Centre in the Eastern Townships.

NEW BRUNSWICK

Mine production of lead was sharply higher in 1970 at the copper-lead-zinc property of Heath Steele Mines Limited in the Newcastle area. The company's expanded facilities, involving a doubling of its mill capacity from 1,500 to 3,000 tons daily, came on stream in the first quarter of 1970. The base-metal property of Brunswick Mining and Smelting Corporation Limited near Bathurst, however, continued to be the principal lead producer in New Brunswick, accounting for about 70 per cent of provincial output.

TABLE 4

Principal Lead Producers in Canada, 1970

Company and Location	Mill Capacity (short tons ore/day)	Grade of Ore Milled in 1970 (principal metals): Lead (%)	Zinc (%)	Copper (%)	Silver (troy oz/ton)	Ore Produced 1970 (1969) (short tons)	Lead in Concentrates and Direct-Shipping Ores 1970 (1969) (short tons)	Remarks
YUKON TERRITORY – NORTHWEST TERRITORIES								
Anvil Mining Corporation Limited, Faro, Y.T.	6,600	4.4	6.4	–	..	1,961,000 (..)	63,476 (11,376)	Mill capacity was increased from 5,500 to 6,600 tons a day.
Pine Point Mines Limited, ~~Pine Point, N.W.T.~~	10,000	3.0	7.1	–	..	3,859,838[4] (3,604,980)	101,780 (102,810)	Ore reserves at the end of 1970 were 43.5 million tons averaging 2.5 per cent lead and 6.0 per cent zinc.
United Keno Hill Mines Limited Calumet and Hector, Elsa and Sadie Ladue mines, Mayo District, Y.T.	500	4.07	5.25	–	27.30	93,215 (87,483)	3,473 (3,860)	Company plans extensive exploration in the Yukon Territory in general, and in Mayo District in particular.
Venus Mines Ltd., Carcross, Y.T.	300	1.15	0.98	..	5.30	23,796 (–)	197 (–)	Mill construction completed and tune-up operations began September 1970.
BRITISH COLUMBIA								
Canadian Exploration, Limited Jersey mine, Salmo	1,900	1.2	2.7	–	..	216,000 (517,648)	2,275 (4,652)	Jersey zinc-lead mine ceased operations August 1, 1970, because of depletion of ore reserves; and existing tungsten mill rehabilitated and began tune-up operations October 1970.

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Grade of Ore Milled in 1970 (principal metals)				Ore Produced 1970 (1969) (short tons)	Lead in Concentrates and Direct-Shipping Ores 1970 (1969) (short tons)	Remarks
		Lead (%)	Zinc (%)	Copper (%)	Silver (troy oz/ton)			
Cominco Ltd., Sullivan mine, Kimberley	10,000	. .	. .	–	. .	2,194,743 (2,157,522)	98,664 (94,095)	In September 1970, company announced that it was immediately reducing both lead concentrate and refined lead metal production by 10 per cent.
Bluebell mine, Riondel	700	. .	. .	–	. .	245,529 (230,956)	10,446 (8,958)	
Copperline Mines Ltd., Ruth-Vermont mine, Golden	600	3.46	4.67	–	4.62	36,228 (–)	1,097 (–)	Mill tune-up operations began October 1970. Mill capacity being increased to 700 tons-a-day.
Kam-Kotia Mines Limited, Silmonac mine, Slocan District	ore custom-milled	7.58	6.79	–	19.0	13,232 (–)	942 (–)	Mill tune-up operations began September 1970.
Leitch Mines Limited, Beaverdell (mine formerly owned by Mastodon-Highland Bell Mines Limited)	115	0.89	0.89	–	13.37	33,225 (37,120)	297 (323)	Exploration and development work is being concentrated in the upper levels of the mine.
Reeves MacDonald Mines Limited,	1,200 (treated at central mill)							
Reeves mine, Remac		1.56	4.75	–	. .	107,312 (201,215)	1,337 (2,322)	
Annex mine, Remac		1.07	9.0	–	3.3	70,714 (–)	647 (–)	New Annex mine started production August 1, 1970.
Utica Mines Ltd., Keremeos	350	. .	. .	–	. .	18,603 (74,915)	12 (68)	Mill ceased operations March 31, 1970, but underground development work is continuing.
Western Mines Limited, Myra Falls, Vancouver Island	1,000	0.75	6.38	1.97	1.36	386,976 (383,931)	2,387 (3,221)	Installed lead circuit in concentrator.

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Grade of Ore Milled in 1970 (principal metals)				Ore Produced 1970 (1969) (short tons)	Lead in Concentrates and Direct-Shipping Ores 1970 (1969) (short tons)	Remarks
		Lead (%)	Zinc (%)	Copper (%)	Silver (troy oz/ton)			
MANITOBA – SASKATCHEWAN								
Hudson Bay Mining and Smelting Co., Limited	6,000 (treated at central mill at Flin Flon)							White Lake mine and Ghost Lake mine are under development in Manitoba.
Chisel Lake mine, Snow Lake, Man.		0.3	10.3	0.8	0.9	281,500 (282,400)	515[1] (572)[1]	
ONTARIO								
Big Nama Creek Mines Limited, Manitouwadge	Ore custom-milled	0.06	3.76	0.80	0.99	88,965 (57,472)	8 (13)	Ore milled at Willroy concentrator. Ore produced in 1969 was from pre-production development work.
Ecstall Mining Limited (Texas Gulf Sulphur Company), Kidd Creek mine, Timmins	9,000	..	..	..	..	3,584,124 (3,617,226)	9,349 (12,524)	Underground development began in 1970, with 3,000-ft shaft from surface to be completed in 1971.
Noranda Mines Limited (Geco Division), Manitouwadge	5,000	..	3.89	1.86	1.82	1,366,176 (1,320,000)	1,742 ..	Mill expanded from 4,000 to 5,000 tons of ore a day.
Willroy Mines Limited, Manitouwadge (includes production from Willecho Mines Limited which was amalgamated with Willroy Mines Limited)	1,700	0.20	4.02	0.85	1.99	388,005 (445,449)	538 (627)	Routine exploration and development.
QUEBEC								
D'Estrie Mining Company Ltd., Stratford Centre	Ore custom-milled	..	..	..	..	.. (–)	.. (–)	Operations began late in 1970 with milling of development ore.

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Grade of Ore Milled in 1970 (principal metals) Lead (%)	Zinc (%)	Copper (%)	Silver (troy oz/ton)	Ore Produced 1970 (1969) (short tons)	Lead in Concentrates and Direct-Shipping Ores 1970 (1969) (short tons)	Remarks
Manitou-Barvue Mines Limited, Golden Manitou mine, Val d'Or	1,600	0.36	2.19	..	4.66	273,200[2] (198,605)[2]	774 (339)	Mill capacity was increased from 1,300 to 1,600 tons a day.
Sullivan Mining Group Ltd., (Cupra Division),[3] Stratford Centre	1,500	0.49	3.29	2.40	0.99	193,450 (232,760)	279 (356)	Ore reserves increased by some 100,000 tons to 636,000 tons as at September 1, 1970.
Sullivan Mining Group Ltd., (Solbec Division),[3] Stratford Centre	Ore custom-milled	0.93	3.71	1.05	2.04	132,060 (196,961)	738 (1,158)	Mine closed in December 1970 because of exhaustion of ore reserves.
NEW BRUNSWICK								
Brunswick Mining and Smelting Corporation Limited, No. 12 mine, Bathurst	6,500	2.93	7.54	0.32	2.19	1,519,981 (1,696,408)	26,612 (28,677)	Both mines and mills closed by a labour strike from March 3 to April 10, 1970.
No. 6 mine, Bathurst	3,500	2.12	5.86	0.33	1.84	1,100,703 (1,134,224)	14,350 (15,993)	
Heath Steele Mines Limited, Newcastle	3,000	2.26	5.40	0.97	2.20	1,030,899 (321,403)	12,324 (1,601)	Mill capacity increased from 1,500 to 3,000 tons a day.
Nigadoo River Mines Limited,[3] Bathurst	1,000	2.63	2.63	0.32	3.59	319,689 (321,397)	7,348 (6,552)	Ore reserves at August 31, 1970 were 2,200,000 tons averaging 2.88 per cent lead, 2.84 per cent zinc, 0.23 per cent copper and 3.67 oz silver a ton.

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Grade of Ore Milled in 1970 (principal metals) Lead (%)	Zinc (%)	Copper (%)	Silver (troy oz/ton)	Ore Produced 1970 (1969) (short tons)	Lead in Concentrates and Direct-Shipping Ores 1970 (1969) (short tons)	Remarks
NOVA SCOTIA								
Dresser Minerals, Division of Dresser Industries Inc., Walton	125	6.3	0.5	0.33	3.58	27,263 (49,870)	1,478 (2,648)	Developing lower levels.
NEWFOUNDLAND								
American Smelting and Refining Company (Buchans Unit), Buchans	1,250	7.02	12.68	1.11	3.73	359,000 (371,000)	24,103 (24,870)	Proven and probable ore reserves are sufficient to support mine production for another 8 to 10 years.

Source: Company reports.

[1] Lead content of lead concentrates only. [2] Production does not include copper ore milled in separate circuit. [3] Production for fiscal years ending August 31. [4] Figure represents tons of ore milled. In 1970, company also produced 92,600 tons of direct-shipping ore of grade averaging 14.5 per cent lead and 21.5 per cent zinc.

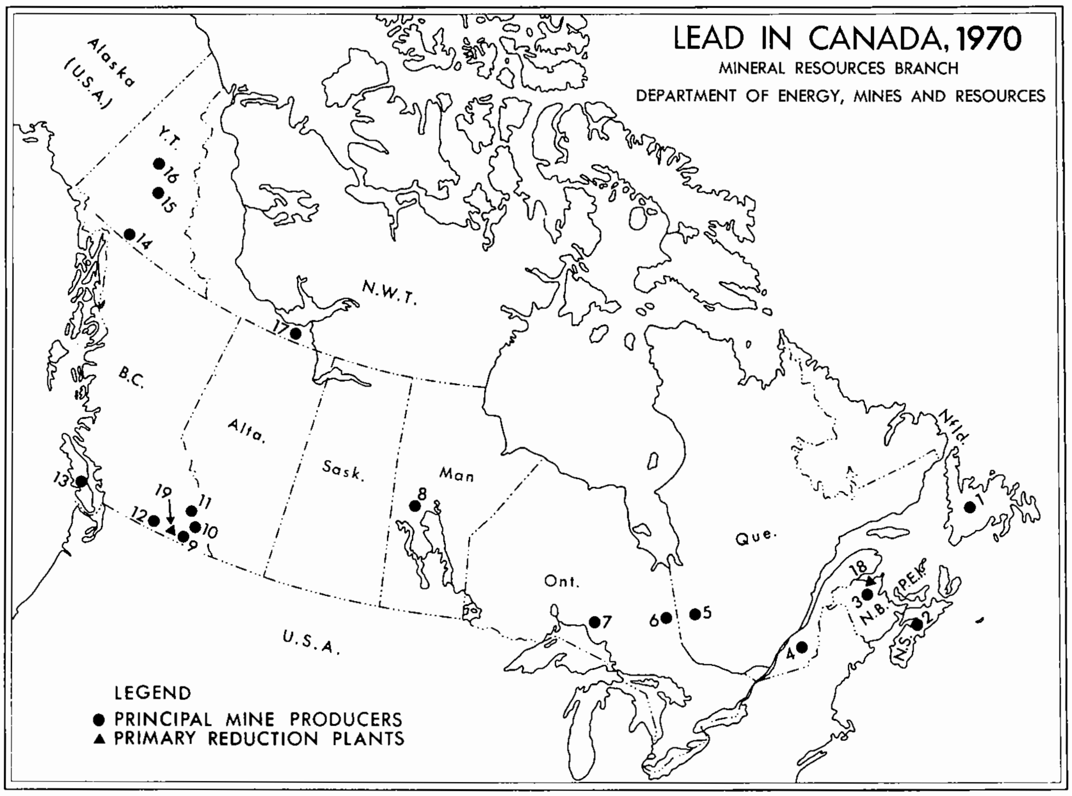
– Nil; . . Not available.

TABLE 5

Prospective* Lead Producing Mines in Canada

Company and Location	Year Production Expected	Mill or Mine Capacity (tons ore/day)	Indicated Ore Reserves (tons)	Average Grade of Ore: Lead (%)	Average Grade of Ore: Zinc (%)	Average Grade of Ore: Copper (%)	Average Grade of Ore: Silver (oz/ton)	Remarks
BRITISH COLUMBIA								
Columbia Metals Corporation Limited, Ferguson	1971	125	100,000	6.0	6.7	..	6.9	Initial production will come from the True Fissure portion of the property.
ONTARIO								
Mattabi Mines Limited, Sturgeon Lake area	1972	3,000	13,000,000	0.84	7.6	0.91	3.13	Initial open-pit production expected to begin about mid-1972.

* Those mines which have announced production plans.
.. Not available.



PRINCIPAL MINE PRODUCERS

(numbers refer to numbers on the map)

1. American Smelting and Refining Company (Buchans Unit)
2. Dresser Minerals, Division of Dresser Industries, Inc.
3. Brunswick Mining and Smelting Corporation Limited (Nos. 12 and 6 mines)
   Heath Steele Mines Limited
   Nigadoo River Mines Limited
4. D'Estrie Mining Company Ltd.
   Sullivan Mining Group Ltd. (Cupra Division)
   Sullivan Mining Group Ltd. (Solbec Division)
5. Manitou-Barvue Mines Limited
6. Ecstall Mining Limited
7. Big Nama Creek Mines Limited
   Noranda Mines Limited (Geco Division)
   Willroy Mines Limited
8. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake mine)
9. Canadian Exploration, Limited
   Reeves MacDonald Mines Limited
10. Cominco Ltd. (Sullivan and Bluebell mines)
11. Copperline Mines Ltd., Ruth-Vermont mine
    Kam-Kotia Mines Limited, Silmonac mine
12. Leitch Mines Limited
    Utica Mines Ltd.
13. Western Mines Limited
14. Venus Mines Ltd.
15. Anvil Mining Corporation Limited
16. United Keno Hill Mines Limited
17. Pine Point Mines Limited

PRIMARY REDUCTION PLANTS

18. East Coast Smelting and Chemical Company Limited
19. Cominco Ltd.

The Anaconda Company (Canada) Ltd. continued exploration and development work at its lead-zinc-copper-silver deposit about 30 miles west of Bathurst. A feasibility study is in progress and it was planned to build a 300-ton-a-day pilot mill to start operations in 1971. The property is known as the Caribou deposit. It is owned 75 per cent by Anaconda and 25 per cent by Cominco Ltd., with Anaconda being in charge of operations.

NOVA SCOTIA AND NEWFOUNDLAND

Dresser Minerals, Division of Dresser Industries, Inc., at Walton, Hants County, continued operations at its 125-ton-a-day concentrator and remained the only lead producer in Nova Scotia. American Smelting and Refining Company, Buchans Unit, was again the sole lead producer in Newfoundland. The company operated a 1,250-ton mill at Buchans in the central part of the province and produced lead, zinc, copper and precious metals concentrates. Bison Petroleum & Minerals Limited did some diamond drilling on its lead-zinc prospect north of Portland Creek in Northwestern Newfoundland. Canadian Javelin Limited holds a 65.5 per cent interest in Bison Petroleum.

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, malleable and easily worked. Lead alloys readily with many other materials, has good corrosion resistance, a high boiling point, a low melting point, and a high specific gravity.

The major use for lead is in lead-acid storage batteries, the bulk of which are used for starting and lighting in automobiles and trucks. There are also new and expanding markets for such storage batteries in electric-powered passenger cars and industrial vehicles, and certain household appliances. Recent improvements in battery manufacture have, however, significantly reduced the weight of lead per battery unit and increased the average battery life. Lead's next important use is as an anti-knock additive in gasoline. Lead consumed for these two purposes in the United States in 1970 accounted for almost 65 per cent of total lead consumption. Other uses for lead are for solders, type metals, bearing metals, and pigments. The metal is also used extensively for cable sheathing and in the manufacture of ammunition and collapsible tubes, caulking materials, corrosive-liquid containers, lead-base babbitts, and plumbing equipment such as pipes, drains and bends.

Because of its unique sound control characteristics, there is an expanding use for lead in sound attenuation where the biggest potentials seem to be in overceiling liners, doors, partition panels and removable walls in both commercial and residential construction. In the allied field of vibration isolation, lead-asbestos anti-vibration pads are now being widely used in foundations for office buildings, hotels and apartments exposed to severe vibration from nearby trains, subways, or heavy haulage vehicles. Because of its sound control qualitites lead is also used in the mounting of various types of equipment including air-conditioning systems, printing presses and commercial laundry machines.

Miscellaneous uses include automotive wheel weights, ship ballast, roofing systems, sprayed lead coatings, 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 merchant 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 anti-fouling paints, wood and cotton preservatives, lubricant-oil additives, polyurethane foam catalysts, molluscicides, antibacterial agents, rodent repellents and rot-resistant textiles. Research programs carried out to consider the antiwear characteristics of organolead compounds in oil lubricants indicate that the use of lead in the lubricating oil market in the United States could reach a potential of over 35,000 tons annually.

TABLE 6

United States Consumption of Lead
by End-Use, 1969-70
(short tons)

	1969	1970p
Batteries	582,546	569,741
Gasoline anti-knock additives	271,128	278,505
Pigments	102,386	97,868
Solder, type metal, terne metal and bearing metals	117,275	99,120
Ammunition and collapsible tubes	91,717	78,487
Caulking	44,857	31,278
Cable sheathing	54,203	50,295
Sheet and pipe	45,225	35,815
Miscellaneous	80,021	55,945
Estimated undistributed consumption	–	42,000
Total	1,389,358	1,339,054

Source: United States Bureau of Mines Mineral Industry Surveys, Lead Industry in December 1970.
pPreliminary; – Nil.

Refined lead is marketed in several grades that vary mainly according to the content of impurities, which include silver, copper, arsenic, antimony, tin, zinc, iron and bismuth. The three principal grades are: corroding (99.94 per cent), chemical (99.90 per cent) and common desilverized (99.85 per cent). The corroding grade has the highest purity and is used chiefly in the manufacture of pigments, battery oxides, and tetraethyl lead. Common lead finds its greatest use in industrial and home construction. Chemical lead possesses superior creep and corrosion resistance and is ideally suited for cable sheathing. Common and corroding lead both sell for the same price but chemical commands a premium above the other two grades.

PRICES

The Canadian price of lead, f.o.b. Toronto and Montreal, which was 16.5 cents a pound at the beginning of 1970, dropped on July 9 to 16 cents. On August 12 the price again moved downward to 15.5 cents. A third decrease to 14.5 cents, occurred October 1 and the price remained at this level for the rest of the year. The United States domestic price for common lead, f.o.b. New York, was 16.5 cents a pound from the beginning of 1970 until July 8 when it dropped to 15.5 cents. A second reduction to 15 cents occurred on August 7. On September 1 one major producer reduced its price to 14.5 cents but other producers did not immediately follow suit. A dual price, 14.5-15.0 cents, then obtained until December 21, with most sales believed to have been made at the 14.5-cent level. Effective December 21, a major producer again reduced its price to 13.5 cents but at year-end other United States lead producers were still studying the situation. On the London Metal Exchange (LME), the settlement and cash sellers' price showed a rising trend during the first quarter of 1970 but thereafter the trend was continuously downward. The high price for the year was £145.00 a metric ton (15.9 cents a pound Can.) on February 19. A low of £109.750 (12.1 cents Can.) was reached on December 31.

TARIFFS

CANADA Item No.		Most Favoured Nation
32900-1	Ores of metals, n.o.p.	free
33700-1	Lead, old, scrap, pig and block	free
33800-1	Lead, in bars and in sheets	5%

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
n.o.p. Not otherwise provided for.

UNITED STATES Item No.		
602.10	All lead-bearing ores	0.75¢ per lb on lead content
	Unwrought lead:	
624.02	Lead bullion	1.0625¢ per lb on 99.6% of the lead content
624.03	Other	1.0625¢ per lb on lead content
624.04	Lead waste and scrap	1.0625¢ per lb on 99.6% of the lead content

Source: Tariff Schedules of the United States, Annotated (1970) TC Publication 304.

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 ($CaCO_3.MgCO_3$). 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. A calcium or high-calcium limestone is required for cement manufacture where a low magnesia content is essential. Both calcium and magnesian limestones are used to make quicklime (CaO) and hydrated lime ($Ca(OH)_2$).

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 92 per cent of Canada's total lime output in 1970, 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 1970 in Nova Scotia, Prince Edward Island, New Brunswick, Saskatchewan and British Columbia, the needs in each of these provinces being supplied from plants in neighbouring provinces or states.

*Mineral Resources Branch.

During 1970, 18 companies operated a total of 23 lime plants in Canada: 1 in Newfoundland, 4 in Quebec, 11 in Ontario, 3 in Manitoba, and 4 in Alberta. A total of 77 kilns was utilized – 19 rotary, 55 vertical, 1 vibratory-grate and 2 rotary-grate. Lime production in 1970 was 1,626,000 tons excluding some captive production such as that from a number of 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

Lime production in the Atlantic provinces during 1970 was limited to one company, Sea Mining Corporation Limited, at Aguathuna, Newfoundland. From a hard, dense, grey, high-calcium limestone of Middle Ordovician age, lime was produced using an oil-fired, rotary kiln, 8½′ x 240′. The product was originally intended for captive use in the production of magnesium hydroxide from sea-water but when a market developed for lime for waste neutralization in 1969 in Newfoundland, production was increased to supply the demand.

Although for many years lime has been produced in the Saint John area of New Brunswick, no production was recorded in 1970. Toward the end of the year Havelock Lime Works Ltd. was constructing a lime-producing facility at Havelock, New Brunswick. The new plant went on stream in Februrary 1971.

QUEBEC

At Joliette, Domtar Chemicals Limited, Lime Division, produced quicklime and hydrated lime from a high-calcium Trenton limestone for the steel and pulp and paper industries. Shipments were made to Maritime consumers as well as to Quebec and Ontario. A new hydrating section under construction during the past year was put into operation in early 1970.

TABLE 1

Canada, Lime Production and Trade, 1969-70

	1969		1970p	
	Short Tons	$	Short Tons	$
Production*				
By type				
Quicklime	1,388,109	15,559,272	1,382,000e	
Hydrated lime	246,753	3,680,024	244,000e	
Total	1,634,862	19,239,296	1,626,000	19,019,000
By Province				
Ontario	1,129,274	12,433,603	1,133,000	12,397,000
Quebec	367,688	4,342,889	357,000	4,123,000
Alberta	86,077	1,627,987	88,000	1,773,000
Manitoba	51,823	834,817	41,000	656,000
Newfoundland	–	–	7,000	70,000
Total	1,634,862	19,239,296	1,626,000	19,019,000
Imports				
Quick and hydrated				
United States	41,138	792,000	33,704	762,000
France	24	13,000	27	13,000
Britain	64	4,000	54	3,000
Total	41,226	809,000	33,785	778,000
Exports				
Quick and hydrated				
United States	194,527	2,288,000	199,174	2,505,000
Guyana	–	–	1,023	13,000
Bermuda	275	6,000	295	6,000
Panama	42	1,000	82	2,000
Other countries	316	8,000	40	1,000
Total	195,160	2,303,000	200,614	2,527,000

Source: Dominion Bureau of Statistics.
*Producers' shipments and quantities used by producers. In 1969, 1,080,366 tons of lime (quick and hydrated) were shipped and 554,496 tons were used at the producing plants.
pPreliminary; – Nil; eEstimated.

Dominion Lime Ltd. produced high-calcium quicklime and hydrated lime from Silurian limestone at Lime Ridge, near Sherbrooke. Markets included the steel, pulp and paper, construction and agricultural industries.

A high-calcium limestone of the Beekmantown formation of Ordovician age 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 0.015 per cent phosphorous–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, operated a limestone quarry and a lime plant at Beachville. The high-calcium limestone was mined, crushed, screened and used primarily as feed to the lime plant which has both vertical and rotary kilns. A new rotary kiln was put on stream in 1970, doubling plant capacity. At Hespeler, Domtar produced lime, crushed stone and agricultural limestone. The lime plant has vertical kilns and produces high-quality, white, quicklime. Both plants also produced hydrated lime.

For many years Cyanamid of Canada Limited operated a quarry at Beachville to supply chemical-grade limestone to the company's lime plant at Niagara Falls where a battery of seven rotary kilns

TABLE 2

Canada, Consumption of Lime 1968-69
(producers' shipments by use)

	1968r		1969	
	Short Tons	$000	Short Tons	$000
Chemical and Metallurgical				
Iron and steel plants	294,388	3,569,576	354,162	4,222,457
Pulp mills	160,693	2,113,253	176,048	2,443,395
Nonferrous smelters	53,751	503,684	71,116	718,610
Sugar refineries	35,417	530,412	32,447	696,441
Cyanide and flotation mills	50,135	566,427	79,106	870,134
Water and sewage treatment	39,958	671,372	36,807	583,753
Other industrial*	657,615	6,876,971	674,121	6,304,575
Construction				
Finishing lime	63,462	1,430,942	63,896	1,621,356
Mason's lime	27,587	460,625	19,685	360,565
Sand-lime brick	31,493	283,238	13,685	109,228
Agricultural	14,190	136,042	18,679	184,178
Road stabilization	6,423	80,761	8,210	92,491
Other uses	20,901	249,622	86,900	1,032,113
Total	1,456,013	17,472,925	1,634,862	19,239,296

*Includes uranium plants, glass works, fertilizer plants, tanneries, and other miscellaneous industrial uses.
rRevised.

produced high-calcium lime for the manufacture of calcium carbide. In 1957 a rotary-kiln lime plant was built at Beachville and in 1967 a calcimatic kiln was installed, and made operative during 1968. Lime manufacture accounts for about half the limestone production, the remainder being used for open-hearth and blast furnace flux, for portland cement manufacture and as a pulverized stone.

Through a subsidiary, Chemical Lime Limited, The Steel Company of Canada, Limited at Hamilton was 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. Additional lime-making capacity will be installed by 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 produced 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.

WESTERN PROVINCES

The Winnipeg Supply and Fuel Company, Limited operates a quarry and lime plant at Spearhill, Manitoba, producing a white, high-calcium lime. Early in 1968 the company closed its lime plant at Stonewall, where a second quarry is operated, and opened a modern lime manufacturing facility at Fort Whyte, a suburb of Winnipeg. Limestone is trucked to Fort Whyte where conventional processing equipment is used in conjunction with a vibratory-grate calciner, which offers maximum control of the calcining operation. Quicklime was supplied to chemical, metallurgical and construction industries and limestone was supplied to The Manitoba Sugar Company, Limited, during 1970.

TABLE 3

Canada, Lime Production, Trade, Apparent Consumption, 1961-70
(short tons)

	Production[1]			Imports	Exports	Apparent Consumption[2]
	Quick	Hydrated	Total			
1961	1,142,354	272,936	1,415,290	38,453	31,197	1,422,546
1962	1,190,848	233,611	1,424,459	36,115	71,583	1,388,991
1963	1,204,824	245,907	1,450,731	44,291	98,084	1,396,938
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	990,125	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
1970p	1,382,000e	244,000e	1,626,000	33,785	200,614	1,459,171

[1] Producers' shipments and quantities used by producers. [2] Production plus imports less exports.
pPreliminary; eEstimated.

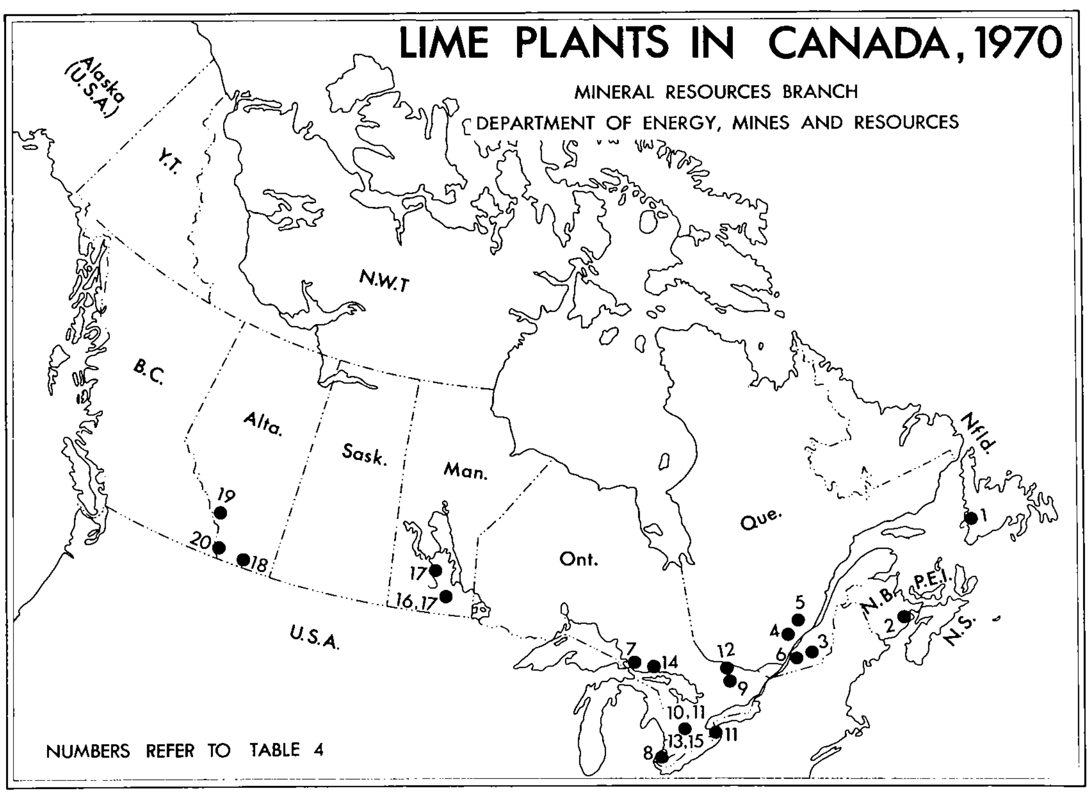


TABLE 4

Canadian Lime Industry – 1970

Company	Plant Location	Type of Quicklime
Newfoundland		
1. Sea Mining Corporation Limited	Aguathuna	High-calcium**
New Brunswick		
2. Havelock Lime Works Ltd.[1]	Havelock	High-calcium
Quebec		
3. Dominion Lime Ltd.	Lime Ridge	High-calcium**
4. Domtar Chemicals Limited	Joliette	High-calcium**
5. Gulf Oil Canada Limited Shawinigan Chemicals Division*	Shawinigan	High-calcium**
6. Quebec Sugar Refinery*	St. Hilaire	High-calcium
Ontario		
7. The Algoma Steel Corporation Limited*	Sault Ste. Marie	High-calcium
8. Allied Chemical Canada, Ltd.*	Amherstburg	High-calcium
9. Bonnechere Lime Limited[2]	Carleton Place	High-calcium
10. Canadian Gypsum Company, Limited	Guelph	Dolomitic**
11. Cyanamid of Canada Limited	Beachville	High-calcium
	Niagara Falls	High-calcium
12. Dominion Magnesium Limited*	Haley	Dolomite
13. Domtar Chemicals Limited	Beachville	High-calcium**
	Hespeler	Dolomitic**
14. Reiss Lime Company of Canada, Limited	Spragge	High-calcium
15. The Steel Company of Canada, Limited	Ingersoll	High-calcium
Manitoba		
16. The Manitoba Sugar Company, Limited*	Fort Garry	High-calcium
17. The Winnipeg Supply and Fuel Company, Limited	Spearhill	High-calcium
	Fort Whyte	High-calcium and dolomitic
Alberta		
18. Canadian Sugar Factories Limited*	Picture Butte	High-calcium
	Taber	High-calcium
19. Steel Brothers Canada Ltd.	Kananaskis	High-calcium**
20. Summit Lime Works Limited	Hazell	High-calcium

[1]New lime plant operative early 1971. [2]No production since June, 1970.
*Production for captive use.
**Hydrated lime produced also.

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 was quarried about 7 miles west of the plant site to provide kiln feed for the production of quicklime and hydrated lime.

Summit Lime Works Limited, near Crowsnest, produced 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.

There was no production of commercial lime in British Columbia in 1970.

MARKETS, OUTLOOK AND TRADE

The metallurgical industry provides the largest single market for lime. With the increased application of the

TABLE 5

World Production of Quicklime
and Hydrated Lime,
Including Dead-Burned Dolomite
Sold or Used 1968-69
(thousand short tons)

Country	1968	1969p
USSR	22,835	23,149
United States	18,637	20,209
West Germany	11,722	11,758
Italy[e]	5,512	6,388
France	4,389	4,685
Japan	3,996	4,657
Belgium	2,872	2,899
Brazil	1,669	1,764
Canada	1,456	1,635
Romania	1,157	1,157
Other countries	19,014	19,207
Total	93,259	97,508

Sources: U.S. Bureau of Mines, Minerals Yearbook Preprint 1969, and Dominion Bureau of Statistics for Canada.
[p]Preliminary; [e]Estimated.

basic oxygen furnace (BOF), greater amounts of lime will be required for use as flux. The addition of hydrated lime in the pelletizing of iron ore concentrates has resulted in a stronger, more stable pellet.

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 anti-pollution measures should result in greater use of lime for water and sewage treatment. Research being done on the removal of sulphur from hydrocarbon fuels includes the formation of calcium sulphide on a fluidized bed of lime followed by the burning of sulphur-free gas. Lime is effective, inexpensive, can be regenerated and the emission of SO_2 to atmosphere is controlled.

Soil stabilization, especially for highways, offers a potential market for lime. However, all soils are not of the physical and chemical characteristics required for a proper reaction with lime to provide a dry, impervious, cemented and stable roadbed. Hydrated lime added to an 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. The 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. 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 Stated in recent years, iron and steel producers have integrated backwards into lime manufacture.

Canada is a net exporter of lime.

PRICES

Canadian Chemical Processing, May, 1970, listed the following prices per short ton for high-calcium lime in carload lots, f.o.b. works over a period from 1965 through 1970 –

Quicklime, bulk	$11.50 – $13.00
Quicklime, bags	17.00 – 18.00
Hydrated lime, bulk	14.00 – 15.00
Hydrated lime, bags	17.50 – 18.50

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General
29010-1	Lime	free	free	25%

Source: The Customs Tariff and Amendments,
Department of National Revenue,
Customs and Excise Division, Ottawa.

UNITED STATES

Item No.		
512.11	Lime, hydrated	
	on and after Jan. 1, 1970	1¢ per 100 lbs incl. weight of containers
	" " " Jan. 1, 1971	0.5¢ per 100 lbs incl. weight of containers
	" " " Jan. 1, 1972	free
512.14	Lime, other	
	on and after Jan. 1, 1970	1¢ per 100 lbs incl. weight of containers
	" " " Jan. 1, 1971	0.5¢ per 100 lbs incl. weight of containers
	" " " Jan. 1, 1972	free

Source: Tariff Schedules of the United States (Annotated), T.C. Publication 304.

Magnesium

D. PEARSON*

Magnesium minerals are more abundant than those of other structural metals, including iron and aluminum. Reserves are inexhaustible in the oceans and brines, and are plentiful also in such minerals as brucite, magnesite and dolomite.

The metal is produced by two basic processes: the high-temperature reduction of magnesium ores such as dolomite or magnesite, and the electrolysis of magnesium chloride derived from sea-water and brines. Canadian production is by the first process.

CANADIAN INDUSTRY

Dominion Magnesium Limited, the only Canadian producer of primary magnesium, has operated a mine and smelter at Haley, Ontario, 50 miles west of Ottawa, since 1942. Dolomite, low in impurities such as silica and the alkali metals, is mined by open pit and calcined in a rotary kiln to produce dolime. Magnesium is recovered by the Pidgeon process wherein the dolime is mixed with ferrosilicon and some fluorite and charged in batches into retorts that are externally heated in electric furnaces. Under vacuum and at high temperature, the magnesium content is reduced and accumulates as crystalline rings called "crowns" in the water-cooled head-sections of the retorts. The plant, which is a major source of employment in the Renfrew area, has 544 retorts in 16 furnaces and a magnesium production capacity of 12,000 short tons a year. Part of the furnace capacity is used for the production of calcium.

The company produces magnesium in the following grades and purities: Commercial 99.90 per cent; High Purity 99.95 per cent; and Refined 99.98 per cent. All specifications of magnesium remelt and extrusion ingot can be supplied and other magnesium products include master alloys, rods, bars, wire and structural shapes.

Commercial-grade magnesium is made by remelting the crowns and casting into ingot forms. This grade is suitable for general fabrication purposes and alloying. The High Purity grade is used mainly for making Grignard reagents (Alkyl-magnesium-halides). It does not represent significant tonnages. The Refined grade is particularly suited for chemical laboratory use, as a reducing agent in the production of uranium, zirconium, titanium and beryllium and similar applications where impurity control is important.

Production of magnesium in Canada in 1970, as reported by the Dominion Bureau of Statistics, was 9,584 short tons, a decrease of almost 10 per cent from that of 1969 (see Table 1). Demand for Canadian magnesium declined during the latter half of the year because of a reduction in the traditional markets such as defence requirements, alloying and as a reducing agent in the production of titanium, zirconium and uranium, all of which were affected by the slackening of economic activity during that period. Dominion Magnesium Limited closed down four of sixteen furnaces during the last quarter of the year to compensate for this loss of business. The company became part of Timmins Investments Limited in August.

Domestic consumption in 1969, the latest year for which statistics are available, was 5,672 short tons, a slight increase from that of 1968 when it was 5,654 tons. Growth in consumption between 1960 and 1969 is shown in Table 2, Canada-Consumption of Magnesium. Aluminum alloying continued to be the largest single outlet for magnesium accounting for 65.5 per cent of the total consumption. There was an increase in magnesium used for making castings between 1968 and 1969 which amounted to 34 per cent.

Canada imported 2,036 tons of magnesium metal and 256 tons of magnesium alloys during 1970.

*Minaral Resources Branch.

TABLE 1

Canada, Magnesium Production and Trade, 1969-70

	1969		1970p	
	Short Tons	$	Short Tons	$
Production* (metal)	10,637	7,263,849	9,584	6,478,000
Imports				
Magnesium metal				
United States	2,023	1,552,000	1,478	1,128,000
USSR	–	–	550	348,000
Britain	–	–	8	25,000
Total	2,023	1,552,000	2,036	1,501,000
Magnesium alloys				
United States	424	1,084,000	222	596,000
Britain	8	14,000	34	80,000
Total	432	1,098,000	256	676,000
Exports				
Magnesium metal				
Britain	..	1,227,000	1,986	1,369,000
West Germany	..	452,000	1,436	1,055,000
United States	..	1,643,000	1,407	1,104,000
France	..	366,000	1,136	806,000
Switzerland	..	144,000	369	270,000
Mexico	..	140,000	277	200,000
Netherlands	..	100,000	243	192,000
Argentina	..	239,000	238	171,000
Other countries	..	415,000	577	395,000
Total	..	4,726,000	7,669	5,562,000

Source: Dominion Bureau of Statistics.
* Magnesium metal, in all forms and in magnesium alloys produced for shipment, less remelt.
p Preliminary; – Nil; .. Not available.

TABLE 2

Canada - Consumption of Magnesium
1960, 1966, 1967, 1968 and 1969
(short tons)

	1960	1966	1967	1968	1969
Castings[1]	158	554	631	593	793
Extrusions[2]	230	572	659	935	529
Alluminum alloys	1,339	3,630	3,253	3,713	3,710
Other uses[3]	472	431	511	413	640
Total	2,199	5,187	5,054	5,654	5,672

Source: Dominion Bureau of Statistics.
[1] Die, permanent mould and sand. [2] Structural shapes, tubing, forgings, sheet and plate. [3] Cathodic protection, reducing agents, deoxidizers, and other alloys.

Seventy-nine per cent of the imports came from the United States and Britain. Five hundred and fifty tons of Russian magnesium was imported.

Exports of magnesium metal amounted to 7,669 tons for a value of $5,562,000. Shipments to Britain, West Germany, the United States and France accounted for a total of about 78 per cent of the exported metal. Exports of magnesium metal to the United States from Canada are possible through the Canada-United States Defence Production Sharing Act. Scrap enters the United States free of duty. The tariff changes negotiated under the Kennedy Round of the General Agreement on Tariffs and Trade have not greatly changed the outlook for the sale of magnesium to the United States. The ultimate United States tariff will be 20 per cent in 1972; the Canadian tariff is 5 per cent.

WORLD INDUSTRY

World production of primary magnesium in 1970 is estimated at 230,300 tons, an increase of 8,600 tons over last year. The output of the United States was 48 per cent of this amount. The United States was the only country to record an increase in production (see Table 4). Norway was the next largest producer followed by Canada, Italy and Japan, in that order. Secondary magnesium is recovered in the United States, Federal Republic of Germany, Britain and Japan, adding a considerable tonnage to the available magnesium, but up-to-date statistics are not available. In 1970 approximately 15,000 short tons of secondary magnesium was produced in the United States.

The General Services Administration stockpile in the United States continued to be an important source of magnesium. About 15,400 tons were sold to industry during 1970. In the first quarter, the Office of Emergency Preparedness completely eliminated the stockpile objectives for magnesium so that by the year-end, 101,000 tons remained as surplus which may be sold only with congressional approval.

During the last decade there have been frequent periods of magnesium shortages and, to satisfy this need, various companies have increased their capacities and planned for future increases.

In the United States production rose to 112,007 tons, the highest since 1952. The Dow Chemical Company, the major producer of magnesium, increased the capacity of its Freeport, Texas plant to 120,000 tons annually in 1970 while construction of its 25,000-ton Dallesport, Washington smelter has been delayed until 1975. National Lead Company is expected to start its 45,000-ton plant late in 1971. Production at American Magnesium Company's 30,000-ton plant has been limited but is expected to reach 10,000 tons annually by mid-1971. A feasibility study for a ferrosilicon and primary magnesium plant using the Pidgeon process at Addy, Washington, is being conducted by the Aluminum Company of America. It is anticipated that production could start in 1974.

TABLE 3

World Primary Magnesium Production
1960 and 1969-70
(thousand short tons)

	1960	1969	1970^{e}
United States	40.1	99.9	112.0
USSR	27.6	49.6	. .
Norway	11.4	35.3	35.2
Canada	7.3	10.6	9.6
Italy	6.0	7.4	7.0
Britain	4.1	4.4	. .
Japan	2.3	6.9	6.9
France	2.4	6.5	. .
China	1.1	1.1	. .
West Germany	0.3	. .	. .
Total	102.6	221.7	230.3*

Sources:
For Canada – Dominion Bureau of Statistics for Canada;
For 1960 – U.S. Bureau of Mines, Minerals Yearbook 1961;
For 1969 – U.S. Bureau of Mines, Minerals Yearbook Preprint for 1969;
For 1970 – U.S. Bureau of Mines, Commodity Data Summaries, Jan, 1971.
* Total includes an estimated 8.7 thousand short tons for other non-communist countries and 51.0 thousand short tons for Communist countries.
^{e}Estimated; . . Not available.

In the fabrication area, Dow began aluminum and magnesium extrusion at two plants during the year. One is an 8,000-ton press at Russelville, Arkansas and the other an 1,800-ton press at Denver, Colorado. Dow leased its major fabrication facility to Phelps Dodge Corporation which is fabricating magnesium for Dow. Kaiser Magnesium, (formerly the Standard Magnesium Division of Kaiser Aluminum & Chemical Corporation), expanded its extrusion facility at Tulsa, Oklahoma. This is the largest secondary magnesium processor in the United States.

The tight magnesium supply which prevailed throughout 1969 continued until about mid-1970. Production was 112,007 tons, an increase of about 11 per cent. Shipments were, however, only slightly higher than last year, 118,693 tons compared to 117,702 tons. Secondary magnesium production is estimated at approximately 15,000 tons.

Imports, which included ingot, alloys, semi-fabricated forms and scrap were 3,294 tons compared to 4,528 tons in 1969 but exports were up 31 per cent at 35,731. Consumption also was higher than last year

TABLE 4

Estimated World Primary Magnesium Capacity in 1970

Country	Company Name	Location	Annual Capacity (short tons)
CANADA	Dominion Magnesium Limited	Haley, Ontario	12,000(F)
FRANCE	Société Générale du Magnésium*	Marignac	7,700(F)
ITALY	Societe Italiana per il Magnesio e Leghe di Magnesio	Bolzano	7,700(F)
JAPAN	Furukawa Magnesium Company Ube Kosan KK	Oyama Ube	6,600(F) 5,500(F)
NORWAY	Norsk Hydro-Elektrisk Kvaelsto-faktieselskab	Heroya near Porsgrund	39,600(E)
UNITED STATES	American Magnesium Company	Snyder, Texas	less than 10,000(E)
	The Dow Chemical Company	Freeport, Texas	120,000(E)
USSR	Various	Estimated at	50,000

Sources: Société Française de Minerais et Métaux, Year Book of the American Bureau of Metal Statistics, Metals Week Feb. 22, 1971.

Process F = Ferrosilicon; E = Electrolytic.

* Formerly Pechiney-Ugine.

at 98,000 tons. Stockpile purchases were 14,600 tons, about 11,000 tons less than those in 1969.

In western Europe, the tight magnesium supply situation continued well into 1970. Production of primary metal was estimated to be about 51,500 tons and consumption was about 82,000 tons. Volkswagen, in West Germany, is the biggest consumer. Last year Norsk Hydro-Elektrisk had planned a smelter in partnership with a German manufacturer to satisfy that country's needs but decided to increase its Heroya plant's capacity from 44,000 to 52,000 tons. This is expected to be finished in 1972 with an additional 9,000 tons in the planning stage. Société Générale du Magnésium in France increased their output to 7,000 tons annually and expect to reach 9,000 tons in 1972. Yugoslavia will have its first magnesium smelter in 1973 at Jajce with an annual production of 4,400 tons.

In Japan, magnesium demand exceeded the current output of the two producers, Furukawa Magnesium Company and Ube Kosan KK. The consumption was reported to be about 13,000 tons. The Ministry of International Trade and Industry (M.I.T.I.) predicts 17,000 tons will be required next year. A reported possible joint Dow and Mitsubishi magnesium venture in Japan has been called off for the time being.

Precise data of production and consumption in the Soviet sphere and China are unavailable. The figure

TABLE 5

Planned Additions to Primary Magnesium Capacity, 1970-1973

		Annual Capacity (short tons)
UNITED STATES		
The Dow Chemical Company, Dallesport, Wash.	(1972)	25,000(E)
American Magnesium Company, Snyder, Texas	(1971)	30,000(E)
National Lead Company, Rowley, Utah	(1971)	45,000(E)
NORWAY		
Norsk-Hydro Elektrisk Kvaelsto-faktieselskab, Heroya	(1972)	55,000(E)
FRANCE		
Société Générale du Magnésium, Marignac	(1972)	9,000(F)
YUGOSLAVIA		
Jajce	(1973)	4,400(F)

E = Electrolytic Process; F = Ferrosilicon Process.

given in Table 3 is satisfactory for comparison purposes. Table 4 shows the estimated primary magnesium capacity in 1970 by plants. The world supply-demand situation is fairly well in balance and it is expected to remain so for the next year. However, the proposed production goals indicate that there could be a world surplus of 100,000 tons by 1973 unless the magnesium producers by aggressive promotion and advertising can encourage industry to develop new uses and use greater quantities of this metal in high production areas such as extrusion and diecasting. The Canadian industry depends to a large extent upon alloying with aluminum which is expected to increase and aero-space applications which fluctuate. Protective tariffs (24 per cent in the United States) affect Canadian exports.

USES

The major use of magnesium continued to be alloying with aluminum. In the United States 40 per cent went into this application whilst the Canadian proportion was about 65 per cent. Castings comprised 11 per cent, structural applications about 15 per cent, cathodic protection about 6 per cent and as a metallurgical reducing agent about 8 per cent in 1969. These comparative levels were expected to continue in 1970. In particular, magnesium and its alloys find increasing use in aircraft and helicopter castings and skins, in missiles and space exploration, in automobiles such as the Volkswagen, hand tools such as chain saw, housings and portable rock drilling equipment and luggage. It also is used in the printing, textile, optical and nuclear energy industries.

PRICES

The Canadian domestic quotation at the end of 1970 for standard alloy was 34 cents a pound.

The United States price of magnesium metal, as quoted in *Metals Week* of December 28, 1970 was as follows:

Magnesium metal, per lb, 10,000 lb lots, pig, ingot, 99.8%	35.25 – 36.65¢
Notched ingot	36-37.45¢
Magnesium die-casting alloy, per lb, carloads, delivered, east of Rockies	31.5¢

TARIFFS

CANADA		Most Favoured Nation
Item No.		
35105.1	Magnesium metal, not including alloys, in lumps, solders, ingots or blocks	5%
43910–1	Alloys of magnesium, namely: ingots, pigs, sheets, strips, bars, rods and tubes	5%
34915–1	Magnesium scrap	free
UNITED STATES		
628.55	Magnesium metal, unwrought and waste and scrap	
	On and after Jan. 1, 1970	28%
	On and after Jan. 1, 1971	24%
	On and after Jan. 1, 1972	20%
	Magnesium waste and scrap	duty temporarily suspended to June 30, 1972.
628.57	Magnesium, unwrought alloys	
	On and after Jan. 1, 1970	11¢ per lb on Mg content + 5.5%
	On and after Jan. 1, 1971	9.5¢ per lb on Mg content + 4.5%
	On and after Jan. 1, 1972	8¢ per lb on Mg content + 4%
628.59	Magnesium metal, wrought	
	On and after Jan. 1, 1970	9.4¢ per lb on Mg content + 4.5%
	On and after Jan. 1, 1971	8¢ per lb on Mg content + 4%
	On and after Jan. 1, 1972	6.5¢ per lb on Mg content + 3.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
Tariff Schedules of the United States, Annotated, TC Publication 304.

Manganese

G. P. WIGLE*

Canada imported 126,823 tons of manganese (Mn content) in ores and concentrates valued at $5,968,000 in 1970 compared with 107,954 tons valued at $5,259,000 in 1969. Brazil has become Canada's principal source of manganese supplying 60,948 tons in 1969 and 41,372 tons in 1970. Imports of ferromanganese, silicomanganese and spiegeleisen were 20,796 tons valued at $2,822,000 compared with 29,083 tons valued at $3,973,000 in 1969.

Manganese ores were in plentiful supply on world markets in 1970. Published prices for manganese ore containing 48 per cent manganese were 53 to 57 cents a long-ton unit, c.i.f. eastern United States ports, in the early part of the year. In August and September they were still at 53 to 57 cents but in December published prices were higher at 59 to 62 cents a long-ton unit of clean 48 per cent Mn ore. The newer producers in Australia, Gabon and Brazil can readily expand their large, mechanized manganese production facilities to assure adequate supplies.

Canada does not produce manganese ore and only minor amounts have been mined intermittently from small occurrences in Nova Scotia, New Brunswick and British Columbia. The known occurrences are too small or too low grade to be of present economic importance. A large low grade deposit near Woodstock, New Brunswick, has been reported to contain 50 million tons grading 11 per cent manganese and 14 per cent iron.

WORLD PRODUCTION AND TRADE

World production of manganese ores estimated at 20 million tons was not significantly increased from 1969. Russia continued to be the principal producer with an output of about 8 million tons. The Republic of South Africa, India, Brazil, and Gabon each produced from 2.5 to 1.5 million tons in 1970 as listed in Table 3.

The principal manganese producer in Brazil, Industria e Comercio de Minerios S.A. (ICOMI), started construction of a manganese pelletizing plant designed to produce 235,000 tons a year. The new plant is expected to be in operation in mid-1971.

The United States is the leading importer and consumer of manganese ores. The U.S. Bureau of Mines, Mineral Industry Surveys, reported imports of 1,735,054 tons and consumption of 2,289,895 tons in 1969. The leading suppliers were Brazil, Gabon, and the Republic of South Africa. United States imports of ferromanganese were 290,976 tons compared with 290,115 tons in 1969. United States consumption of ferromanganese was 979,174 tons.

USES AND SPECIFICATIONS

The major use of manganese is in steel manufacture where it is used to remove sulphur, as a deoxidizer, and as an alloying constituent to improve the properties of strength, hardness and hardenability. The Hadfield or manganese steels, containing 10 to 14 per cent manganese, are noted for their ability to work-harden. The Brinell hardness of the metal is about 200 after heat treatment but steel-rail frogs have hardened in use to over 500 Brinell. Light blows of high velocity cause shallow deformation and hardening while heavy impacts produce deep hardening. Fine-grained manganese steels have unusual toughness and strength and are often used for making gears, spline shafts, axles, cylinders for compressed gas, crusher parts and many other products.

Major use distribution of manganese ore in the United States in 1968 was 94 per cent metallurgical, 5 per cent chemical and miscellaneous, and 1 per cent in the dry-cell battery industry. In Canada, 98 per cent of consumption was metallurgical grade ore, nearly all used in the steel industry, and 1.7 per cent battery and chemical grade.

*Mineral Resources Branch.

The principal form in which manganese is used by the steel industry is ferromanganese, the most important of the ferroalloys used in steelmaking. The gross weight of ferromanganese used in Canada in 1969 (1968) was 70,305 (71,470) tons and of silicomanganese was 22,043 (21,904) tons; consumption of two other important ferroalloys, ferrosilicon and ferrochrome, was 50,737 (51,449) tons and 25,035 (34,696) tons respectively. Standard or high-carbon ferromanganese contains 74 to 82 per cent manganese, 7.5 per cent carbon and not over 1.25 per cent silicon, 0.35 per cent phosphorus or 0.05 per cent sulphur. Low-carbon ferromanganese is used when it is important to limit carbon entering the steel and is available in several grades containing 0.75 per cent or less carbon and 80 to 85 per cent manganese.

TABLE 1

Canada, Manganese Trade and Consumption, 1969-70

	1969		1970p	
	Short Tons	$	Short Tons	$
Imports				
Manganese, in ores and concentrates[1]				
Brazil	60,948	2,857,000	41,372	1,873,000
Gabon	–	–	27,099	1,340,000
United States	5,657	699,000	10,178	1,003,000
Ghana	15,121	658,000	15,086	570,000
Congo-Kinshasa	13,440	537,000	16,505	513,000
India	–	–	10,914	422,000
Other countries	12,788	508,000	5,669	247,000
Total	107,954	5,259,000	126,823	5,968,000
Ferromanganese including spiegeleisen[2]				
South Africa	22,655	2,820,000	18,478	2,302,000
United States	1,627	383,000	1,021	256,000
Norway	184	30,000	185	32,000
Japan	33	9,000	37	12,000
France	25	12,000	–	–
Total	24,524	3,254,000	19,721	2,602,000
Silicomanganese, including silico spiegeleisen[2]				
United States	120	35,000	316	81,000
Norway	920	138,000	372	72,000
South Africa	3,519	546,000	387	67,000
Total	4,559	719,000	1,075	220,000
Exports				
Ferromanganese[2]				
United States	5,508	781,000	494	117,000
Britain	–	–	65	13,000
Colombia	4	1,000	3	1,000
Total	5,512	782,000	562	131,000
Consumption[2]				
Manganese ore				
Metallurgical grade	166,175	..	..	..
Battery and chemical grade	2,310	..	..	..
Total	168,485			

Source: Dominion Bureau of Statistics.
[1]Mn content. [2]Gross weight.
pPreliminary; – Nil; .. not available.

TABLE 2

Canadian Manganese Imports, Exports and Consumption, 1960-70
(gross weight, short tons)

	Imports			Exports	Consumption	
		Ferromanganese				
	Manganese Ore[1]	Under 1% Silicon	Over 1% Silicon	Ferro-manganese	Ore	Ferro-manganese
1960	56,350	15,495	2,366	729	73,019	40,177
1961	76,016	12,121	2,173	238	78,642	44,545
1962	90,725	14,986	2,726	136	85,410	52,284
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
1970p	126,823	19,721	1,075	562	..	..

Source: Dominion Bureau of Statistics.

[1]From 1964, Mn content, prior years gross weight.
pPreliminary; .. Not available.

MINERALS AND SOURCES

Manganese occurs in many minerals that are widely distributed in the earth's crust but very few are of economic importance. The most common sources of the element are the minerals pyrolusite (MnO_2) and psilomelane (MnO_2H_2O.K,Na,Ba variable). These minerals may be accompanied by other oxides of manganese such as wad or bog manganese, hausmannite (Mn_3O_4) and braunite ($3Mn_2O_3MnSiO_2$). The carbonate rhodocrosite ($MnCO_3$) and the silicate rhodonite ($MnSiO_3$) are not usually of commercial importance but may constitute the source of enriched oxide deposits due to decomposition and reconcentration.

World production of manganese comes almost entirely from oxides of the element. In contrast to the ores of many other metals, manganese ores are not always reduced to the metal but are used as chemicals and in batteries in the form of oxides. The term 'manganese ore' is usually applied only to ores containing over 35 per cent manganese. Ores with less than 35 per cent manganese are described as ferruginous manganese or manganiferous ores.

Russia, with very large manganese reserves, is the leading world producer, and is the only major industrial nation that is self-sufficient in manganese. Important manganese deposits are also found in the Republic of South Africa, India, Brazil, Gabon, Ghana, Guyana and China. Australia has become a major producer in very recent years. Many other countries contribute to world production.

METALLURGICAL-GRADE MANGANESE ORE

Manganese ores having a manganese-iron ratio of 7 to 1 or more are preferred for making ferromanganese because it is possible to maintain a high productive capacity in the ferroalloy plant. High silica is undesirable because it increases the quantity of slag with attendant high loss of manganese. Because any particular ore is seldom of ideal composition most ferromanganese producers use ores from more than one source and blend them to attain the specifications they require. Manganese ores imported by the United States in 1970 and used in producing ferromanganese, silicomanganese and manganese metal varied in grade from 35 per cent to 55.7 per cent manganese and averaged 48.8 per cent. General specifications for metallurgical-grade ore and the bases for price quotations call for 46 to 48 per cent manganese and maxima of 7 per cent iron, 8 per cent silica, 0.15 per cent phosphorus, 6 per cent alumina, and 1 per cent zinc. The ore should be in hard lumps of less than 4 inches and not more than 12 per cent should pass a 20 mesh screen. Representative analyses of manganese ores and concentrates from different sources are shown in Table 6.

TABLE 3

World Production of Manganese Ores
(thousands of short tons)

Country	Per cent Mn[e]	1968	1969[p]	1970[e]
USSR	. .	7,236	7,700[e]	8,000
Republic of South Africa	30+	2,173	2,430	2,500
India	32-53	1,766	1,412	1,500
Brazil	38-50	1,852	2,166[e]	2,150
Gabon	50-53	1,382	1,502	1,500
China[e]	30+	990	1,100	1,100
Australia	35-54	822	1,016	1,100
Ghana	48+	456	385	400
Japan	30-43	344	332	400
Congo (Kinshasa)	42+	355	343	350
Hungary	30−	172	172	200
Morocco	35-53	177	144	200
Guyana	36-42	144	. .	. .
Ivory Coast	32-47	129	140	. .
Romania	35	88	88	90
Philippines	30+	73	22	50
Mexico	45+	65	158	150
New Hebrides	49-55	60[e]	. .	. .
Italy	30−	56	58	60
Malaysia	30-40	50	. .	. .
Iran	35+	13	39	. .
Thailand	40+	45	33	. .
Other countries[1]		279	624	250
Total		18,727	19,864	20,000

Sources: U.S. Bureau of Mines, Minerals Yearbook 1969; Indian Mining and Engineering Journal; 1970, author's estimate.

[1] Includes some 25 countries, each producing less than 35,000 tons a year.
[e]Estimated; [p]Preliminary; . . Not available.

TABLE 4

Principal Manganese Additive Materials

	Manganese	Silicon	Carbon
Ferromanganese			
high-carbon (standard)	74-82%	1.25% max.	7.5% max.
medium-carbon	74-85	1.50 max.	1.50 max.
low-carbon	80-85	7.00 max.	.75 max.
Silicomanganese	65-68	18-20	1.5
Spiegeleisen	16-28	1.00-4.50	6.5
Electrolytic metal	99.87	0.025	0.004

Source: *E & MJ Metal and Mineral Markets*, November 1965.

TABLE 5
United States Consumption
Manganese Ferroalloys and Metal, 1968-70
(short tons, gross weight)

	1968	1969	1970
Ferromanganese:			
High carbon	852,641	925,894	852,021
Medium and low carbon	106,892	125,888	127,153
Silicomanganese	150,846	150,013	..
Spiegeleisen	23,140	21,516	..
Manganese metal	21,038	21,966	..

Source: Mineral Industry Surveys, U. S. Bureau of Mines, Department of the Interior, Washington, D.C.
.. Not available.

TABLE 6

Representative Analyses of Manganese Ores and Concentrates
(per cent)

Country of Origin	Mn	Fe	SiO_2	Al_2O_3	P	Moisture	Ratio Mn/Fe
Ghana[1]	52	1.3	7.9	2.6	0.12	5.1	39.7
Ghana[1]	46	1.6	18.6	3.1	0.05	0.5	29.0
Guyana	39	7.2	14.2	19.3	0.07	0.4	5.4
Guyana	52	2.6	7.1	3.2	0.11	4.8	20.0
Egypt	51	6.9	1.4	.8	0.08	1.0	7.5
Egypt	49	8.2	2.2	1.0	0.08	0.7	6.0
Brazil (Amapa)[2]	50	4.1	2.7	6.0	0.07	4.5	12.3
Brazil (Urucum)	45	12.2	1.5	2.1	0.22	5.6	3.7
Mexico[3]	47	1.8	9.7	1.1	0.01	1.2	25.5
Gabon (Moanda)	50-52	2-4	1-3	5-7	0.09-0.013	..	..
Congo Republic (Kisenge)	48.98	2.39	7.07	4.46	0.125	..	..
"	49.67	2.38	5.90	5.75	0.114	..	..
"	50.54	2.37	4.56	4.50	0.142	..	..
India	49	6.3	9.0	1.6	0.14	3.5	7.1
India	40	15.7	2.3	6.0	0.03	1.3	2.5
Turkey	46	0.9	9.9	1.3	0.02	6.3	50.4
Republic of South Africa	40	16.2	2.3	6.1	0.03	0.4	2.5
South West Africa	47	5.6	12.2	1.4	0.04	0.9	8.5
Philippines	49	3.4	8.2	2.9	0.12	3.2	14.4
USSR (Chiatura)[4]	53	1.2	..	2.0	0.17	7.5	44.2
USSR (Nikopol)[5]	49	1.5	..	1.4	0.20	12.0	32.7

Source: Compiled from a survey of technical and trade publications.

Note: [1] 12.5 to 13.5% CaO+MgO; [2] 0.18% As; [3] 0.25% As, 8.42% CaO and 1.38% BaO; [4] 0.15 to 1.6% CaO+MgO; [5] 1.1 to 2.3% CaO+MgO.

..Not available.

BATTERY-GRADE MANGANESE ORE

Battery-grade manganese ores are subject to chemical and physical specifications but the principal requirement is a high manganese dioxide (MnO_2) content. Ores that are suitable for the manufacture of dry-cell batteries are usually suitable for metallurgical use but metallurgical ores are less frequently suitable for battery manufacture. Tests are carried out by making batteries from trial lots of ore and placing the batteries in test service. The composition of a battery-grade ore should generally be within the following limits:

	Per Cent
MnO_2	75 – 85
Total Mn	48 – 58
Absorbed moisture	3 – 5
Iron as Fe	0.2 – 3.0
Silicon as SiO_2	0.5 – 5.0
Other metallic impurities	0.1 – 0.2

CHEMICAL-GRADE MANGANESE ORE

Manufacturers of manganese chemicals use ores of various grades including high-grade ores and concentrates also suitable for metallurgical use. These are used to make manganese chemicals such as hydroquinone, potassium permanganate, sulphates, and chlorides for use in the welding rod, glass, dye, paint and varnish, fertilizer, pharmaceutical and photographic industries.

Manganese ores of various grades are used in the manufacture of electrolytic manganese metal and in the production of synthetic manganese dioxide for the metallurgical, chemical and battery industries.

CANADIAN SUPPLIERS AND CONSUMERS

Union Carbide Canada Limited, Metals and Carbon Division, uses metallurgical-grade ore to manufacture standard high-carbon ferromanganese, medium and low-carbon ferromanganese and silicomanganese. Chromium Mining & Smelting Corporation, Limited produces manganese alloys at its plant in Beauharnois, Quebec. Imported electrolytic manganese is used by Atlas Steels 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–*in Nova Scotia:* Sydney Steel Corporation, Sydney; *in Quebec:* Atlas Steels Division of Rio Algom Mines Limited, Tracy, Dosco Steel Limited, Montreal; *in Ontario:* The Algoma Steel Corporation, Limited, Sault Ste. Marie; Atlas Steels, Welland; Burlington Steel Division of Slater Steel Industries Limited, Hamilton; Dominion Foundries and Steel, Limited, Hamilton; The Steel Company of Canada, Limited, Hamilton.

Consumers of battery-grade ore are National Carbon Limited and Mallory Battery Company of Canada Limited, both of Toronto, and Ray-O-Vac Division of ESB Canada Limited, Winnipeg.

PRICES

United States prices published by *Metals Week* of December 29, 1969 and December 28, 1970 were:

	December 29, 1969	December 28, 1970
Manganese ore		
per long ton unit (22.4 lb) Mn content		
Min. 48% Mn (low impurities)	(N) 53-57¢	(N) 59-62¢
Min. 46% Mn	(N) 50¢	(N) 56-58¢
Ferromanganese		
f.o.b. shipping point, freight equalized to nearest main producer, carload lots, lump, bulk per long ton of alloy		
Standard 74-76% Mn	(N) $164.50	(N) $169.50
78% Min. Mn	(N) 170.00	190.00
low-phosphorous	(N) 185.00	(N) 220.00
Imported standard 74-76% Mn delivered Pittsburgh-Chicago	160-164	180.00
Medium carbon per lb Mn	17.75¢	19.5¢
"MS" manganese, per lb Mn	19.0¢	21.0¢

PRICES (Cont'd)

Low-carbon, per lb Mn		
0.10% C	28.65¢	30.5¢
0.30% C	28.65¢	30.5¢
0.75% C	28.65¢	30.5¢
Ferromanganese silicon, 0.05% C per lb alloy	15.55¢	16.8¢
Ferromanganese briquettes per lb alloy	8.50¢	9.2¢
Manganese metal		
Electrolytic metal, 99.9% per lb Mn, boxed f.o.b. shipping point		
Regular	30.25¢	33.25¢
Hydrogen-removed	30.25¢	33.25¢
4-5% N	31.25¢	34.25¢
6% N	33.25¢	36.25¢
Silicomanganese		
per lb of alloy, f.o.b. shipping point, freight equalized to nearest main producer, carload lots, lump, bulk		
12½-16% Si, 3% C	8.45¢	10.65¢
High Mn, 15.5-17% Si, 1.75-2.25% C	8.95¢	11.90¢
16-18½% Si, 2% C	8.45¢	10.65¢
18½-21% Si, 1½% C	8.75¢	11.38¢
Briquettes	9.55¢	11.00¢

(N) Nominal.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General
CANADA				
32900-1	Manganese ore	Free	Free	Free
33504-1	Manganese oxide	Free	Free	Free
35104-1	Electrolytic manganese metal	Free	Free	20%
37501-1	Ferromanganese, spiegeleisen, and other alloys of manganese not more than 1% Si, on the Mn content, per lb	Free	0.5¢	1.25¢
37502-1	Silicomanganese, silico spiegel and other alloys of manganese, more than 1% Si, on the Mn content, per lb	Free	0.75¢	1.75¢

UNITED STATES

Item No.		
601.27	Manganese ore (duty temporarily suspended to end of June 1973)	
	On and after Jan. 1, 1970	0.17¢ per lb on Mn content
	On and after Jan. 1, 1971	0.15¢ per lb on Mn content
	On and after Jan. 1, 1972	0.12¢ per lb on Mn content

TARIFFS (Cont'd)

632.32	Manganese metal, unwrought, waste and scrap (duty temporarily suspended on waste and scrap to end of June 1971)	
	On and after Jan. 1, 1970	1.6¢ per lb + 12% ad. val.
	On and after Jan. 1, 1971	1.5¢ per lb + 11% ad. val.
	On and after Jan. 1, 1972	1.5¢ per lb + 10% ad. val.
607.35	Ferromanganese not containing over 1% C	
	On and after Jan. 1, 1970	0.4¢ per lb on Mn content + 3%
	On and after Jan. 1, 1971	0.3¢ per lb on Mn content + 2.5%
	On and after Jan. 1, 1972	0.3¢ per lb on Mn content + 2%
607.36	Ferromanganese, containing over 1% C but not over 4% C	
	On and after Jan. 1, 1970	0.6¢ per lb on Mn content
	On and after Jan. 1, 1971	0.55¢ per lb on Mn content
	On and after Jan. 1, 1972	0.46¢ per lb on Mn content
607.37	Ferromanganese, containing over 4% C	
	On and after Jan. 1, 1970	0.43¢ per lb on Mn content
	On and after Jan. 1, 1971	0.35¢ per lb on Mn content
	On and after Jan. 1, 1972	0.3¢ per lb on Mn content

Sources: Tariff Schedules of the United States annotated (1970) TC Publication 304. The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

Mercury

J. G. GEORGE*

The Pinchi Lake mine, located some 30 miles north of Fort St. James, British Columbia, was again in 1970 the main source of Canada's mine output of mercury. Only minor quantities were derived from other producers in southern British Columbia. The Pinchi Lake mine, operated by Cominco Ltd., restarted operations in August 1968 with a mill with rated capacity of 800 short tons** of ore a day. In 1970, the mill processed some 393,000 tons of cinnabar ore. 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.

Silverquick Development Co. (B.C.) Ltd. continued construction of a 500-ton-a-day concentrator at its mercury property near Gold Bridge in the Bridge River district of southern British Columbia. It was reported that the company's mine, mill and roasting facilities were rescheduled to begin operations about mid-1971, with an annual production goal said to be 3,000 flasks† of mercury. Proven ore reserves have been estimated at about 400,000 tons grading 0.1 per cent mercury and indicated reserves at 1,000,000 tons of similar grade. All of these reserves are in the No. 1 open-pit area. Empire Metals Corporation Ltd. (formerly Empire Mercury Corporation Ltd.) did further development work at its Manitou Mercury property north of Gold Bridge in the Bridge River district of British Columbia. Probable ore reserves at the property were previously reported to be 700,000 tons grading 1.1 pounds of mercury per ton. Highland Mercury Mines Limited did some percussion drilling and other exploration work on its mercury prospect near Cominco's Pinchi Lake mine. Some other companies explored mercury prospects in the Pinchi Lake area, the Kamloops Lake area, and the Bridge River district, all in British Columbia.

Canadian imports of mercury in 1970, at 153,300 pounds, were slightly higher than the 133,600 pounds imported in 1969. Statistics on Canadian production and exports of mercury are not available. Reported consumption in Canada in 1969 was 308,814 pounds. Consumption figures for 1970 are not yet available.

WORLD REVIEW

In 1970, Spain and Italy together produced about 38 per cent of the estimated world mine output of 279,000 flasks of mercury. The seven largest producing countries, in declining order of output, were Spain, Italy, Russia, United States, Mexico, Mainland China and Yugoslavia.

Mine output of mercury in the United States declined to about 28,000 flasks in 1970 compared with 29,360 flasks in 1969. The United States is believed to be the world's largest consumer of mercury but has always produced less than its requirements. Overall consumption in 1970 in the United States was estimated at 61,490 flasks, representing a considerable reduction from the 79,104 flasks consumed in 1969.

The decline in usage of mercury in 1970 in the United States was attributed mainly to the reduced pace of the United States economy and the problem of mercury pollution. The pollution factor became serious when fish caught in Lake St. Clair and Lake Erie were found, early in 1970, to have relatively high mercury levels and declared unsafe for 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 remove the mercury from

*Mineral Resources Branch.
**The short ton (2,000 pounds avoirdupois) is used throughout this review, unless otherwise specified.
†The flask of 76 pounds avoirdupois is used throughout this review.

the bottoms of these and other lakes and rivers where it has been dumped for years remains unsolved. Although demand for mercury in other foreign countries in 1970 was believed to be better than in the United States, it is thought that the worldwide pollution problem could eventually affect, adversely, the use of mercury as a cathode in the electrolytic preparation of chlorine and caustic soda, one of its two major uses. The danger of mercury poisoning has also cut into other markets for mercury, such as in the agriculture and pulp and paper industries.

TABLE 1

Canadian Mercury Production, Trade and Consumption, 1969-70

	1969		1970p	
	Pounds	$	Pounds	$
Production	..	..	..	..
Imports (metal)				
Mexico	65,400	465,000	79,000	504,000
Spain	10,800	78,000	51,200	337,000
United States	37,800	261,000	22,300	127,000
Sweden	–	–	800	19,000
Yugoslavia	15,800	109,000	–	–
Netherlands	3,800	27,000	–	–
Total	133,600	940,000	153,300	987,000
Consumption (metal)				
Heavy chemicals	242,464		..	
Electrical apparatus	5,095		..	
Gold recovery	1,611		..	
Miscellaneous	59,644		..	
Total	308,814		..	

Source: Dominion Bureau of Statistics.
pPreliminary; – Nil; .. Not available.

TABLE 2

Canadian Mercury Production, Trade and Consumption, 1961-70

	Production	Imports		Exports	Consumption
	Metal (pounds)	Metal (pounds)	Salts ($)	Metal (pounds)	Metal (pounds)
1961	–	312,913	3,764	..	150,588
1962	–	245,059	3,838	..	135,291
1963	–	447,592	9,521	..	147,396
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	..	197,900	..	..	327,939
1969	..	133,600	..	..	308,814
1970p	..	153,300	..	..	..

Source: Dominion Bureau of Statistics.
pPreliminary; – Nil; .. Not available.

A weakness developed in the mercury market in 1970 because of oversupply coupled with a relatively stagnant consumption rate. As a result, prices declined substantially and some mine producers in the United States suspended operations whilst others curtailed output. Only 701 flasks of surplus stocks of mercury held in United States government stockpiles were sold to industry in 1970 by General Services Administration (GSA), because of the unfavourable market conditions. For the same reason, GSA cancelled all monthly offerings of stockpiled mercury during the last four months of 1970. Market conditions were somewhat aggravated by substantial increases in production in some countries including Canada, Ireland and Turkey. Mercury prices declined almost continuously in 1970, with the New York price dropping from slightly under $500 a flask at the beginning of the year to $350 at year-end.

TABLE 3

World Production of Mercury
(flasks of 76 pounds)

	1966	1969p	1970e
Spain	70,054	64,406	60,000
Italy	53,549	48,733	46,000
Russiae	40,000	47,000	*
United States	22,008	29,360	28,000
Mexico	22,104	22,500	22,000
Mainland Chinae	26,000	20,000	*
Yugoslavia	15,896	14,330	15,000
Japan	4,846	5,599	*
Turkey	3,420	4,800e	*
Philippines	2,443	3,478	*
Peru	3,166	3,360	*
Other countriese	1,508	21,777	108,000
Total	264,994	285,343	279,000

Sources: Minerals Yearbook 1968, United States Department of the Interior, for 1966 figures. Preprint from the 1969 Bureau of Mines Minerals Yearbook, United States Department of the Interior, on mercury for 1969 figures. Commodity Data Summaries, January 1971, Bureau of Mines, United States Department of Interior, for 1970 statistics.

* Data not available; estimate included in figure for "Other countries".

p Preliminary; e Estimated.

At the end of 1970, United States government stockpiles contained a total of 200,105 flasks of mercury; the stockpile objective being 126,500 flasks. The surplus of 73,605 flasks, however, requires Congressional approval before it can be released. These stocks are also exclusive of excess mercury held by the United States Atomic Energy Commission (AEC). In June 1969, these surplus AEC stocks, which do not require Congressional authorization prior to being sold, were declared to be 15,000 flasks. Between then and the end of 1970, a total of only 1,500 flasks of surplus AEC mercury were sold.

OUTLOOK

Fears of pollution continue to weaken demand for mercury and to depress free market prices. Because of these environmental hazards, involved in several of mercury's uses, as well as the continuing lag in the United States and other economies, the outlook for mercury for 1971 and some years thereafter is thought to be somewhat less favourable than it has been in recent years. In one of mercury's major markets, the electrolytic production of chlorine and caustic soda, the future trend might be toward a greater use of diaphragm cells (in which mercury is not required), instead of mercury cells, in the installation of such new manufacturing plants and expansion of existing facilities. Indications are that in 1971 consumption could be lower, at least in the United States, whereas world production, if not somewhat higher, is not expected to decrease significantly. With supply, therefore, again expected to exceed demand in 1971 no meaningful improvement in prices is expected in the near term. Much will also depend on whether or not Spain and Italy, the world's two largest producing countries, continue to withhold a portion of their supplies from the market.

USES

One of the oldest but now relatively unimportant uses of mercury is for recovering gold and silver from their ores by amalgamation. The two major uses in recent years have been for electrical apparatus and for the electrolytic production of chlorine and caustic soda. Together they accounted for about 50 per cent of mercury consumed in the United States in 1970. Electrical uses include mercury lamps, batteries, rectifier bulbs, oscillators, and various kinds of switches including "silent" switches for use in the home. Mercury lamps are adaptable to higher-voltage supply lines than those used with incandescent lamps and, for this reason, 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 conditions of 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 important applications are in mildew-proofing paints, industrial and control instruments, pharmaceuticals, insecticides, fungicides, bactericides, and dental preparations. Several mercury compounds, especially the chloride, oxide and sulphate, are good

TABLE 4

United States Mercury Consumption, by Uses,
Primary and Secondary in Origin
(flasks of 76 pounds)

Use	1966	1969	1970p
Agriculture (includes fungicides and bactericides for industrial purposes)	2,374	2,689	1,812
Amalgamation	248	195	216
Catalysts	1,932	2,958	2,041
Dental preparations	1,334	3,053	1,799
Electrical apparatus	16,257	18,650	15,789
Electrolytic preparation of chlorine and caustic soda	11,541	20,720	14,977
General laboratory use	1,563	2,041	1,513
Industrial and control instruments	4,097	6,981	4,035
Paint:			
Antifouling	140	244	193
Mildew-proofing	8,280	9,486	8,771
Paper and pulp manufacture	612	558	316
Pharmaceuticals	232	724	571
Redistilled	7,267	*	*
Other	15,632	10,805	7,621
Total	71,509	79,104	61,490**

Sources: Preprint from the 1969 Bureau of Mines Minerals Yearbook, United States Department of the Interior, on mercury for 1966 and 1969 figures. Mineral Industry Surveys, United States Department of the Interior, Bureau of Mines, Mercury in the fourth quarter of 1970, for 1970 figures.

* In 1969 and 1970 "redistilled" mercury is broken down and included in the categories for which it is used.

**The items do not add to the total which has been increased to cover approximate total consumption.

p Preliminary.

TABLE 5

Average Monthly Prices of Mercury in 1970
at New York, London and CIF Main European Port
($ U.S. per flask of 76 pounds)

	New York	London* (U.S. Equiv.)	CIF Main European Ports** (U.S. Equiv.)	
			Low	High
January	482.500	560.93	488.00	500.53
February	462.474	508.80	453.90	464.70
March	459.762	508.80	456.30	469.20
April	467.227	508.80	456.60	469.20
May	442.000	508.80	433.80	445.80
June	411.136	508.80	408.53	421.33
July	409.091	508.80	410.67	419.47
August	358.476	508.80	367.50	377.40
September	351.048	508.80	352.80	363.00
October	341.591	508.80	342.40	354.13
November	353.421	508.80	351.90	369.00
December	354.500	508.80	354.60	365.40

Sources: Metals Week for the New York prices; Metal Bulletin (London) for the London and CIF Main European Port prices.

*Ex-warehouse prices.

**CIF Main European Port (Min. 99.9%) prices.

catalysts for many chemical reactions, including those involved in the making of plastics. Mercury's military uses include fulminate for munitions and blasting caps, and as a catalyst in the manufacture of chemicals for chemical warfare. 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.

PRICES

The price of mercury per flask f.o.b. New York, as quoted in *Metals Week,* fluctuated in 1970 between a high of $498 in January and a low of $328 in September. Average for the year was $407.77 a flask compared with an average of $504.04 for 1969. The London ex-warehouse price, as quoted in *Metal Bulletin (London),* remained at £235 per flask from the beginning of January 1970 until the end of that month when it declined to £212, at which level it remained for the rest of the year.

TARIFFS

CANADA

Item No.		Most Favoured Nation
92805-2	Mercury metal	free

UNITED STATES

Item No.		
601.30	Mercury ore	free
632.34	Mercury metal, unwrought	15¢ per lb*

Sources: For Canadian rates, The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States rates, Tariff Schedules of the United States Annotated (1970) TC Publication 304.

* On and after January 1, 1971.

Molybdenum

G.P. WIGLE*

Production of molybdenum in Canada in 1970 was 35.3 million pounds valued at $62.6 million compared with 29.6 million pounds valued at $53.4 million in 1969. Canada was second only to the United States among world producers of molybdenum, and supplied approximately 23 per cent of estimated non-communist world production of 155.3 million pounds.

Non-communist world mine production capacity at the end of 1970 was 160 million pounds of molybdenum a year. Production, 155 million pounds, exceeded consumption and an excess of capacity is expected to continue for at least four years, assuring adequate supplies for continuing growth in consumption.

Most of the production increase, of about 9 per cent from 1969, came from Canada and the United States. Substantial additions to molybdenum output are assured in both countries from new molybdenum and copper-molybdenum mines scheduled for production during the next four to five years; several of them had started construction and mine development during 1970.

The prices of molybdenum established by American Metal Climax, Inc., on May 5, 1969, remained unchanged through 1970 at U.S. $1.72 a pound of contained molybdenum in molybdenite (MoS_2) concentrates, and U.S. $1.92 a pound of contained molybdenum in molybdenum trioxide (MoO_3).

The United States General Services Administration in the fiscal year ended June 30, 1970, sold 13.2 million pounds of molybdenum valued at $22.9 million. However, 12.3 million pounds of that amount was sold on a negotiated basis to domestic producers for delivery over the next eight years, the remainder was sold on an off-the-shelf basis. In July 1970 the GSA proposed to sell an additional 3.5 million pounds to producers and 2.8 million pounds remained for sale under a previous authorization on an off-the-shelf basis. The inventory of the national stockpile at December 31, 1970 showed a total of 41.3 million pounds of molybdenum consisting of 22.7 million pounds in MoS_2 concentrates, 11 million pounds in MoO_3, and 7.5 million pounds in ferromolybdenum.

PRODUCTION AND DEVELOPMENTS

CANADA

Brenda Mines Ltd., after a period of tune-up operation, reached production near design capacity at the end of March 1970, and milled 23,443 tons a day during the remainder of the year. The average milling rate in the last six months was 24,273 tons a day. Grade of ore milled was 0.221 per cent copper and 0.065 per cent molybdenum. Production for the year was 8.1 million pounds of molybdenum and 14,313 tons of copper. Molybdenum recovery was 87.25 per cent and copper recovery was 90.53 per cent. Ore reserves at the end of the year were estimated at 165 million tons averaging 0.182 per cent copper and 0.049 per cent molybdenum.

The Mount Copeland Mine, of King Resources Company, 18 miles northwest of Revelstoke, British Columbia, came into production at 200 tons of molybdenum ore a day in mid-1970. Ore reserves were estimated by the company at 180,000 tons averaging 1.82 per cent molybdenite. Annual production should be over one million pounds of molybdenum.

*Mineral Resources Branch.

TABLE 1

Canada, Molybdenum Production, Trade and Consumption
1969-1970

	1969		1970P	
	Pounds	$	Pounds	$
Production (shipments)[1]				
British Columbia	26,904,593	48,322,575	32,860,500	58,072,000
Quebec	2,746,668	5,065,010	2,493,000	4,553,000
Total	29,651,261	53,387,585	35,353,500	62,625,000
Exports				
Molybdenum in ores and concentrates				
Britain	7,502,000	13,733,000	8,307,100	16,011,000
Japan	3,684,300	8,063,000	5,029,900	11,173,000
Netherlands	3,484,300	6,478,000	4,850,900	9,758,000
France	3,798,700	6,867,000	4,761,200	9,123,000
Belgium and Luxembourg	742,600	1,525,000	2,482,100	4,657,000
West Germany	3,096,100	6,112,000	1,786,000	3,603,000
Sweden	1,595,500	3,058,000	1,028,500	2,167,000
Italy	899,800	1,738,000	762,100	1,692,000
India	44,800	98,000	332,600	752,000
Brazil	224,400	417,000	299,700	616,000
Other countries	600,100	1,203,000	693,900	1,418,000
Total	25,672,600	49,292,000	30,334,000	60,970,000
Imports				
Molybdic oxide[2]				
United States	76,600	80,000	73,900	82,000
Ferromolybdenum				
United States[3]	482,609	1,035,545	65,299*	144,310*
Consumption (Mo content)				
Ferrous and nonferrous				
Alloys	1,678,124	..	..	..
Electrical and electronics	14,822	..	..	..
Other uses[4]	113,736	..	..	..
Total	1,806,682	..	..	..

Source: Dominion Bureau of Statistics.
[1]Producers' shipments (Mo content) of molybdenum concentrates, molybdic oxide and ferromolybdenum; [2]Gross weight; [3]United States exports of ferromolybdenum (gross weight) to Canada, reported by the U.S. Bureau of Commerce, Exports of Domestic and Foreign Merchandise (Report 410). Value in U.S. Currency. Imports of ferromolybdenum are not available separately in official Canadian Trade Statistics; [4]Chiefly pigment uses.

* First 9 months only; PPreliminary; .. Not available.

Endako Mines Ltd. operated at capacity during 1970. Production was 18.2 million pounds of molybdenum of which 9.4 million pounds were in molybdenite (MoS_2) concentrates and 8.8 million pounds were in the roasted product, molybdic oxide (MoO_3). The average number of tons milled a day was 27,721, grade of ore milled was 0.182 per cent MoS_2, and recovery was 82.39 per cent. Proven and probable ore reserves at the beginning of 1970 were 214 million tons averaging 0.146 per cent MoS_2.

Boss Mountain Division of Brynnor Mines Limited, operated at an annual milling rate of 591,000 tons. Production in 1970 was 2,456,000 pounds of molybdenum. Ore reserves above the adit level were

TABLE 2

Molybdenum – Canadian Production, Trade and Consumption, 1960-70
(pounds)

	Production[1]	Exports[2]	Imports: Molybdic Oxide[3]	Imports: Ferro-molybdenum[4]	Consumption[5]
1960	767,621	. .	656,062	230,600	1,042,077
1961	771,358	. .	266,399	211,779	1,135,610
1962	817,305	. .	328,424	121,358	1,261,380
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	21,376,766r	23,792,700	452,600	316,692	1,430,895
1968	22,464,273r	22,704,500	1,359,300	284,600	1,543,432
1969	29,651,261r	25,672,600	76,600	482,609	1,806,682
1970p	35,353,500	30,334,000	73,900	. .	. .

Source: Dominion Bureau of Statistics.

[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.

pPreliminary; rRevised; . . Not available.

2.5 million tons grading 0.23 per cent molybdenum. Development and stope preparation proceeded below the adit level in preparation for mining some one million tons of ore averaging 0.29 per cent molybdenum.

British Columbia Molybdenum Limited, a subsidiary of Kennecott Copper Corporation, operated its 6,000-ton-a-day mine and concentrator near Alice Arm, British Columbia, at capacity during 1970. Production for the year was about 6 million pounds of molybdenum.

Red Mountain Mines Limited, near Rossland in south central British Columbia suspended mining operations temporarily on December 22, 1970, but planned to start milling material from a new ore zone in February 1971. Production in 1970 was 587,455 pounds of molybdenum.

The molybdenum producers in eastern Canada at the end of 1970 were: Molybdenite Corporation of Canada Limited at Lacorne, Quebec; Preissac Molybdenite Mines Limited in the Preissac area near Val d'Or, Quebec; and Gaspé Copper Mines, Limited, which recovers molybdenum, 377,000 pounds in 1970, at its copper mining operations at Murdochville in the Gaspé Peninsula of Quebec. Cadillac Moly Mines Limited in the Preissac area ceased operation in mid-1970.

Beattie-Duquesne Mines Limited converted molybdenite concentrates from various producers to molybdic oxide at its roasting plant at Duparquet, Quebec.

Masterloy Products Limited, near Ottawa, Ontario, operated its new enlarged ferroalloy and special alloy plant at a record rate in 1970. Masterloy produced ferromolybdenum, ferrocolumbium, and ferrovanadium for domestic and export markets. The new plant is equipped to produce more than 2,000 tons a year of various ferroalloys.

DEVELOPMENTS

Lornex Mining Corporation Ltd., managed by Rio Algom Mines Limited, proceeded with construction and development in preparation for production from its large copper-molybdenum property some 33 miles south of Ashcroft in the Highland Valley of British Columbia. A production rate of 38,000 tons of ore a day was planned. The orebody was estimated to contain 293 million tons averaging 0.427 per cent copper and 0.014 per cent molybdenum. It was estimated that $120 million would be required to bring the property to production in the early months of 1972. Annual production was expected to be about 54,000 tons of copper and 2.5 million pounds of molybdenum.

Utah Construction & Mining Co. continued preparation for production at its copper-molybdenum property near Port Hardy in the northern part of Vancouver Island. This 33,000-ton-a-day mining and milling project is scheduled for production in the latter part of 1971 or early 1972. Capital expenditure was estimated at $73.5 million. Ore reserves were estimated at 280 million tons averaging 0.52 per cent copper and 0.029 per cent molybdenum. Annual output is expected to be about 53,000 tons of copper and 1.9 million pounds of molybdenum.

Placer Development Limited, announced its intention to develop and prepare for production by June 1972 the property of Gibraltar Mines Ltd., about 35 miles north of Williams Lake in the Cariboo district of British Columbia. The new mine and plant are to have a design capacity of 30,000 tons of ore a day. Ore reserves are estimated at over 200 million tons averaging 0.39 per cent copper and 0.016 per cent molybdenite (MoS_2). Estimated capital expense of bringing the property into production is $74 million.

Highmont Mining Corp. Ltd. proceeded with development, sampling, metallurgical test work and feasibility studies on its copper-molybdenum property in the Highland Valley adjoining to the east of Lornex. Teck Corporation Limited entered into an agreement to arrange financing and direct continued exploration and development of the Highmont property. If the feasibility studies support a decision to bring the property to production it is expected that the milling rate will be about 25,000 tons of open-pit ore a day. Metallurgical recovery tests indicated a recovery of 92 per cent for copper and 83 per cent for molybdenum.

The molybdenum property of Adanac Mining and Exploration Ltd., about 14 miles northeast of Atlin near the Yukon border in northern British Columbia, is undergoing an extensive program of underground drifting, bulk sampling, pilot plant metallurgical tests and production feasibility studies. The work is being carried out by Kerr Addison Mines Limited under an agreement to make a production decision by September 1, 1971. If a favourable decision on production is reached Kerr Addison would arrange the financing to bring the property to production by mid-1973 and acquire a 60 per cent interest. Earlier feasibility studies and open-pit designs indicated a waste to ore ratio of 1.3:1 for about 70 million tons averaging 0.141 per cent molybdenite (0.0846 per cent Mo). Initial laboratory tests indicated a recovery of 90 to 93 per cent of contained molybdenum.

Among other molybdenum and copper-molybdenum properties in British Columbia explored and studied for their production possibilities were those of Bell Molybdenum Mines Limited near Alice Arm, Della Mines Ltd. in the Cassiar district, Sileurian Chieftain Mining Company Limited in the Alice Arm area, and Valley Copper Mines Limited in the Highland Valley.

UNITED STATES

The United States has the largest annual production of molybdenum and has produced more than half the world supply since 1925. The United States is also the foremost exporter of molybdenum with overseas sales of 57.6 million pounds in concentrates in 1969 and an estimated 58 million pounds exported in 1970. Production was 99.8 million pounds in 1969 and an estimated 107 million pounds in 1970. Consumption was 51.6 million pounds and an estimated 47 million pounds in the respective years.

New molybdenum production facilities planned for completion during the next five years will maintain United States dominance among world molybdenum producers by a wide margin until at least 1980 despite the completion of presently planned production increases in other countries.

American Metal Climax, Inc., (AMAX) is the largest single producer of molybdenum with an annual output of some 60 million pounds from its Climax and Urad mines in Colorado.

The largest of the many new molybdenum mines being developed for production throughout the world is the AMAX Henderson mine, near the Urad, that AMAX expects to bring into production in 1975 at an annual capacity of 50 million pounds of molybdenum. The Henderson orebody contains an estimated 300 million tons of ore averaging 0.49 per cent molybdenite (MoS_2).

Duval Corporation started production in mid-1970 at its $166-million Sierrita open-pit copper-molybdenum mine, some 20 miles south of Tucson, Arizona. The ore zone was estimated to contain 414 million tons averaging 0.35 per cent copper and 0.036 per cent molybdenum. Annual production of molybdenum is expected to be some 12-14 million pounds at a planned mining and milling rate of 72,000 tons a day.

JAPAN

Molybdenum consumption in Japan has grown from about 5 million pounds in 1960 to over 16 million

TABLE 3

Molybdenum Production in Ores and Concentrates, 1968-70
(Mo content, thousands of pounds)

	1968	1969	1970[e]
United States	93,477	99,807	107,000
Canada	22,464[r]	29,651[r]	35,353[p]
Chile	8,521	10,675	10,000
Peru	1,784	370	
South Korea	423	220	
Japan	622	593	(3,000)
Norway	660	660	
Mexico	176	150	
Philippines	95	35	
Total	128,222	142,161	155,353

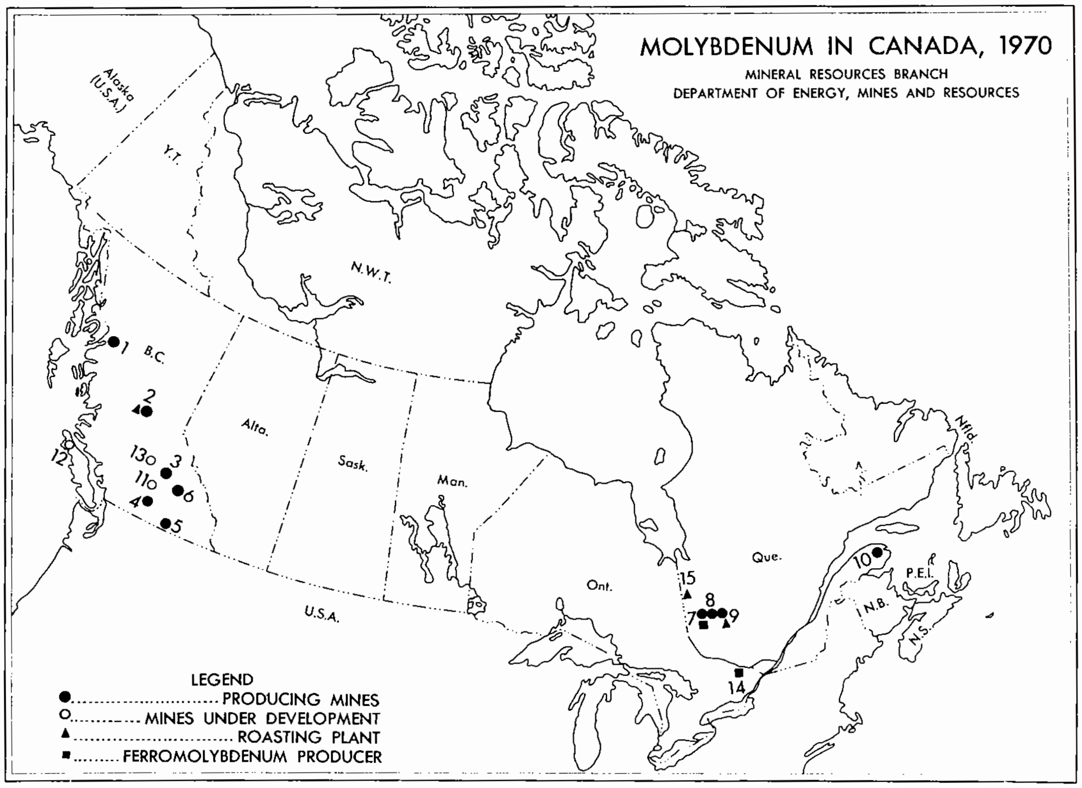
Sources: U.S. Bureau of Mines, Minerals Yearbook; Dominion Bureau of Statistics; Company reports.

[e]Estimated; [r] Revised; [p]Preliminary.

pounds in 1969. Canada's exports of molybdenum to Japan were 4.5 million pounds in 1968 and 3.7 million pounds in 1969 with an aggregate value of $18.4 million. Export of Canadian molybdenum to Japan in 1970 was about 5 million pounds.

Japan's rapidly increasing steel production and the growing use of molybdenum in steelmaking will make Japan an ever more important customer for Canada's molybdenum output. Japan could require over 25 million pounds of molybdenum in 1975 and some 40 million pounds in 1980. Japan produces about 500,000 pounds of molybdenum a year from its own mineral resources.

American Metal Climax, Inc. and a group of 10 Japanese companies began building in September 1970, a 12-million-pound-a-year molybdenite conversion plant in Japan. AMAX has a 34 per cent share of the equity in the $5.5-million roaster; the remaining 66 per cent is apportioned among Japanese participants. The design capacity of this modern roaster is similar to the capacity of the molybdenite roasting plant at Rotterdam, Netherlands, that is operated by a subsidiary of AMAX.



PRODUCING MINES

(numbers refer to number on map)

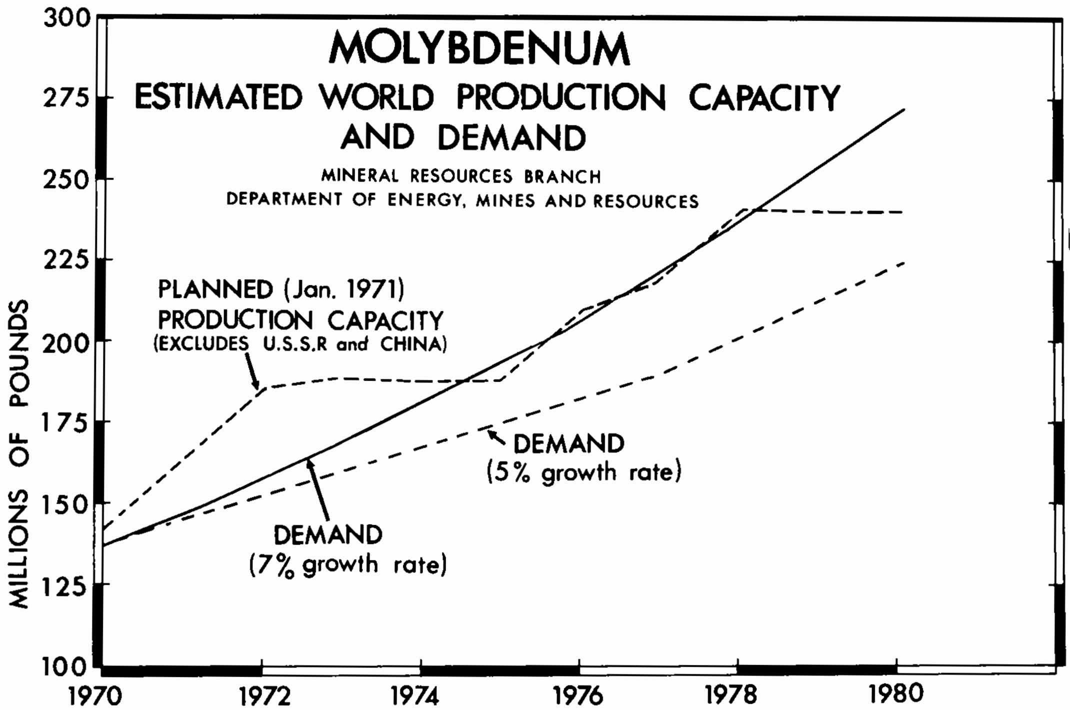
1. British Columbia Molybdenum Limited
2. Endako Mines Ltd.
3. Brynnor Mines Limited (Boss Mountain)
4. Brenda Mines Ltd.
5. Red Mountain Mines Limited
6. King Resources Company Mount Copeland Mine
7. Preissac Molybdenite Mines Limited
8. Cadillac Moly Mines Limited (ceased operation mid-1970)
9. Molybdenite Corporation of Canada Limited
10. Gaspé Copper Mines, Limited

MINES UNDER DEVELOPMENT

11. Lornex Mining Corporation Ltd.
12. Utah Construction & Mining Co.
13. Gibraltar Mines Ltd.

PROCESSING PLANTS

2. Endako Mines Ltd.
7. Preissac Molybdenite Mines Limited
9. Molybdenite Corporation of Canada, Limited
14. Masterloy Products Limited (ferroalloy plant)
15. Beattie-Duquesne Mines Limited (roaster)



OUTLOOK

Molybdenum production capacity in the non-communist countries increased about 13 per cent to approximately 160 million pounds a year in 1970. Combined present and planned new production capacity, barring unforeseen delays in development and construction at mining projects already undertaken, will exceed consumption, as indicated by demand projections based on 7 per cent annual growth, by some 20 to 25 million pounds a year by 1972. Capacity, however, even at an annual 240 million pounds would be overtaken by demand in 1978.

A sustained annual growth of 7 per cent in demand is needed through 1978 to market the already-planned increased production, and reduce stocks that may accumulate prior to 1974. Sales from stockpile even in limited amount are a significant market factor during a period of possible oversupply. The principal factor in the growth of molybdenum consumption is its favourable relation to steel production with due consideration for the presently confident predictions of continuing growth in world output of steel.

PRODUCTS AND USES

The steel and iron industries are the principal consumers of molybdenum accounting for over 80 per cent of total consumption, the balance being used in high-temperature alloys, as molybdenum metal, in lubricants, chemicals, pigments and in catalysts.

Approximately 70 per cent of United States' molybdenum consumption was in the form of molybdic oxide (MoO_3), some 22 per cent was used as ferromolybdenum, and about 4 per cent as molybdenum powder. Molybdenum is used in lesser amounts in the molybdates of ammonium, sodium, and calcium, as purified molybdenite in lubricants, and as molybdenite for direct addition to steel when sulphur is also to be added.

Molybdenite concentrate is roasted to form technical-grade molybdic oxide (MoO_3) which is the starting material for manufacturing most other molybdenum products. Technical-grade molybdic oxide, or roasted molybdenite concentrate, is also made into briquettes with pitch and both forms of MoO_3 are used to add molybdenum to steel and iron. Molybdic oxide is also used to make ferromolybdenum containing 55 to 75 per cent Mo, an additive which is adaptable to any steelmaking process.

Ferromolybdenum is made in the electric arc furnace or by the thermite process.

Typical analyses of molybdenite and molybdic oxide concentrates from Endako Mines Ltd. are:

	MoS_2 concentrate	MoO_3 concentrate
Molybdenum	53 per cent	59-60 per cent
Copper	0.015 " "	0.017 " "
Lead	0.006 " "	0.006 " "
Bismuth	0.015 " "	0.017 " "
Iron	0.14 " "	0.015 " "
Silica	6.5 " "	7.0 " "
Moisture and reagents	4-6 " "	Sulphur 0.05-0.10 " "

Small additions of molybdenum promote uniform hardness, hardenability and toughness and are used in nearly all kinds of steels. The adding of molybdenum to molten steel is a straight-forward operation, losses are small, and addition is commonly made in the oxide form or as ferromolydenum. It raises the strength of low- and high-alloy steels for use at high temperatures. It improves the corrosion resistance of chromium-nickel stainless steels giving a superior product for handling of corrosive chemicals.

The petroleum and chemical industries use molybdenum as a catalyst, and in structural components of process equipment and containers. It is also used in the production of pigments for inks, lacquers and paints noted for their permanence and brilliance. Molybdenum metal and molybdenum-base alloys are used in high-temperature applications, thermocouples, electronics, missile parts and in structural parts of nuclear reactors. Small amounts of sodium molybdate are used to replace molybdenum deficiencies in soils.

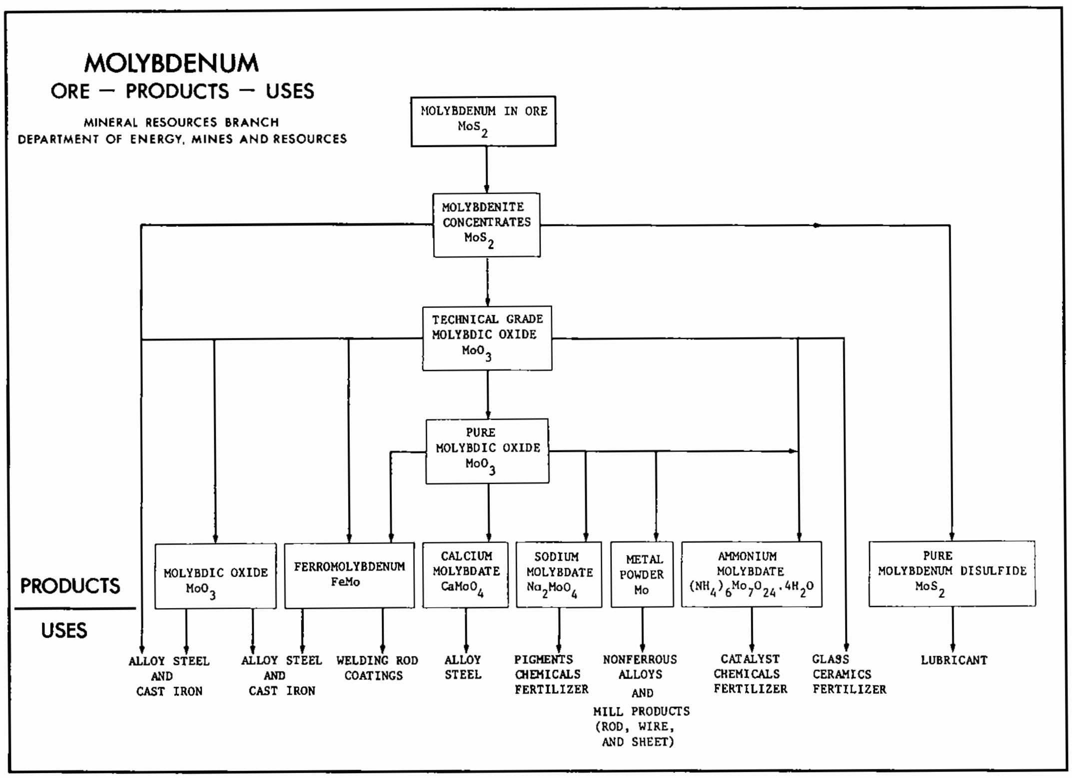


TABLE 4

United States Consumption of Molybdenum by End Use, 1969
(thousands of pounds of contained molybdenum)

	1969
Carbon steel	3,536
Stainless and heat resisting	6,259
Alloy steel	21,105
Tool steel	3,486
Cast irons	4,274
Superalloys	2,516
Cutting and wear resistant materials	3
Welding and hardfacing rod and materials	412
Other alloys and nonferrous alloys	196
Mill products made from metal powder	1,899
Chemical and ceramic uses:	
Pigments	1,102
Catalysts	1,514
Other	820
Miscellaneous and unspecified	4,501
Total	51,623

Source: Mineral Industry Surveys, U.S. Bureau of Mines.

ORE OCCURRENCES AND GRADE

Molybdenum (Mo) does not occur in the free uncombined metallic form in natural mineral occurrences. 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 co-product 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 minable ores is generally relatively low, ranging from about 0.50 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 per ton, among producers whose principal or only product is molybdenite and 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.

In British Columbia, the Mount Copeland Mine of King Resources Company came into production at 200 tons a day in mid-1970 with estimated ore reserves of 180,000 tons averaging 1.82 per cent MoS_2, or 21.84 pounds of molybdenum per ton. Endako Mines Ltd., Canada's largest molybdenum producer, estimated its ore reserves at 214 million tons averaging 0.146 per cent MoS_2, or 1.75 pounds of molybdenum per ton. Endako mines and treats approximately 1,025 tons of ore to produce one ton of molybdenum in molybdenite (MoS_2) concentrates. Brenda Mines Ltd., equipped to handle 24,000 tons of ore a day from reserves estimated to contain 0.183 per cent copper and 0.049 per cent molybdenum, mines and mills approximately 2,550 tons of ore to produce one ton of co-product molybdenum and 4.5 tons of copper.

PRICES

Prices in U.S. dollars per pound of contained molybdenum f.o.b. shipping point

	Dates of Price Changes		
	Jan. 11, 1967	May 5, 1969	Dec. 30, 1970
Molybdenum concentrates, 95% MoS_2, containers extra	US $1.62	US $1.72	US $1.72
molybdic oxide (MoO_3)			
" " in bags	1.81	1.91	1.91
" " in cans	1.82	1.92	1.92
Ferromolybdenum, 0.12-0.25% C,			
5,000 lb lots, lump	2.11	2.21	2.21
" powder	2.17	2.27	2.27
Molybdenum powder, f.o.b. shipping point, hydrogen reduced, 99.95% per lb		3.73	4.00

TABLE 5

Prices per Pound of Contained Molybdenum
in Principal Molybdenum Products
1946-70
(f.o.b. shipping point)

	Molybdenite Concentrate	Molybdic Oxide	Ferro-molybdenum	Molybdenum powder Hydrogen-reduced
1946	U.S. $0.75	U.S. $0.80	U.S. $0.95	U.S. $2.60-$3.00
1947	.75	.80	.95	2.60- 3.00
1948	.75	.80	.95	2.60- 3.00
1949	.90	.95	1.10	2.60- 3.00
1950	$0.90- 1.00	$0.96- 1.14	$1.13- 1.32	2.60- 3.00
1951	1.00	1.14	1.32	3.00
1952	1.00	1.14	1.32	3.00
1953	1.00	1.14	1.32	3.00
1954	1.00- 1.05	1.14- 1.25	1.32- 1.49	3.00
1955	1.05- 1.10	1.24- 1.30	1.46- 1.54	3.00
1956	1.10- 1.18	1.30- 1.38	1.54- 1.68	..
1957	1.18	1.38	1.68	..
1958	1.18- 1.25	1.38- 1.46	1.68- 1.76	3.15- 4.10
1959	1.25	1.46	1.76	3.15- 4.10
1960	1.25	1.46	1.76	3.15- 4.10
1961	1.25- 1.40	1.46- 1.59	1.76- 1.89	3.55
1962	1.40	1.59	1.89	3.55
1963	1.40	1.59	1.89	3.55
1964	1.40- 1.55	1.59- 1.74	1.89- 2.04	3.55- 3.75
1965	1.55	1.74	2.04	3.75
1966	1.55	1.74	2.04	3.75
1967	1.62	1.81	2.11	3.75
1968	1.62	1.81	2.11	3.75
1969	1.62- 1.72	1.81- 1.91	2.11- 2.21	3.75- 4.00
1970	1.72	1.91	2.21	4.00

Sources: United States Bureau of Mines, Information Circular 8446; and Metals Week.
.. Not available.

TARIFFS

CANADA Tariff 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, 1971	free	free	25%
92828.1	Molybdenum oxides and hydroxides	10%	15%	25%
	From Jan. 1, 1969 to Jan. 31, 1973 (except for molybdenum oxide which remains as above)	free	15%	25%

TARIFFS (Cont'd)

UNITED STATES

601.33	Molybdenum ores and concentrates	
	On and after Jan. 1, 1970	16.5¢ per lb on Mo content
	On and after Jan. 1, 1971	14¢ per lb on Mo content
418.26	Calcium molybdate	
	On and after Jan. 1, 1970	14¢ per lb on Mo content +4%
	On and after Jan. 1, 1971	12¢ per lb on Mo content +3.5%
419.60	Molybdenum compounds	
	On and after Jan. 1, 1970	14¢ per lb on Mo content +4%
	On and after Jan. 1, 1971	12¢ per lb on Mo content +3.5%
628.72	Molybdenum metal, unwrought	
	On and after Jan. 1, 1970	14¢ per lb on Mo content +4%
	On and after Jan. 1, 1971	12¢ per lb on Mo content +3.5%
628.74	Molybdenum metal, wrought	
	On and after Jan. 1, 1970	17.5%
	On and after Jan. 1, 1971	15%
628.70	Molybdenum metal, waste and scrap (suspended)	
	On and after Jan. 1, 1970	14.5%
	On and after Jan. 1, 1971	12.5%
607.40	Ferromolybdenum	
	On and after Jan. 1, 1970	14¢ per lb on Mo content +4%
	On and after Jan. 1, 1971	12¢ per lb on Mo content +3.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1969).

Brenda Mines — Copper molybdenum open pit and main plant near Peachland, British Columbia. (Photo by Hunter)

Natural Gas

J.W. FRASER*

Canadian gas production in 1970 followed the strong upward trend of recent years as net withdrawals reached 2,276,578 MMcf** equivalent to 6,237 MMcf/d, for a growth rate of 15.1 per cent. The 1970 growth rate is somewhat lower than the 17 per cent increase recorded in 1969, but represents a larger actual volume increase in 1970 because of the larger base production upon which it is calculated. Exports to the United States rose by 14.7 per cent to 2,138 MMcf/d, considerably surpassing the 12.6 per cent gain in 1969. Imports continued to decline in importance, dropping to 30 MMcf/d in 1970, which now represents less than 1 per cent of the total Canadian supply.

The steadily increasing demand for gas spurred exploration over a broad front for new reserves. Significant additions to reserves were again made by continued development in the Strachan-Ricinus area of Alberta. Improved economics resulting from higher gas prices and new drilling and production techniques prompted companies to develop shallow gas-bearing sandstones in southern Alberta and southwestern Saskatchewan which had previously been ignored. Exploration and development in northeastern British Columbia also added to reserves in that province. In spite of these efforts, however, the record production rates in 1970 held net additions to Canadian reserves to the lowest level in recent years. The Canadian Petroleum Association estimated proved remaining marketable reserves in Canada at the end of 1970 to be 53,375,628 MMcf, an increase of only 2.7 per cent over the 1969 level. These estimates do not include any allowance for recently discovered gas in the Canadian Arctic Islands. During 1970, Panarctic Oils Limited made a gas discovery on King Christian Island, its second since beginning its exploration program. Evaluation of the King Christian well has not been completed but it is considered to be a major discovery.

Three groups of companies are currently working on separate proposals for a major gas pipeline from northern Canada. Initially such a line would mainly transport gas from the Prudhoe Bay field in Alaska which will be recovered in conjunction with oil when productions begins there. However, the line would also be available to any Canadian production developed along the route. One of the groups, the Northwest Project Study Group, has constructed a short test section of pipeline near Norman Wells, Northwest Territories, to obtain actual operating experience under northern conditions. New guidelines issued by the federal government state that initially only one oil and one gas pipeline will be allowed to be built in a designated transportation corridor, which will probably follow the Mackenzie River valley for much of the route. Additional conditions in the guidelines will ensure access to these pipelines for all producers, will provide for opportunities for Canadian participation and will ensure protection of the environment.

The National Energy Board (NEB) approved additional export permits in September, but the total volume approved were cut to 6.3 trillion cubic feet from the more than 9 trillion cubic feet originally requested. Four companies which are currently exporting gas from Canada were allowed additional exports, but in three cases the term of the license was shortened and the total volumes approved were

* Mineral Resources Branch.
**Mcf = 1,000 cubic feet
MMcf = 1,000,000 cubic feet
Mcf/d = 1,000 cubic feet per day.

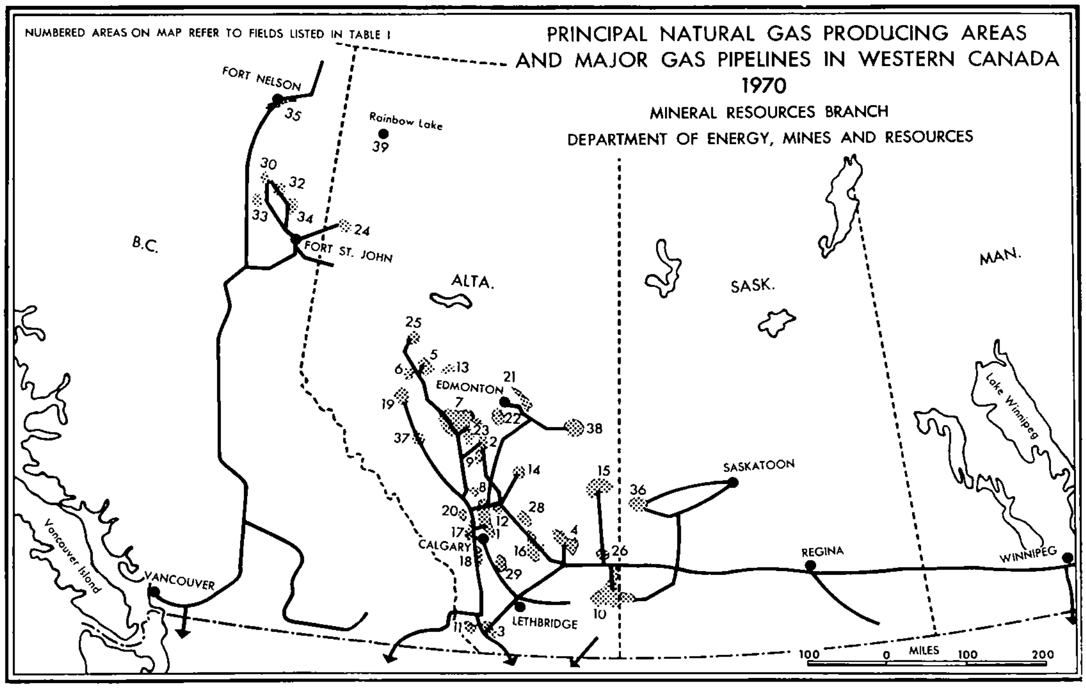


TABLE 1

Canadian Natural Gas Fields Producing 10 Million Mcf or More, 1969-70
(numbers in brackets refer to map location)

	1969 (Mcf)	1970 (Mcf)
Alberta		
Crossfield (1)	152,607,267	154,367,756
Edson (19)	92,198,978	105,121,126
Kaybob South (25)	22,638,840	95,113,312
Westerose South (2)	88,274,906	93,296,817
Windfall (5)	70,241,399	76,051,777
Medicine Hat (10)	57,574,032	61,807,677
Crossfield East (1)	53,526,600	57,681,683
Jumping Pound (17)	20,277,035	54,949,774
Homeglen-Rimbey (9)	47,973,109	51,490,694
Harmattan-East (8)	49,405,643	50,911,678
Harmattan-Elkton (8)	49,741,109	50,121,890
Carstairs (12)	44,810,623	48,805,481
Cessford (4)	54,840,698	48,215,969
Pembina (7)	41,577,717	45,378,692
Gilby (9)	39,180,317	45,218,834
Provost (15)	34,434,150	41,681,555
Nevis (14)	32,476,535	41,302,333
Brazeau River (37)	18,009,725	38,773,018
Wildcat Hills (20)	33,840,899	34,428,750
Ferrier	4,189,268	32,348,996
Ghost Pine	25,196,300	28,529,412
Jumping Pound West (17)	17,355,500	28,159,621
Kaybob (25)	22,638,840	26,195,788
Carson Creek (13)	27,287,358	25,612,079
Lookout Butte (3)	26,465,708	24,509,944
Sylvan Lake (2)	25,492,529	23,433,959
Minnehik-Buck Lake (23)	20,586,806	22,513,798
Pine Creek (6)	22,925,719	22,003,808
Hussar (16)	23,946,399	20,880,820
Judy Creek (13)	17,385,188	20,406,621
Rainbow (39)	14,094,889	18,404,128
Bigstone	17,787,242	17,806,972
Swan Hills (13)	12,637,319	17,448,125
Bindloss (26)	15,945,637	15,814,042
Wimborne (12)	17,135,942	14,914,607
Viking-Kinsella (38)	14,347,722	14,435,438
Olds (12)	14,919,643	13,865,799
Pincher Creek (3)	14,529,819	13,611,416
Alderson (10)	10,405,584	13,188,026
Turner Valley (18)	12,189,699	12,885,062
Countess (16)	10,988,054	12,175,735
Whitecourt	527,720	10,887,388

TABLE 1 (Cont'd)

Golden Spike (22)	10,347,645	10,325,955
Carson Creek North	3,751,043	10,009,414
British Columbia		
Clarke Lake (35)	102,176,861	104,278,387
Laprise Creek (30)	26,210,563	25,908,115
Nig Creek (32)	19,039,190	16,577,741
Jedney (30)	18,486,525	17,311,108
Rigel (34)	15,238,425	16,791,212
Saskatchewan		
Coleville-Smiley (36)	12,765,403	12,339,918

Source: Provincial government reports. Volumes shown are gross production figures measured at pressure base of 14.65 psia, standard pressure for provincial government statistics.

reduced. A fifth application for approval to start exports to United States midwest markets through a new pipeline system from Alberta across southern Saskatchewan was rejected.

PRODUCTION

Net withdrawals in 1970 totalled 2,276,578 MMcf or 6,237 MMcf/d. This represents an annual increase of 15.1 per cent which is somewhat lower than the 17.0 per cent annual increase recorded in 1969. Alberta continued to produce more than 80 per cent of total Canadian production, thereby maintaining its position as the primary supply area in Canada. Crossfield and Edson continued to be the two main producing fields in Alberta, followed closely by the large Kaybob South field which showed a fourfold increase in production in 1970. Fields in British Columbia contributed more than 17 per cent of the Canadian total, slightly more than in 1969, and the Clarke Lake field in the Fort Nelson area remained the major producer.

Table 2 shows the amount of gas which was reinjected into reservoirs, either as a conservation measure to increase the ultimate recovery of liquid hydrocarbons, or as a part of distributor's storage operations. At the Kaybob South field, for example, the volume of residue gas returned to the producing reservoir, after liquid hydrocarbons and sulphur have been removed in gas plants, is almost two thirds of the original volume introduced into the plants for processing. This is done to maintain reservoir pressure and thereby increase the recovery of these products to a maximum. In oil fields such as Golden Spike and Rainbow Lake, natural gas and some natural gas liquids are reinjected to maintain reservoir pressure and increase the ultimate crude oil recovery from the reservoir. Volumes shown under Distributor's Storage in Table 2 represent gas which is stored by distributors during low demand periods. Gas is later withdrawn as required to meet peak demands in the winter. Most of the stored gas is in former producing fields which have been largely 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 large consuming areas.

TABLE 2

Pressure Maintenance Injection and Storage of Natural Gas in Canada, 1969-70
(Mcf)

	1969	1970p
	Input	Input
Alberta		
Aerial	168,029	185,065
Ante Creek	1,008,434	1,323,808
Bigstone	2,231,925	1,643,385
Bonnie Glenn	–	474,011
Carson Creek	20,188,840	14,138,803
Carstairs	2,619,124	2,343,401
Crossfield	10,727,884	11,157,755
Crossfield East	2,601,665	3,809,176
Duhamel	133,193	341,283
Gilby	267,446	359,088
Golden Spike	9,290,556	8,604,118
Harmattan East	38,208,437	39,464,908
Harmattan-Elkton	32,477,407	33,212,257
Joarcam	1,211,448	1,217,442
Judy Creek	54,203	2,239,033
Kaybob South	23,874,078	52,634,093
Leduc-Woodbend	1,251,668	1,128,495
Pembina	2,115,073	2,430,820
Rainbow	8,433,914	12,196,537
Rainbow South	623,417	939,125
Redwater	–	324,888
Swan Hills	–	561,878
Turner Valley	493,225	461,924
Virginia Hills	–	362,597
Waterton	9,705,198	11,814,517
Westerose South	12,379,958	9,889,460
Willesden Green	127,144	985,742
Windfall	37,388,119	36,029,217
Wizard Lake	246,189	5,168,418
Zama	182,678	–
Distributor's Storage		
Bow Island	1,784,900	1,945,525
Carbon	2,590,354	3,028,911
Lloydminster	287,587	265,552
Viking-Kinsella	1,461,365	1,021,838
Total (14.65 psia)	224,133,458	261,703,070
Volume (adjusted to 14.73 psia)	222,923,137	260,289,873
Ontario	54,916,596	80,852,342

TABLE 2 (Cont'd)

Saskatchewan (14.73 psia)	6,504,731	6,324,237
Total Canada (14.73 psia)	284,344,464	347,466,452

Source: Provincial government reports.
PPreliminary; – Nil.

EXPLORATION AND DEVELOPMENT

ALBERTA

Exploration and development activity related to shallow gas bearing zones in Alberta increased in 1970. This increase in shallow well drilling was reflected in the 9 per cent reduction in footage drilled although the number of wells drilled was only slightly lower than the number drilled in 1969. Successful gas well completions made up 34 per cent of total completions and 28 per cent of total footage in 1970, compared to 24 per cent and 22 per cent, respectively, in 1969.

Improved economics resulting from higher gas prices and new drilling and production techniques have increased the attractiveness of shallow gas sands in southern Alberta. One area which has seen a particular increase in this activity is the Alderson-Medicine Hat area, the location of some of the earliest gas discoveries in western Canada. Particular attention has been devoted to the development of the Upper Cretaceous Milk River sands, which occur at a depth of approximately 1,000 feet in this area. Substantial reserves have been developed in these sands which were previously undeveloped because of production difficulties. New drilling practices, which utilize air drilling through the producing horizons have overcome production problems which occurred when the drilling mud used during conventional drilling operations essentially sealed off the formations. Alberta Eastern Gas Limited was one of the first companies to develop these special techniques for large scale development of Milk River reserves, and a number of companies are now involved in this play.

Although activity increased in the shallower plays in Alberta, exploration and development continued in the deeper, more costly plays in western Alberta where gas reservoirs as a rule are generally larger. Substantial new reserves were outlined by continuing drilling in the Strachan-Ricinus area. The Ricinus West field, which was designated by the Alberta Oil and Gas Conservation Board after the 1969 reef discovery by the Banff et al Ricinus 6-25 well, was extended 3 miles to the northwest by Banff Aquit Ricinus West 10-33, and 2 miles to the south by Banff Aquit Ricinus West 7-13. As a result of these extensions and other further development in the field, it has now been enlarged to 25 sections. The Strachan field limits have also been extended to the northwest and the Ricinus field was enlarged with the inclusion of an additional 37 sections at the southern end. Six miles southeast of Ricinus, tests of the Devonian reef at Mobil GPD Banner James 11-35-33-7W5 were reported to have recovered gas containing 80 per cent hydrogen sulphide.

A number of other discoveries were reported from exploratory drilling throughout the province. Twenty-five miles south of Calgary, a Mississippian gas discovery was reported at Sun Pacific Hartell 11-12-19-2W5, located 3 miles east of the Turner Valley field limits. Thirty miles northeast of Calgary, production was indicated from the Crossfield member at GPD Noel Beiseker 11-31-28-26W4, the same horizon which produces in the Crossfield field, 8 miles to the southwest. Approximately 110 miles northwest of Edmonton, a gas discovery was reported in the Beaverhill Lake formation at Atkinson et al Chickadee 6-15-60-14W5, 6 miles northeast of the Windfall field. In northwestern Alberta, gas was reported in the Keg River formation at Sunlite et al Amigo 2-7-120-8W6, located 25 miles northeast of the Rainbow Lake-Zama production area. In addition to these discoveries, a number of other discoveries were reported close to established producing fields. At year-end there were 2,490 operating gas wells, out of 3,010 capable of production.

BRITISH COLUMBIA

The number of exploratory wells completed increased by more than 20 per cent and exploratory footage increased by a similar amount, but a slightly lower level of development drilling held the net increase in well completions in 1970 to about 7 per cent.

A substantial gas flow was reported during testing of the Devonian Slave Point formation at Atkinson Sunlite Helmet b-2-k, 80 miles northeast of Fort Nelson. A number of potential Slave Point gas wells have been drilled in this general area, and have been capped pending construction of pipeline connections. Development of additional Slave Point gas reserves was undertaken in and near the established Slave Point fields in the Fort Nelson area. In the Sikanni Chief area, 125 miles northwest of Fort St. John, a net pay section of 320 feet was encountered in the Mississippian Debolt formation at Arco Pacific FPC Grassy a-75-D. Further development was carried out in a number of the fields in the Fort St. John area. There has been no further drilling off the west coast of British Columbia since Shell Canada Limited completed its fourteen well program in May, 1969. However, at the end of 1970 offshore acreage under federal permits amounted to 15 million acres, a slight decrease from 1970.

In total, 21 exploratory wells and 29 development wells were successfully completed, an increase over the 17 exploratory and 26 development wells completed in 1969. Gas wells in the province capable of production

TABLE 3

Canada, Production of Natural Gas, 1969-70
(14.73 psia)

	1969r		1970p	
	Mcf	$	Mcf	$
Gross new production				
New Brunswick	106,520		131,160	
Quebec	137,897		165,825	
Ontario	11,237,888		17,081,414	
Saskatchewan	69,369,509		78,485,722	
Alberta	1,883,369,659		2,184,366,998	
British Columbia	322,527,686		343,123,269	
Northwest Territories	684,177		892,630	
Total, Canada	2,287,433,336		2,624,247,018	
Waste and flared				
Saskatchewan	10,713,632		16,439,239	
Alberta	60,879,431		60,770,130	
British Columbia	12,472,051		10,950,548	
Northwest Territories	640,454		810,691	
Total, Canada	84,705,568		88,970,608	
Reinjected				
Saskatchewan	–		–	
Alberta	216,831,751		253,089,758	
British Columbia	8,057,812		5,607,924	
Total, Canada	224,889,563		258,697,682	
Net withdrawals				
New Brunswick	106,520	95,016	131,160	117,354
Quebec	137,897	20,684	165,825	24,676
Ontario	11,237,888	4,275,152	17,081,414	6,498,554
Saskatchewan	58,655,877	7,429,604	62,046,483	8,182,855
Alberta	1,605,658,477	218,106,264	1,870,507,110	296,425,322
British Columbia	301,997,823	32,910,416	326,564,797	36,386,719
Northwest Territories	43,723	18,452	81,939	33,740
Total, Canada	1,977,838,205	262,855,588	2,276,578,728	347,669,220
Processing shrinkage				
Saskatchewan	2,318,798		2,154,180	
Alberta	230,611,934		251,995,181	
British Columbia	6,630,366		6,426,897	
Total, Canada	239,561,098		260,576,258	
Net new supply, Canada	1,738,277,107		2,016,002,470	

Source: Dominion Bureau of Statistics.
rRevised; pPreliminary; – Nil.

remained the same at 683, out of which 286 were in operation in 1970.

SASKATCHEWAN AND MANITOBA

The search for shallow gas reserves in the Upper Cretaceous Milk River sands, similar to those in the Alderson-Medicine Hat area of Alberta, was extended into the Sandhills area of southwestern Saskatchewan during 1970. In this area, following a discovery at Okalta et al Big Stick L. 10-32-14-24W3, 65 miles west of Swift Current, the three company team of Oakwood Petroleums Ltd. (formerly Okalta Oils,

TABLE 4

Canada, Production, Trade and Total Sales of Gas, 1960-1970
(Mcf)

	Net Withdrawals	Imports	Exports	Sales in Canada
1960	522,972,327	5,570,949	91,045,510	320,701,484
1961	634,130,669	5,574,355	168,180,412	370,739,542
1962	894,671,614	5,575,466	319,565,908	412,061,509
1963	993,388,491	6,877,438	340,953,146	451,598,298
1964	1,134,210,700	8,046,365	404,143,095	504,503,388
1965	1,236,798,360	15,673,069	403,908,528	573,016,494
1966	1,341,831,241	43,550,818	426,223,806	635,514,622
1967	1,471,735,152	52,871,671	505,164,622	698,223,437
1968	1,696,679,650	88,227,825	607,355,445	765,786,814
1969r	1,977,838,205	37,732,703	669,815,767	843,164,967
1970p	2,276,578,728	11,877,827	768,112,547	917,440,879

Source: Dominion Bureau of Statistics. Figures in Tables 4 and 12 differ for imports and exports because of different reporting procedures and timing.
pPreliminary; rRevised.

TABLE 5

Canada, Liquids and Sulphur Recovered From Natural Gas, 1960-70

	Propane	Butane	Condensate/ Pentanes Plus	Sulphur
	(barrels)	(barrels)	(barrels)	(long tons)
1960	2,064,623	1,536,621	2,460,649	404,591
1961	2,875,823	2,157,309	5,444,034	487,679
1962	3,671,683	2,744,044	10,802,436	1,035,988
1963	4,353,871r	3,273,625r	21,759,526	1,281,999
1964	7,615,121r	5,656,888r	25,275,285r	1,472,583
1965	10,371,256	6,957,833	27,864,189	1,589,586
1966	12,643,278	8,230,620	29,354,168r	1,729,455
1967	14,171,019	9,890,125	30,749,780	2,168,646
1968	15,977,317	10,499,003	33,200,698	3,042,105
1969r	17,941,218	11,759,888	37,687,140	3,714,312
1970p	21,282,340	13,203,811	43,308,157	4,241,616

Sources: Dominion Bureau of Statistics and provincial government reports.
pPreliminary; rRevised.

Limited), Union Gas Company of Canada, Limited, and Jefferson Lake Petrochemicals of Canada Ltd. undertook a program to delineate the limits of this new producing area and develop productive capacity. Although total footage drilled in Saskatchewan dropped sharply from the 1969 level, a higher proportion was devoted to gas development, resulting in a substantial increase in the number of successful completions to 25 exploratory wells and 38 development wells in 1970 compared to 21 exploratory and 24 development in 1969. There were 364 wells operating out of 559 capable of production in Saskatchewan at the end of 1970.

Drilling in Manitoba dropped to about one-third the 1969 level and was concentrated mainly in the southwestern corner of the province. However, companies continued to evaluate the onshore extension of the sediments underlying the Hudson Bay area. One slim hole, Merland et al White Bear Creek Prov. STH #1, located about 115 miles southeast of Churchill was drilled to a total depth of 1,401 feet but no details have been released on this test. There were no

TABLE 6

Canada, Wells Drilled, by Province, 1969-70

	Oil		Gas		Dry*		Total	
	1969	1970	1969	1970	1969	1970	1969	1970
Western Canada								
Alberta	464	304	437	617	942	903	1,843	1,824
Saskatchewan	528	469	42	63	592	401	1,162	933
British Columbia	42	36	43	50	81	91	166	177
Manitoba	15	2	–	–	67	17	82	19
Yukon and Northwest Territories	–	1	2	1	54	68	56	70
Westcoast offshore	–	–	–	–	4	–	4	–
Hudson Bay offshore	–	–	–	–	2	–	2	–
Sub-total	1,049	812	524	731	1,742	1,480	3,315	3,023
Eastern Canada								
Ontario	5	10	49	63	164	96	218	169
Quebec	–	–	–	–	3	4	3	4
Atlantic Provinces	–	–	–	–	–	–	–	–
East coast offshore	–	–	–	–	1	14	1	14
Sub-total	5	10	49	63	168	114	222	187
Total, Canada	1,054	822	573	794	1,910	1,594	3,537	3,210

Source: Canadian Petroleum Association.
*Includes suspended wells; – Nil.

TABLE 7

Footage Drilled in Canada for Oil and Gas, by Province, 1969-70

	Exploratory		Development		All Wells	
	1969	1970	1969	1970	1969	1970
Alberta	4,858,852	4,451,720	3,737,169	3,325,273	8,596,021	7,776,993
Saskatchewan	1,923,654	1,081,004	1,728,425	1,398,639	3,652,079	2,479,643
British Columbia	426,457	498,881	421,426	401,051	847,883	899,932
Manitoba	82,629	42,709	63,318	12,017	145,947	54,726
Northwest Territories	274,401	361,710	–	–	274,401	361,710
Westcoast-offshore	36,923	–	–	–	36,923	–
Hudson Bay-offshore	5,143	–	–	–	5,143	–
Total, western Canada	7,608,059	6,436,024	5,950,338	5,136,980	13,558,397	11,573,004
Ontario	317,569	147,152	86,437	160,990	404,006	308,142
Quebec	21,023	35,757	–	–	21,023	35,757
Atlantic Provinces	–	–	–	–	–	
Eastcoast-offshore	13,085	149,220	–	–	13,085	149,220
Total, eastern Canada	351,677	332,129	86,437	160,990	438,114	493,119
Total, Canada	7,959,736	6,768,153	6,036,775	5,297,970	13,996,511	12,066,123

Source: Canadian Petroleum Association.
– Nil.

gas discoveries in Manitoba during 1970, and there is no gas production in the province.

NORTHWEST TERRITORIES AND THE YUKON

Undoubtedly one of the most spectacular features on the Canadian exploration scene in 1970 was the Panarctic King Christian D-18 well on King Christian Island which encountered high pressure gas at shallow depth (2,010 feet) during drilling operations in late October, 1970, and burned until brought under control by a relief well in January, 1971. Although unfortunate from an operational viewpoint, the fire nevertheless served as a vivid reminder of the hydrocarbon potential in the Arctic frontier areas. King Christian Island is a small island off the southwest coast of Ellef Ringnes Island at about 78° North Latitude. Operations to control the wild well were unique in that they were successfully completed under extreme weather conditions and total darkness of an Arctic winter. Subsequent testing of the gas reservoir through the relief well, Panarctic King Christian D-18A, indicated a major gas discovery had been made but the detailed results of tests have not been released. The well was the second major discovery out of the first seven wells drilled by Panarctic, the first being the Drake Point discovery near the northeast end of Melville Island. During 1970, Panarctic also drilled and abandoned Panarctic Homestead Hecla J-60, approximately 25 miles west of Drake Point, and Panarctic Towson Point G-63, 65 miles southeast of Drake Point. Panarctic Hoodoo Dome F-27, located 200 miles northeast of Drake Point on Ellef Ringnes Island was also drilled to total depth of 11,072 feet. The only other well completed during 1970 was Elf Cape Norem A-80, located about 70 miles north of Drake Point on the southeast shore of Mackenzie King Island, which was abandoned at a total depth of 9,744 feet. However, at year-end Panarctic had another well under way on Amund Ringnes Island, Elf was nearing total depth at a second well on Mackenzie King Island, and Sun Oil Company was operating wells on Melville and Bathurst Islands. Additional groups of companies are scheduled to start operations in the Arctic islands during 1971.

No gas discoveries were reported from drilling on the mainland. However, the increasing emphasis on exploration in the northern areas was indicated by an increase in the total number of wells completed to 70 in 1970 compared to 56 in 1969, and an increase of more than 30 per cent in total footage drilled. Land under federal permits and leases in the Northwest Territories and the Yukon at the end of 1970 amounted to 437.4 million acres compared to 441 million acres in 1969.

EASTERN CANADA

The search for major new reserves off Canada's east coast covered a broad area in 1970, and although no commercial discoveries were made encouraging oil and gas shows were encountered in several tests. Shell Canada Limited was the major operator, utilizing two semi-submersible drilling rigs to complete 13 wells in 1970. Drilling on two new locations was under way at year-end. The tests were spread over an area extending from about 150 miles southwest of Halifax to a point about 220 miles east of Halifax, although most of the wells were located within about 100 miles to the north and south of Sable Island. Drilling depths ranged from 6,800 feet to 15,700 feet.

Two wells were drilled in the area between Prince Edward Island and Cape Breton Island. HB Fina Northumberland Strait F-25, located approximately 50 miles southeast of Charlottetown, Prince Edward Island, was drilled to 9,876 feet without encountering any significant oil or gas occurrences. A second well drilled by the same team 44 miles to the northwest, HB Fina East Point E-49, was plugged and suspended at a depth of 11,569 feet in November, due to adverse weather conditions.

Four exploratory wells were completed in Quebec, two of which were on islands in the Gulf of St. Lawrence. ARCAN Anticosti #1 was drilled to a total depth of 12,620 feet at a location on the south shore of Anticosti Island. La Société Acadienne de recherches pétrolières Ltée (SAREP), the Quebec subsidiary of Texaco Exploration Company, under agreement with The Quebec Hydro-Electric Commission (Hydro-Quebec) drilled a 10,519 foot test, SAREP HQ Brion Island #1 on Brion Island, one of the most northerly islands in the Madgalen Island group in the Gulf of St. Lawrence. Gulf Oil Canada Limited suspended drilling operations at its Gulf Sunnybank #1 well in the Gaspé area after drilling to 11,600. In December, Husky Oil Ltd. began the first of two wells to be drilled in the Trois Rivières area on the south shore of the St. Lawrence River.

Despite the widespread exploratory activity, southwestern Ontario continues to be the only area in eastern Canada with significant commercial gas production. Total footage and total wells drilled in Ontario declined by about one quarter, but the number of successful gas well completions rose to 63 in 1970 from 49 in 1969. Aquitaine Company of Canada Ltd. as operator for a group of companies, drilled a slim hole test, Pen Island #2, to 1,446 feet at a location near the Manitoba-Ontario border on the south shore of Hudson Bay. This is the second test in the group's continuing exploration program to explore the large acreage of land both on shore and off shore in this area.

Acreage under federal permits in Hudson Bay and Hudson Strait declined to 113.2 million acres in 1970, from 125.8 million at the end of 1969. Acreage holdings off the east coast rose, however, increasing to 281.4 million acres at the end of 1970 compared to 259 million in 1969. Industry plans to evaluate this large acreage spread have been hampered somewhat by the availability of off-shore rigs capable of operating off eastern Canada. This situation was eased somewhat by the completion of two semi-submersible drilling rigs in Halifax shipyards during 1970.

RESERVES

Proved remaining marketable reserves of natural gas in Canada rose by 1,424,633 MMcf to 53,375,628 MMcf in 1970, according to the annual estimates of the Canadian Petroleum Association (CPA). These net additions (gross additions less production) were well below the 4,284,534 MMcf added in 1969, and represent a growth of 2.7 per cent in 1970, as compared to 9.0 per cent in 1969. It is, in fact, one of the lowest increases in recent years, reflecting, in part, the high demands being made on Canadian producers to supply the steadily enlarging domestic and export markets. Increases resulting from revisions and extension's to existing pools amounted to 3,009,930 MMcf, discoveries in 1970 added 193,682 MMcf and gas in storage increased by 20,205 MMcf. These increases were offset by estimated net production of 1,799,184 MMcf.

Virtually all of the additions to reserves were made in British Columbia, where reserves were increased more than 15 per cent, such that the province now contains about 18 per cent of total Canadian natural gas reserves. More than three quarters of total Canadian proved reserves are located in Alberta, but there was very little change in total provincial reserves after allowing for production in 1970. CPA estimates for the Northwest Territories remained the same as in 1969, since no allowance was made for the recent discoveries in the Arctic Islands.

TABLE 8

Canada, Estimated Year-End Marketable Reserves of Natural Gas, 1969-70 (millions of cubic feet)

	1969	1970
Alberta	41,508,096	41,607,827
British Columbia	8,339,347	9,626,692
Saskatchewan	849,740	844,213
Eastern Canada	247,514	290,598
Northwest Territories	1,006,298	1,006,298
Total	51,950,995	53,375,628

Source: Canadian Petroleum Association.

NATURAL GAS PROCESSING

A high level of new plant construction and expansion resulted in a near-record increase of 1,531 MMcf/d in Canadian gas processing capacity in 1970. A major factor in the increase was the completion of the Alberta Natural Gas Company 'straddle' plant at Cochrane, Alberta which accounted for two thirds of the new capacity. Total input capacity for all Canadian plants reached 10,458 MMcf/d at the end of 1970. These facilities, operating at design capacity, could, on a daily basis extract 72,772 barrels of propane, 47,984 barrels of butane, 179,502 barrels of pentanes plus, and 15,418 long tons of sulphur leaving 8,313 MMcf of residue gas. Approximately 550 MMcf/d of residue gas would be reinjected into reservoirs as part of enhanced recovery operations designed to increase the ultimate recovery of crude oil and natural gas liquids. All of the increase in capacity in 1970 was in Alberta. At the end of 1970, more than 89 per cent of the raw gas processing capacity, 96 per cent of liquid recovery capacity and 98 per cent of sulphur recovery capacity were concentrated in Alberta.

Alberta Natural Gas Company's new straddle plant is located on the main pipeline of the Foothills Division of The Alberta Gas Trunk Line Company at Cochrane, 20 miles west of Calgary, Alberta. It is designed to reprocess pipeline gas to recover natural gas liquids which were not removed during initial field processing, before the gas continues to markets in Canada and the western United States. The plant has an inlet capacity of 925 MMcf/d which yields 760 MMcf/d of sales gas and 12,000 barrels daily of stabilized, commingled propane, butane and pentanes plus. These liquids are shipped by a series of pipelines, including batch shipments through the Interprovincial Pipe Line Company's oil pipeline, to plants in Superior, Wisconsin and Sarnia, Ontario for fractionation into separate natural gas liquids as required for marketing. The Cochrane plant is the second of its type in Canada. The first one is that of Pacific Petroleums, Ltd. which, since 1964, has operated a 'straddle' plant at the eastern end of the Alberta Gas Trunk system near Empress, Alberta. This plant has the capacity to reprocess 1,500 MMcf/d of pipeline gas before it is delivered to the Trans-Canada Pipe Lines Limited system. A third reprocessing plant is being built by Dome Petroleum Limited adjacent to the existing Empress plant to reprocess the increased volumes of gas going to market. It is expected to start operations in December, 1971, with a capacity of 1,500 MMcf/d.

A major addition to gas processing capacity was made in January, 1970 when Hudson's Bay Oil and Gas Company Limited began operation at the second cycling plant in the Kaybob South field. This plant has a raw gas capacity of 170 MMcf/d, and is capable of producing 12,450 barrels of pentanes plus and 1,030 long tons of sulphur daily. Gas sales are limited to 21 MMcf/d at present, since most residue gas is reinjected so that the plant can initially recover a high percentage of the liquid hydrocarbons dissolved in the gas before the reservoir is depleted. Other large new plants completed during the year included the Gold Creek

TABLE 9

Canada, Natural Gas Processing Plant Capacities, by Fields, 1970
(millions of cubic feet a day)

Main Fields Served	Raw Gas Capacity	Residue Gas Produced
Alberta		
Alderson (2 plants)	24	24
Acheson	6	5
Alexander, Westlock	36	35
Bassano	2	2
Bigstone	48	36
Black Butte	10	10
Bonnie Glen, Wizard Lake	50	40
Boundary Lake South	25	22
Braeburn	16	15
Brazeau River	104	96
Burnt Timber, Wildhorse Creek, Hunter Valley	40	33
Calling Lake	15	15
Carbon	155	150
Caroline (2 plants)	53	45
Carson Creek	100	48
Carstairs (2 plants)	339	284
Cessford (7 plants)	216	209
Chigwell (2 plants)	12	10
Countess (2 plants)	27	26
Crossfield (2 plants)	319	218
East Crossfield (2 plants)	146	87
Edson	377	339
Enchant	5	5
Ferrier (2 plants)	110	94
Ferrier South	20	19
Ghost Pine (2 plants)	129	126
Gilby (8 plants)	135	122
Golden Spike	45	reinj.
Greencourt	30	28
Harmattan-Elkton, Harmattan East	246	reinj.
Harmattan-Elkton (2 plants)	47	19
Homeglen-Rimbey, Westerose	422	357
Hussar (2 plants)	100	95
Hussar, Rosebud	5	5
Innisfail	15	10
Judy Creek, Swan Hills (2 plants)	120	96
Jumping Pound	244	200
Kaybob	95	92
Kaybob South, Fox Creek	212	36
Kaybob South, Beaverhill	170	21
Kessler	6	5
Lac La Biche	25	25
Leduc-Woodbend	35	31
Lone Pine Creek	51	41
Marten Hills	133	130
Marten Hills South	24	24
Minnehik-Buck Lake	70	63
Mitsue	21	15
Morinville, St. Albert	22	20
Nevis, Stettler (2 plants)	170	139
Okotoks	30	13
Olds	100	76
Oyen	3	3
Paddle River	30	28
Parflesh	2	2
Pembina, Pembalta System (9 plants)	91	74
Pembina (4 plants)	62	56
Pincher Creek	204	145
Prevo	5	4
Princess (3 plants)	19	19
Provost (4 plants)	127	120
Rainbow Lake (2 plants)	44	reinj.
Rainier	3	3
Redwater	11	8
Retlaw	7	7
Samson	3	3
Savanna Creek	75	63
Sedalia	5	5
Sibbald	6	5
Simonette	15	11
Strathmore	2	2
Sturgeon Lake South	19	9
Sylvan Lake	32	29
Sylvan Lake, Hespero	59	53
Three Hills Creek	10	9
Turner Valley	100	85
Ukalta	6	6
Vulcan	25	22
Warwick	9	9
Waterton	258	170
Wayne-Rosedale (3 plants)	57	54
Wildcat Hills	112	95
Willesden Green	9	8
Wilson Creek	15	10
Wimborne	60	46
Windfall, Pine Creek	215	132
Wintering Hills	20	20
Wood River	5	5

TABLE 9 (cont'd)

Main Fields Served	Raw Gas Capacity	Residue Gas Produced
Worsley	57	52
Pipeline at Ellerslie*	70	66
Pipeline at Empress**	1,500	1,460
Saskatchewan		
Cantuar	25	24
Coleville, Smiley	52	51
Dollard	2	2
Milton	4	4
Smiley	4	3
Steelman	38	30
Verger	4	4
West Gull Lake	15	14
British Columbia		
Fort St. John	395	300
Boundary Lake (2 plants)	27	24
Clarke Lake	530	440
Ontario		
Port Alma	15	15
Corunna (2 plants)	5	5
Becher	1	1

Source: Natural Gas Processing Plants in Canada (Operators List 7), January 1970, Department of Energy, Mines and Resources.
*Plant reprocesses gas owned by Northwestern Utilities Limited.
**Plant reprocesses gas owned by Trans-Canada Pipe Lines Limited.

plant of Atlantic Richfield Canada Ltd. with 60 MMcf/d capacity, the Tenneco Oil & Minerals, Ltd. plant at Nordegg with 50 MMcf/d capacity, and the Shell Canada Limited plant at Burnt Timber with 40 MMcf/d capacity. Shell also expanded its Jumping Pound plant, raising raw gas capacity by 54 MMcf/d to 244 MMcf/d. The Amerada Division, Amerada Hess Corporation doubled capacity at its Olds plant to 100 MMcf/d. New smaller plants were also completed at Greencourt, Mitsue, Waskahigan, Ukalta and Warwick and dehydration-compression facilities were installed in several shallow gas fields in southern Alberta. Existing processing facilities at Ghost Pine, Gilby, Brazeau River, Ferrier South and Pigeon Lake were also expanded.

At the beginning of 1971 there were a number of large projects under construction, which, if completed on schedule, will provide an increase in capacity in 1971 considerably in excess of the expansion achieved in 1970.

TRANSPORTATION

In September, the NEB approved permits authorizing substantial increases in exports to the United States, and at the same time approved expansion of pipeline facilities to transport these additional volumes of gas. A portion of the newly authorized construction was completed in 1970, which increased pipeline mileage by 2,600 miles. However, substantial additional construction will be required in 1971 and 1972 to meet market commitments.

Substantial additional pipeline capacity in the form of pipeline and compressor capacity is being developed in the main transmission lines. During 1970, Trans-Canada Pipe Lines Limited laid 159 miles of 36-inch line, and added 96,800 compressor horsepower at various locations in Manitoba and Saskatchewan. In addition, Trans-Canada applied to the NEB in December for approval of its 1971 and 1972 construction program, which involves construction of 695 miles of pipeline and additional compressor capacity. The program proposes construction of 414 miles of 36-inch line in eastern Manitoba and northern Ontario. The balance, in western Canada, will include 230 miles of 42-inch line, the first installation of 42-inch pipe in the Trans-Canada system. A portion of the new capacity will provide gas for a new 180-mile, 12-inch line built in 1970 by Inter-City Gas Limited from the Trans-Canada system at Spruce, Manitoba to Fort Frances, Ontario. Approximately 120 miles of this line is located in Canada, and it will serve both Canadian and United States customers.

The approval of large new exports to markets in the Pacific northwest area of the United States and California created a need for additional capacity in transmission lines serving these areas. Alberta Natural Gas Company completed a short loop section of 36-inch line and installed an additional 36,300 compressor horsepower in its section of line in southeastern British Columbia. Westcoast Transmission Company Limited has an extensive expansion program in prospect, which started in the 1970-71 winter season with a 112-mile, 24-inch transmission line northward from the company's processing plant at Fort Nelson, British Columbia to the Beaver River field on the British Columbia-Yukon border. During 1971, 234 miles of 36-inch loop will be added to the mainline, and in 1972 a further 63 miles of loop will be added in addition to a 36-mile, 20-inch line extending from Beaver River to the Pointed Mountain field. During 1970, Union Oil Company of Canada Limited constructed 43 miles of 6- to 10-inch line from the Milligan Creek field to tie in with the Westcoast system near Fort St. John.

Since a substantial proportion of Canadian gas production comes from fields in Alberta, pipeline

TABLE 10

Gas Pipeline Mileage in Canada, 1966-70

	1966	1967	1968	1969r	1970p
Gathering					
New Brunswick	6	6	6	6	6
Quebec	–	1	1	1	1
Ontario	1,167	1,163	1,142	1,193	1,245
Saskatchewan	684	714	794	805	832
Alberta	2,978	2,979	3,350	3,843	4,031
British Columbia	484	513	611	668	714
Total	5,319	5,376	5,904	6,516	6,829
Transmission					
New Brunswick	13	14	13	13	13
Quebec	112	121	148	148	148
Ontario	3,479	3,558	3,518	3,612	3,651
Manitoba	957	1,022	1,146	1,227	1,414
Saskatchewan	3,629	3,911	4,332	4,504	4,695
Alberta	5,165	5,327	5,620	6,054	6,368
British Columbia	1,580	1,660	1,758	2,370	2,374
Total	14,935	15,613	16,535	17,928	18,663
Distribution					
New Brunswick	32	32	32	32	32
Quebec	1,361	1,417	1,487	1,572	1,651
Ontario	13,315	13,737	14,497	15,059	15,121
Manitoba	1,344	1,443	1,522	1,665	1,719
Saskatchewan	1,789	1,914	2,031	2,126	2,193
Alberta	3,623	4,296	5,781	6,721	7,704
British Columbia	4,264	4,466	4,610	5,004	5,297
Total	25,728	27,305	29,960	32,179	33,717
Total, Canada	45,982	48,294	52,399	56,623	59,209

Source: Dominion Bureau of Statistics.
pPreliminary; rRevised; – Nil.

systems in the province are being expanded to meet the new demands. The Alberta Gas Trunk Line Company, the major gathering and transmission system in the province, continued the expansion of its system which began in 1969, adding 469 miles of new pipeline and 83,000 compressor horsepower. The main transmission line of the Foothills Division of the company was extended northward from Kaybob into the Gold Creek area of central-western Alberta with the construction of 82 miles of 36-inch line and associated facilities to tie-in fields along the route. New construction elsewhere in the system included approximately 125 miles of 42-inch line, marking the first time pipe of this diameter has been used in the Canadian gas industry. A number of companies throughout Alberta increased field gathering facilities.

Utility companies, that is franchise companies that distribute gas to customers, continued a moderate expansion of their systems utilizing both steel and plastic pipe. In western Alberta, Northwestern Utilities, Limited laid a 68-mile, 8-inch line from the Simonette processing plant to provide service to a coal mining project at Grande Cache. Saskatchewan Power Corporation installed almost 300 miles of new lines, including 180 miles of 12-inch transmission line from the new Beacon Hill field in western Saskatchewan to Prince Albert. In Ontario, expansion by the Union Gas Company of Canada, Limited included 20 miles of 20-inch transmission line near Chatham, and 19 miles of 34-inch line between Hamilton and Oakville.

MARKETS AND TRADE

Domestic sales rose by 8.8 per cent in 1970 to 2,514 MMcf/d slightly less than the 10.1 per cent increase achieved in 1969. Export sales however, increased by 14.7 per cent to 2,138 MMcf/d, surpassing the 12.6 per cent gain recorded in 1969.

TABLE 11

Canada, Sales of Natural Gas by Province, 1970P

	Mcf	$	Average $ / Mcf	Number of Customers Dec. 31/70
New Brunswick	62,062	172,554	2.78	1,580
Quebec	50,704,583	47,852,254	0.94	213,595
Ontario	405,981,777	318,589,198	0.74	827,674
Manitoba	51,546,350	32,842,755	0.64	129,085
Saskatchewan	79,660,140	37,986,486	0.48	145,567
Alberta	232,699,632	71,697,399	0.31	320,073
British Columbia	96,786,335	73,176,302	0.76	252,234
Total, Canada	917,440,879	582,316,948	0.63	1,889,808
Previous Totals				
1966	635,514,622	416,212,202	0.65	1,626,783
1967	698,223,437	454,722,005	0.65	1,689,157
1968	765,786,814	490,767,434	0.64	1,767,010
1969	843,164,967	537,186,938	0.64	1,836,303

Growth in Ontario markets accounted for about three quarters of the total increase in sales of gas consumed in Canada in 1970. Sales in Ontario rose by 15.5 per cent to 1,112 MMcf/d, and now make up almost 45 per cent of all sales in Canada. Imports of United States gas into Ontario continued to decline in importance as most growth was met by Canadian gas supplies. As a result, imports dropped to 30 MMcf/d, less than one third the 1969 level. Sales increases of about 8 per cent in British Columbia and Manitoba, and 3 per cent in Alberta, were achieved in 1969, while Saskatchewan and Quebec were essentially unchanged.

Industrial sales continue to be the most important, in terms of volumes used, in all provinces except Manitoba and New Brunswick, where residential sales take the highest volumes. On a Canada-wide basis, industrial sales made up 53.4 per cent of the total volumes consumed, while residential and commercial customers used 26.3 per cent and 20.3 per cent respectively. However, because of different rate structures which apply to the three categories, residential sales contributed 42.4 per cent of the total revenue of $582.3 million, and industrial and commercial sales accounted for 34.8 per cent and 22.8 per cent respectively.

Following lengthy hearings which extended from October, 1969 to March, 1971, the NEB recommended the approval of additional exports of 6.3 trillion cubic feet of natural gas over the next 15 to 20 years, and in September the Canadian government approved these increases. However, NEB concern over the amount of available gas which is surplus to Canadian requirements was evidenced by the fact that the terms of three of the licenses were less than originally requested, which in effect reduced the total amount of gas approved, and one application was rejected. In addition, conditions were imposed governing border prices and provision was made to keep under review the price of Canadian gas in export markets relative to competing gas supplies or alternative energy sources.

Westcoast Transmission Company Limited received a license to increase exports to El Paso Natural Gas Company by 76 MMcf/d over a 20-year period, beginning November 1, 1970. Westcoast also received a second license allowing deliveries of 733 MMcf/d starting November 1, 1971, and 809 MMcf/d beginning November 1, 1972. The total volume authorized under this second license to the end of October, 1989, is slightly more than 5 trillon cubic feet. When deliveries begin under the latter license, the first license will be revoked, in addition to two earlier licenses granted in 1955 and 1967. Because of new contractual arrangements with El Paso which will come into effect with the increase in deliveries on November 1, 1971, Westcoast's average selling price will increase from 26.31 cents per Mcf to 33 cents, with further escalation to 37 cents per Mcf over the contract period. The contract provides for protection against losses to Westcoast due to exchange rate fluctuations. Westcoast also received permission to expand its system capacity by looping the main line and extending northward into new supply areas at Beaver River in British Columbia and Pointed Mountain in the Northwest Territories.

Alberta and Southern Gas Co. Ltd. received approval to increase exports by a maximum of 205 MMcf/d beginning November 1, 1970. However, the term of the license was shortened to 15 years from the 23 years originally requested, which in effect reduced the total volume approved to 1,012,000 MMcf, as opposed to the 1,525,000 MMcf requested. Alberta Natural Gas

Company received approval of proposed expansion of its pipeline system to move the additional volumes of Alberta and Southern gas. Canadian-Montana Pipe Line Company, which buys gas through Alberta and Southern, received approval to increase maximum daily exports by 12 MMcf/d beginning on November 1, 1970. However, the length of this license was also shortened from 23 years to 15 years and authorized exports were cut from the requested 84,000 MMcf cubic feet to 55,000 MMcf. An application by Alberta and Southern for additional exports from Alberta was under consideration by the Alberta government at the end of the year.

Trans-Canada Pipe Lines Limited was granted licenses to increase maximum deliveries to its United States subsidiary, Great Lakes Gas Transmission Company, by 196 MMcf/d, to Michigan Wisconsin Pipe Line Company by 50 MMcf/d, and to Midwestern Gas Transmission Company by 7 MMcf/d. However, the term of the licenses was cut to 20 years from November 1, 1970, instead of the 25 years requested by Trans-Canada, thus reducing the total volume approved to 1,872,000 MMcf from 2,336,000 MMcf requested in the original application. Trans-Canada also received approval for amendments to existing licenses which permit the company to export 30,000 MMcf to Tennessee Gas Pipeline Company at Niagara Falls, Ontario during the year ending December 31, 1971, in addition to interruptable sales not exceeding 15,000 MMcf in 1969 and 1970. Certificates were also issued to Trans-Canada for the expansion of pipeline facilities.

An application by Consolidated Natural Gas Limited to export more than 300 MMcf/d from Alberta to markets in the midwestern United States area was rejected by the NEB. The company, which has been signing up reserves mainly in the Strachan-Ricinus area of Alberta was seeking its first export contract in addition to a certificate for the construction of approximately 400 miles of new pipeline in Saskatchewan which would have been required to move the gas to markets.

The application by Consolidated Natural Gas was related to first phase of a system proposed by Consolidated in 1969 to export large amounts of gas from Canada to the midwestern United States. The second phase of the Consolidated proposal would have involved construction of a 1,700 mile, 36-inch line from the Northwest Territories to connect with the parent company's system at North Branch, Minnesota. In place of this second line, Consolidated has now joined with other companies to support a proposal by The Alberta Gas Trunk Line Company to build an extension of its present system to tap northern gas supplies. Under this proposal, Alberta Gas Trunk would extend its existing system with a major transmission line, 48 inches or more in diameter, for 350 miles through the Rainbow Lake area of northwestern Alberta to the Northwest Territories border. A second company, in which Canadian companies, along with Alberta Gas Trunk, would have a majority interest, would build the next 900-mile section which would follow a route down the Mackenzie Valley to Norman Wells, and then swing westward to the Yukon-Alaska border in the Old Crow area. The final 300-mile section in Alaska to the Prudhoe Bay area would be owned by Alaskan interests. Construction of the line would be timed to coincide with the availability of solution gas when oil production starts in the Prudhoe Bay area. Although initially the line would be designed to transport gas from Alaskan operations, it would be a common carrier and would thus take gas from Canadian operations if, as and when it becomes available. Estimated throughput of the line would initially be 1,500 MMcf/d, eventually increasing to 3,000 MMcf/d by 1980. In December, Alberta Gas Trunk was joined by three companies, Columbia Gas System, Northern Natural Gas Company and Texas Eastern Transmission Corporation, which are major transmission and distribution companies in the United States. The Canadian National Railways system is also co-operating in the investigations.

A second group studying the feasibility of a gas pipeline in the north is the Northwest Project Study Group (NPSG) which was formed in July to conduct an extensive research and feasibility study on a 2,500-mile pipeline which would transport natural gas from Alaska and northern Canada to markets in Canada and the United States midwest. The group is composed of Trans-Canada Pipe Lines Limited together with two American gas distribution companies which serve the United States midwest area, and three American companies with oil and gas production interests in Alaska. The three gas distributing companies have carried out initial studies on the pipeline, which would originate in the Prudhoe Bay area and trend southeastward across portions of the Northwest Territories, Alberta and Saskatchewan to Trans-Canada's present export point at Emerson, Manitoba. The present study is expected to take over one year and will consist of extensive studies into four broad areas: (a) ecological investigation, (b) engineering and design, (c) gas reserves and availability, and (d) financing and economic feasibility. An important aspect of the program is a test loop of 48-inch pipeline which is being constructed at the Sans Sault Rapids on the Mackenzie River in order to provide actual operating data on pipelines under various conditions in the Arctic. NPSG will also co-operate in some aspects of study with the Mackenzie Valley Pipe Line Research Limited, an organization formed by 15 oil and gas companies to study the feasibility of constructing oil pipelines from the Canadian Arctic and Alaska to markets in Canada and the United States.

The third major pipeline under consideration is that of Mountain Pacific Pipeline Ltd., which is sponsored by Westcoast Transmission Company Limited, Canadian Bechtel Limited, and three other gas transmission and distribution companies which have operations in the western United States. The proposed line would consist of an 1,100-mile, 48-line from the Prudhoe Bay area to Fort Liard in the Northwest Territories. From this point, a 40-inch line would extend 950 miles south to an export point at Kingsgate on the southern boundary of British Columbia. A second large diameter line from the Fort Liard area would extend to the southeast to serve Canadian and mid-continent United States markets.

Although three gas pipelines proposals are under consideration, only one major line will initially be allowed under a set of guidelines for northern pipelines which were set out by the Canadian government in August. The guidelines were issued in order to assist the industry and other interested parties in the planning of northern developments. Under these proposals only one oil and one gas pipeline will be allowed to be built along a designated transportation "corridor". Each line will have to act as a common carrier at published tariffs, or as a contract carrier at negotiated prices, for all oil and gas tendered to the system. The means by which Canadians will have a substantial opportunity to participate in all phases of the project will be an important element in Canadian government consideration of the proposals. The lines will be under the jurisdiction of the NEB , which will ensure that sufficient research has been done to assess the effects of the line on the environment. Any certificates issued will be strictly conditioned in respect of preservation of the ecology and environment, prevention of pollution, prevention of thermal and other erosion, freedom of navigation and the protection of the rights of northern residents. Additional benefits for northern residents are anticipated by a provision which requires that applicants must undertake to provide specific programs leading to employment of residents of the north, both during the construction phase and during the operation of the pipeline.

OUTLOOK

A strong demand for Canadian gas can be expected to continue. One of the major factors contributing to this demand has been the growing concern over atmospheric pollution in both Canada and the United States, which has resulted in progressively more stringent legislation governing the emission of pollutants into the atmosphere. Natural gas, because of its clean burning qualities, is replacing other fuels to an increasing degree in order to meet these new standards. For example, in calculating future Canadian gas requirements in connection with last year's export applications, the National Energy Board made substantial allowance for the large Hearn power generating station in Toronto, Ontario, which is converting from coal to natural gas.

In the United States the rapidly growing needs of the economy are generating unprecedented demand for all forms of energy, including natural gas. This situation has been aggravated by a critical domestic supply situation. It is true that United States gas reserves increased in 1970, reversing the downward trend of recent years. However, the increase results from the inclusion of reserves in the Prudhoe Bay area of Alaska which had not previously been counted in the United States total. This gas is dissolved in the oil and will not be available, therefore, until oil production starts at Prudhoe Bay, and major transcontinental trunklines are completed to transport the gas to southern market areas. The proposed TAPS oil pipeline across Alaska had not been approved by the beginning of 1971, and oil production can not start until some form of transportation is developed. As a result the Alaskan gas reserves will not be able to relieve the supply situation in the United States for a number of years. Therefore, Canadian gas will continue to be an important supplementary supply source for American distributing companies. This, in fact, has been illustrated by the announced plans of several companies to seek approval of additional exports in the coming year.

While strong demand appears to be assured, however, the rate of growth will be controlled by the availability of supplies. This is particularly true with respect to the growth in export sales. Indeed, in 1970, as previously indicated, the NEB authorized exports below the levels requested by exporting companies, and rejected one application because it estimated there would be insufficient surplus gas to meet the export contracts after taking into consideration future Canadian requirements and recent discovery trends. Net reserve additions in the established producing areas in western Canada were the lowest in several years in 1970 due to record production levels. While the potential of Canadian frontier areas appears very promising, it is difficult to predict when commercial supplies from these areas will become available. Two major gas discoveries have been made in the Arctic Islands but substantial development will be required to prove up the reserves necessary to justify the massive capital expenditures which would have to be made to build necessary transportation facilities to utilize these discoveries. Exploration off Canada's east coast has not produced any major gas or oil discoveries as yet, although gas and oil shows have been reported in several wells.

During 1971 growth of consumption in Canada is expected to continue near the annual rate of approximately 10 per cent which has been experienced in recent years. This will raise domestic sales to approximately 2,700 MMcf/d in 1971. Substantial new exports have been approved, but the actual increase in 1971 will depend upon the rate at which facilities are installed to market the gas. However, an increase of at least 15 per cent, similar to that achieved in 1970, can

TABLE 12

Canada, Supply and Demand of Natural Gas .
(MMcf)

	1969[r]		1970[p]	
Supply				
Gross new production		2,287,434		2,624,247
Field waste and flared		−84,706		−88,971
Reinjected		−224,890		−258,698
Net withdrawals		1,977,838		2,276,578
Processing shrinkage		−239,561		−260,576
Net new supply		1,738,277		2,016,002
Removed from storage	65,024		70,743	
Placed in storage	−66,300		−93,088	
Net storage		−1,276		−22,345
Total net domestic supply		1,737,001		1,993,657
Imports		34,936		10,860
Total supply		1,771,937		2,004,517
Demand				
Exports		680,109		780,176
Domestic Sales				
Residential	231,459		241,793	
Industrial	443,286		489,503	
Commercial	168,420		186,145	
		843,165		917,441
Field and Pipeline Use				
In production	135,757		154,447	
Pipeline	99,294		117,184	
Other	13,297		18,829	
Line pack changes	+3,622		+7,101	
Total field, etc. use		251,970		297,561
Gas unaccounted for		−3,307		+9,339
Total demand		1,771,937		2,004,517
Total domestic demand		1,091,828		1,224,341
Average daily demand		2,991		3,354

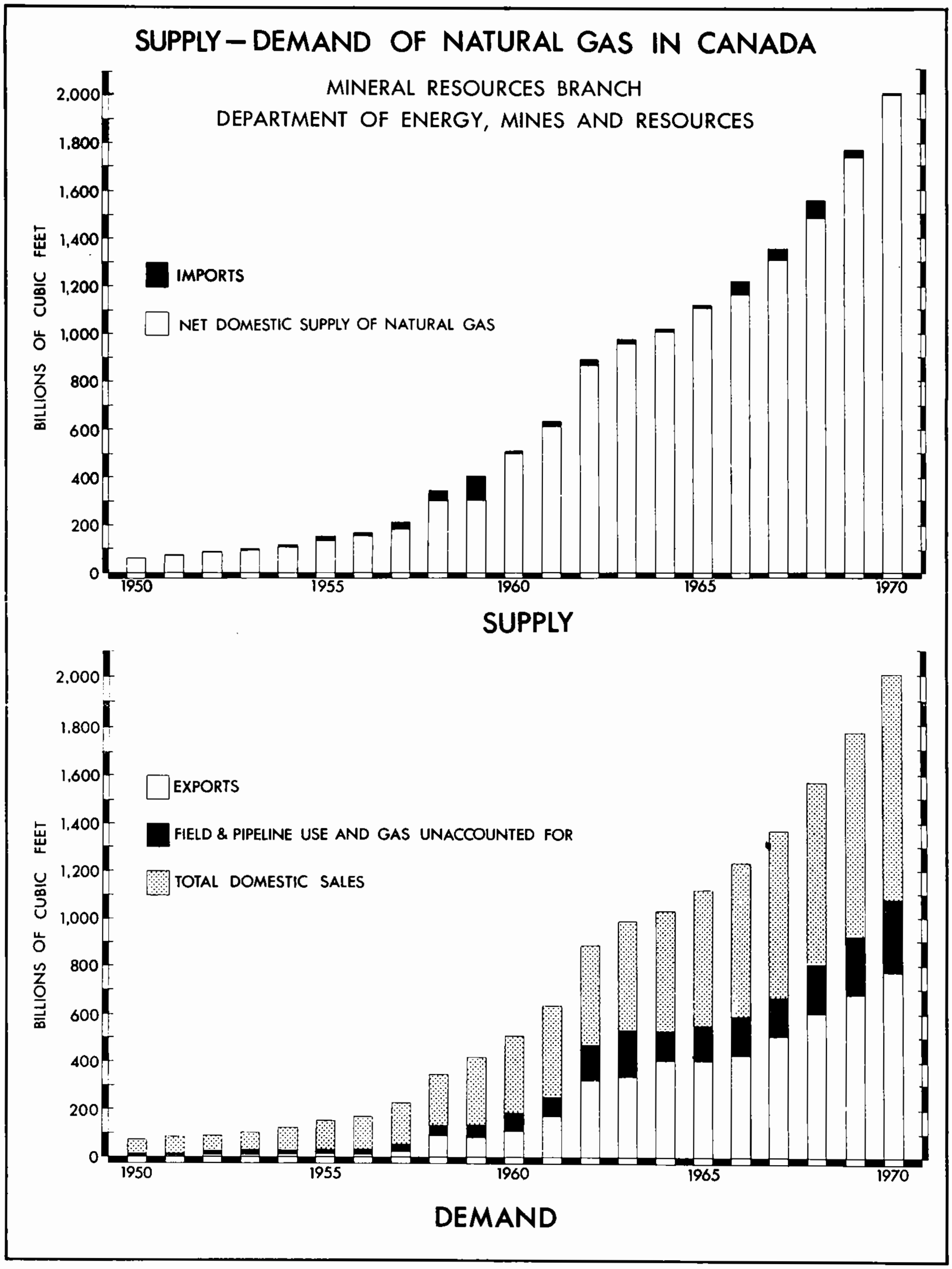
Sources: Dominion Bureau of Statistics and provincial government reports.
[p]Preliminary; [r]Revised.

be expected and this would raise exports to more than 2,400 MMcf/d. To meet such domestic and export sales, net withdrawals would rise to about 7,000 MMcf/d.

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


SUPPLY—DEMAND OF NATURAL GAS IN CANADA
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
BILLIONS OF CUBIC FEET
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
IMPORTS
NET DOMESTIC SUPPLY OF NATURAL GAS
1950
1955
1960
1965
1970
SUPPLY
EXPORTS
FIELD & PIPELINE USE AND GAS UNACCOUNTED FOR
TOTAL DOMESTIC SALES
DEMAND

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 and is becoming common as a fuel for air conditioners, incinerators, dishwashers and laundry equipment. In industrial areas, such as southwestern Ontario, 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, is an important petrochemical feed-stock that is sometimes recovered from pipeline gas. 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 has recently become 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

P.R. COTE*

NEPHELINE SYENITE

Nepheline syenite is a white to whitish-grey, medium-grained igneous rock resembling granite in texture and is made up of nepheline, potash and soda feldspars, and accessory mafic minerals such as biotite, hornblende, and magnetite. The major industrial uses of this material are found in the glass and ceramics industry and although nepheline syenite is a rock type known to occur in many parts of Canada, it is requisite for industrial application that iron-bearing accessory minerals be readily removed from the bulk rock composition.

The world nepheline syenite industry began in 1932 with the staking of five claims on the whitish granitoid rocks forming Blue Mountain in Methuen Township, some 25 miles northeast of Peterborough, Ontario. The task of commercially developing this resource was a long and arduous one. Following staking, there began a long period of persistent efforts on mining and milling techniques in conjunction with intense efforts in market research and development which ultimately led to the establishment of an industry based on this unique material – now almost an indispensable ingredient in the manufacture of glass. The low content of iron-bearing minerals–about 3 per cent–which are removed by magnetic separation makes the Blue Mountain material particularly suitable for use in the glass industry. Today, some 40 years after the original staking, two mills are in operation on Blue Mountain, extracting rock from three quarries to produce by far the majority of nepheline syenite consumed in the world. Only two other countries in the world, Norway and the USSR, produce nepheline syenite.

Over the years, glass manufacturers have attempted to reduce the wear in tank furnaces while at the same time improve the quality and yield of the glass batch. One material in particular – nepheline syenite – has probably done more toward this end than all others and over the past 30 years has become a desirable ingredient in glass manufacture.

Nepheline syenite is an excellent source of alumina and in addition the material lowers the melting temperature thus economizing on fuel consumption and lengthening the life of furnace refractories. Further, nepheline syenite absorbs considerable amounts of additional silica during melting and so contributes towards the speed of melting.

Industrial uses for nepheline syenite other than glass manufacture are many and markets are expanding rapidly for use in ceramics, enamels, and as a filler in paints, papers, plastics and foam rubber.

CANADIAN PRODUCTION AND DEVELOPMENTS

Production originates from two operations in Canada, both located on Blue Mountain in Methuen Township. The deposit upon which both mines are located is pear-shaped, approximately 5 miles in length, and up to 1.5 miles in width. The iron content of the rock is distributed quite uniformly, but none the less, selective quarrying, blending of quarry material, and careful pit development are necessary to ensure a mill product capable of meeting rigid 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.

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*Mineral Resources Branch.

Indusmin Limited at Nephton, Ontario, a subsidiary of Falconbridge Nickel Mines Limited, operates the largest of the two mills. This deposit was originally worked by Canadian Nepheline, Limited. Ore is mined from two open pits, the Cabin Ridge and the Craig. Rock is blasted from the pit face and loaded by electric shovels into trucks for haulage to the 1,000-ton-a-day mill. The mill, built in 1956, operates three shifts a day, seven days a week producing a number of 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, some 18 miles south of the mill. From there transportation is by rail to domestic and exports markets. Exports to the United States account for about 65 per cent of sales.

International Minerals & Chemical Corporation (Canada) Limited [IMC (Canada)] operates a mill on the Blue Mountain deposit about 4 miles east of the Indusmin operation. The mill, capable of producing some 600 tons a day of finished product, was constructed in mid-1956 on a portion 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 size and iron content suitable for many industrial uses. Rock is mined from an open pit adjacent to the mill and reserves are sufficient for many years. A certain degree of blending from various portions of the pit is required to ensure an acceptable mill feed.

Production is railed to Havelock for distribution to various markets. Approximately 90 per cent of the product is exported to the United States. IMC (Canada) produces three grades of nepheline syenite for glass, ceramic, enamel, fibre and other applications.

In 1970, nepheline syenite shipments amounted to 491,000 short tons valued at $6,149,000 representing a slight decrease in tonnage compared to 1969 (500,517 short tons). Despite this, revenue from sales

TABLE 1

Canada–Nepheline Syenite–Production, Exports and Consumption, 1969-70

	1969		1970p	
	Short Tons	$	Short Tons	$
Production (shipments)	500,517	5,935,239	491,000	6,147,000
Exports				
United States	364,008	4,559,000	365,050	4,620,000
Australia	3,001	66,000	3,795	87,000
Britain	6,378	101,000	5,259	78,000
Italy	4,136	83,000	2,312	57,000
Puerto Rico	4,315	63,000	3,200	46,000
Japan	7,673	116,000	1,910	32,000
Greece	165	4,000	1,435	28,000
France	639	16,000	875	22,000
Other countries	5,298	112,000	4,111	93,000
Total	395,613	5,120,000	387,947	5,063,000
	1968		1969p	
Consumption[1] (available data)				
Glass and glass fibre	56,961r		54,809	
Whiteware	9,369		10,051	
Mineral wool	9,568		9,500e	
Porcelain enamel	219		467	
Paint	569		894	
Other[2]	2,880		2,309	
Total	79,566r		78,030	

Source: Dominion Bureau of Statistics.

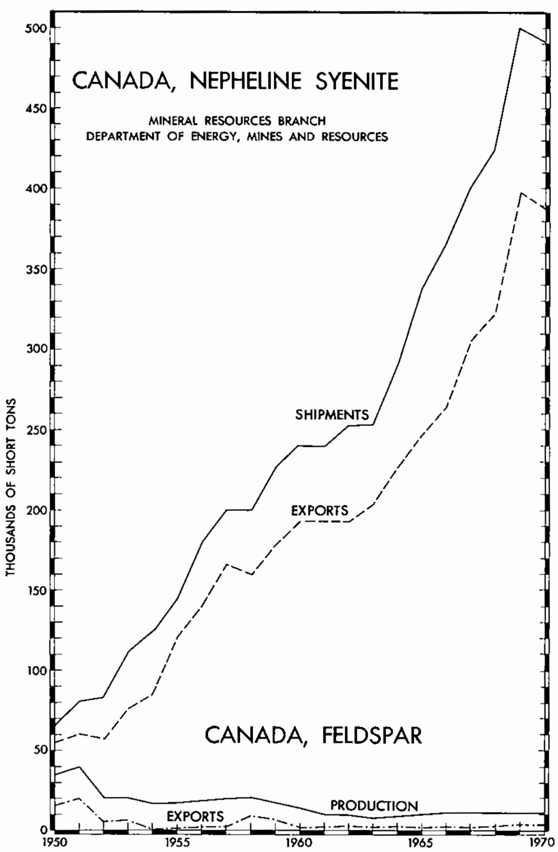
[1]Adjusted total and breakdown from Mineral Resources Branch; [2]Includes miscellaneous chemicals, gypsum products, rubber products and other minor uses.

pPreliminary; rRevised; eEstimated.

increased marginally. It is noteworthy that the substantial increases in shipments in 1969 over 1968 (+ 18 per cent) due in large part to inadequate feldspar supplies in the United States were almost maintained in 1970 despite a return to more normal supply conditions by U.S. producers. Indeed, preliminary export figures indicate that exports to the United States increased marginally in 1970 over 1969.

OTHER DOMESTIC SOURCES

Nepheline syenite is known to occur in many localities in Canada, but to date, the Blue Mountain deposit is the only one that has proven to beneficiate 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 was unacceptable due to considerable variation in the nepheline content and an overabundance of iron-bearing accessory minerals. Tontine Mining Limited continued exploration work on a large nepheline syenite intrusive located near Port Coldwell on the north shore of Lake Superior.

Nepheline syenite occurs in several localities in southern British Columbia, notably in the Ice River area near Field and in the vicinity of The Big Bend 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.

TABLE 2

Canada, Nepheline Syenite–Production and Exports 1961-70
(short tons)

	Production*	Exports
1961	240,320	194,598
1962	254,418	193,658
1963	254,000	203,262
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	500,517	395,613
1970[p]	491,000	387,947

Source: Dominion Bureau of Statistics.
*Producers' shipments.
[p]Preliminary.

MARKETS

Approximately 79 per cent of nepheline syenite produced in Canada is exported. In 1970, exports decreased marginally to 387,949 tons from 395,613 tons in 1969. Accounting for the majority of the decrease was slightly eroded markets in Europe and a substantial decrease in sales to Japan. However, the major export market, the United States accounting for some 94 per cent of all exports increased slightly over 1969 levels. In 1969, exports to the United States increased markedly over 1968 due in large part to a shortage in that country of feldspar – a competing material in the glass industry. Canadian producers have been successful in maintaining these markets despite a return to more normal supply conditions.

Approximately 20 per cent of producers' shipments are consumed domestically and of this 70 per cent is used in glass and glass fibre manufacture.

Although available data indicates a slight decrease in domestic consumption, registered mostly in the glass manufacture sector, consumption for other purposes including whitewares and fillers increased slightly indicating a growing diversification of uses.

Nepheline syenite is used in a number of industrial applications but more than 75 per cent of production is consumed in the glass industry. On the average, 15 to 20 per cent by weight of the glass batch is nepheline syenite. Material with a size range minus 30 mesh plus 200 mesh and with an iron content of less than 0.1 per cent is required in the production of flint glass. 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 analyses of 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 for finely-ground material in the whiteware industry is developing. 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 both as 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. Some 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 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 high-iron content material is used in the manufacture of mineral wool and as an aggregate.

WORLD REVIEW

The Norsk Nefelin Division of Christiania Spigerwerk is western Europe's only producer of nepheline syenite. Production began in 1961 and has increased steadily from 23,000 metric tons in 1963 to 80,000 metric tons in 1968. Production capacity is currently being increased to 140,000 tons of finished product a year. It is anticipated that by 1970, production from the plant in northern Norway near the village of Hammerfest will reach 200,000 tons of product a year. The lenticular deposit is over 1 mile in length and extends to a depth of at least 750 feet. 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 long-term charter, and ships finished products to storage and distribution centres in major market areas. New loading facilities are speeding shipments and the loading rate is 1,000 tons an hour.

Nepheline syenite is an important source of alumina for aluminum production in the Soviet Union. 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 syenite 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.

OUTLOOK

The outlook for nepheline syenite markets remains good. However, current concern as to the impact or detrimental effect of non-returnable glass containers on the environment could result in some decreased use in this application, which a few years ago held promise of rapid growth in consumption. The market for finely-ground material used in the ceramic industry and as fillers is expending and both Canadian producers operated near capacity to meet growing consumer demands. Their ability to provide an uninterrupted supply of quality material, meeting rigid consumer specifications, has been a major factor in expanding traditional markets and outlining new product applications. European markets are expected to remain extremely competitive due to increased production from Norway and some erosion of the market is to be anticipated. The long term outlook suggests a growth rate in markets in the order of 5 per cent a year at least to 1975.

PRICES

Nepheline syenite prices vary from low-purity crushed rock in bulk at approximately $5 a ton to over $24 a ton for finely-ground high-purity products suitable for whitewares and filler applications. The average price of nepheline syenite used in the glass industry is in the order of $12 a ton f.o.b. plant.

TARIFFS

The largest export market is the United States where entry is duty free.

Feldspar

Feldspar is the name of a group of minerals that are aluminum silicates of potassium, sodium and calcium. Feldspars are of value to the ceramic industry as a source of alumina, potash and soda. Manufacturers of cleaning compounds use crushed feldspar for its moderately abrasive properties. High-calcium feldspars such as labradorite and feldspar-rich rocks like anorthosite find limited use as building stones and for other decorative purposes.

Feldspars occur in many rock types but commercially viable deposits are for the most part restricted to coarse-grained granite pegmatites. The feldspar from these pegmatites is generally hand-cobbed to remove quartz and other unwanted associated minerals. The feldspar 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.

Feldspar has been a long-standing source of alumina and alkalis in glass making and an important

TABLE 3

Canada, Feldspar, Production and Trade, 1961-70
(short tons)

	Production*	Imports	Exports	Consumption
1961	10,507	1,721	2,626	7,455
1962	9,994	1,901	3,698	6,818
1963	8,608	2,600	3,282	6,009
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	..	..	7,370
1970[p]	11,000	..	..	...

Source: Dominion Bureau of Statistics.
*Producers' shipments.
[p]Preliminary; .. Not available.

TABLE 4

Canada–Feldspar–Production, 1969-70, Consumption, 1968-69

	1969		1970[p]	
	Short Tons	$	Short Tons	$
Production[1]	12,385	301,375	11,000	311,000
	1968		1969	
Consumption[2] (available data)				
Whiteware	6,228		6,095	
Porcelain enamel	303		417	
Cleaning compounds	366		407	
Other[3]	446		451	
Total	7,343		7,370	

Source: Dominion Bureau of Statistics.
[1]Producers' shipments; [2]Breakdown by Mineral Resources Branch; [3]Includes artificial abrasives, electrical apparatus, glass, paper and other minor uses.
[p]Preliminary.

constituent in ceramic products. Alternative raw materials such as nepheline syenite have made significant inroads into feldspar's markets so that domestic consumption in the manufacture of glass, pottery and enamel has remained at about the same level for the past decade. Feldspar now produced in Canada is consumed in the ceramic industry in southern Ontario and northwestern New York State. The trend toward standardization of methods in glass manufacture demanding uniformity of quality has favoured the use of nepheline syenite in a wide range of products formerly utilizing feldspar.

TABLE 5
World Production of Feldspar, 1968-1970
(short tons)

	1968	1969^p^	1970^e^
United States	747,800	754,863	723,000
West Germany	317,247	319,200	319,000
USSR	263,200	274,400	. .
Italy	185,609	232,785	224,000
France	188,160	187,040	185,000
Mexico	88,488	92,035	. .
Finland	59,995	69,446	. .
Japan	72,913	65,063	67,000
Spain	52,105	56,000	. .
Yugoslavia	48,543	50,400	. .
Other countries	406,744	437,297	974,000
Total	2,430,804	2,538,529	2,492,000

Sources: U.S. Bureau of Mines Minerals Yearbook Preprint 1969 and U.S. Commodity data Summaries, January 1971.
[p]Preliminary; [e]Estimated; . . Not available.

CANADIAN PRODUCTION AND DEVELOPMENTS

Production of feldspar in Canada in 1970 was 11,000 tons; all produced by International Minerals & Chemical Corporation (Canada) Limited from its mine at Buckingham, Quebec. Production has remained almost constant, in the order of 10,000 tons a year since the early 1960's and had previously declined steadily from 1947, when some 55,000 tons were produced.

MARKETS

Canadian feldspar is now consumed almost entirely in the ceramics industry. 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 its 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". Potash feldspars utilized for ceramics are usually required to contain not less than 8 per cent K_2O and preferably over 10 per cent K_2O. The soda (Na_2O) content should be as low as possible, ideally zero; iron (Fe_2O_3) content under 0.1 per cent. Feldspar is important as a flux in the firing of whiteware bodies and glazes and is used principally in Canada in the manufacture of electric porcelain and vitreous sanitaryware. It must be minus 325 mesh and have a very low quartz and iron content – Fe_2O_3 should not exceed 0.1 per cent. For cleaning compounds, feldspar should be white and free of quartz. In the United States, in recent years, there has been a marked increase in the consumption of a feldspar-silica mixture for glass manufacture. Normally the mixture contains from 30 to 50 per cent feldspar.

PRICES

United States feldspar prices, as quoted in *Engineering and Mining Journal* of December, 1970, were as follows:

per short ton, f.o.b. mine or mill,
carload lots, depending on grade

North Carolina	
200 mesh, dry ground	$20.50 - 21.50
40 mesh, dry ground	$21.00
20 mesh, flotation	$11.00
200 mesh, flotation	$20.50 - 26.00
Georgia	
200 mesh	$23.50
325 mesh	$24.50
40 mesh granular	$20.00
Connecticut	
30 mesh, granular	$13.50
200 mesh, granular	$20.50
325 mesh, granular	$21.50
20 mesh, granular	$13.50
Maine	
200-325	$24.00

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%

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

UNITED STATES

522.31	Feldspar, crude	
	On and after Jan. 1, 1970	5¢ per long ton
	On and after Jan. 1, 1971	2¢ per long ton
	On and after Jan. 1, 1972	free
522.41	Feldspar, crushed, ground or pulverized	
	On and after Jan. 1, 1970	5%
	On and after Jan. 1, 1971	4%
	On and after Jan. 1, 1972	3.5%

Source: Tariff Schedules of the United States Annotated (1970) TC Publication 304.

Nickel

ROBERT J. SHANK*

The shortage of nickel that existed in the non-communist world since 1966 ended during 1970 as increasing world productive capability combined with lagging economic growth rates in North America and Japan to produce a balanced supply-demand position at the end of the year. There were no major disruptions to producing facilities in 1970, and the Sudbury plants of The International Nickel Company of Canada, Limited (Inco) and Falconbridge Nickel Mines Limited were back to full operations early in the year, much sooner than was expected following the serious labour strikes of 1969. Barring unforeseen production interruptions, the supply of nickel should be more than adequate to meet expected demand for the next few years.

Canadian mine production of nickel rose to a record 308,042 tons valued at $829,643,800 in 1970. This compares with 213,611 tons valued at $481,055,140 in 1969 and 264,358 tons valued at $528,235,798 in 1968, which was the previous highest year. Consumption in Canada rose to 17,000 tons** from the 14,500 tons** used in 1969.

Consumption of nickel in the non-communist world rose strongly to 492,500** tons as adequate supplies became available. The comparable usage in 1969 was 422,000 tons.**

CANADIAN OPERATIONS AND DEVELOPMENTS

Nickel ores were mined in four provinces during 1970; Ontario, Manitoba, British Columbia, and Quebec. Three companies operated integrated mine-mill-smelter and refinery complexes producing refined metal from their own ores and from the ores of other mines on a custom or purchase basis.

The International Nickel Company of Canada, Limited is the world's largest producer of nickel. Deliveries in 1970 of 259,435 tons accounted for 53 per cent of consumption in the non-communist world. Inco operated eleven mines, four concentrators, and two smelters at Sudbury, Ontario, as well as a nickel refinery at Port Colborne. Five more mines are being prepared for production, and two concentrators and a nickel refinery are under construction in Ontario. The refinery, employing the new Inco Pressure Carbonyl process, will be capable of producing 50,000 tons of nickel pellets and 12,500 tons of nickel powders annually when completed in 1972. A major addition to the sulphuric acid plant and expansion of the iron ore plant have been postponed. During 1970, Inco completed the erection of a 1,250 foot high chimney – the tallest in the world – at Copper Cliff to facilitate the dispersion of sulphur dioxide furnace gases. In Manitoba, Inco operated two mines, a concentrator, smelter, and refinery at Thompson. Two more mines were under development in Manitoba. Expansions of operations now under way are expected to raise the company's Canadian production capacity to between 307,500 and 315,000 tons of nickel a year by the mid-1970's.

Falconbridge Nickel Mines Limited, Canada's second largest producer, operated eight mines, four

*Mineral Resources Branch.

**Estimate by The International Nickel Company of Canada, Limited.

TABLE 1

Canada – Nickel Production, Trade and Consumption, 1969-70

	1969		1970[p]	
	Short Tons	$	Short Tons	$
Production[1]				
All forms				
Ontario	146,781	329,076,314	227,988	611,532,800
Manitoba	64,920	147,621,637	78,074	212,649,000
British Columbia	1,489	3,396,208	1,150	3,174,000
Quebec	155	353,861	830	2,288,000
Saskatchewan	266	607,120	–	–
Total	213,611	481,055,140	308,042	829,643,800
Exports				
Nickel in ores, concentrates, matte and speiss				
Norway[2]	35,829	64,992,000	46,450	114,678,000
Britain	35,165	76,757,000	40,092	108,339,000
Japan	5,913	10,752,000	9,954	23,675,000
France	–	–	75	150,000
Other countries	69	93,000	88	209,000
Total	76,976	152,594,000	96,659	247,051,000
Nickel in oxide sinter				
United States	19,491	38,026,000	27,335	64,958,000
Britain	6,231	11,504,000	10,269	25,793,000
Belgium and Luxembourg	–	–	4,975	12,624,000
Australia	459	883,000	957	2,495,000
Italy	937	1,792,000	150	400,000
Other countries	1,891	3,607,000	209	500,000
Total	29,009	55,812,000	43,895	106,770,000
Nickel and nickel alloy scrap				
West Germany	1,663	6,215,000	748	5,028,000
United States	2,270	7,028,000	2,268	3,433,000
Britain	104	321,000	411	2,200,000
Netherlands	278	820,000	267	1,516,000
Other countries	723	2,521,000	622	2,468,000
Total	5,038	16,905,000	4,316	14,645,000
Nickel anodes, cathodes, ingots, rods				
United States	86,768	178,038,000	103,385	255,040,000
Britain	11,111	21,817,000	26,376	70,230,000
West Germany	298	791,000	3,007	20,417,000
Belgium and Luxembourg	251	513,000	6,405	14,938,000
China (communist)	50	275,000	2,027	12,853,000
Japan	393	854,000	2,225	7,992,000
India	553	1,208,000	1,934	7,499,000
Australia	1,420	3,086,000	1,886	5,755,000
Netherlands	15	80,000	443	4,310,000
Italy	1,712	4,039,000	1,474	4,285,000
France	880	2,033,000	1,364	3,885,000
Sweden	24	57,000	523	2,919,000
Other countries	768	2,325,000	2,154	7,858,000
Total	104,243	215,116,000	153,203	417,981,000

TABLE 1 (Cont'd)

	1969		1970^p	
	Short Tons	$	Short Tons	$
Nickel and nickel alloy fabricated material, n.e.s.				
United States	2,049	6,590,000	1,757	7,349,000
Netherlands	303	1,074,000	531	2,330,000
Brazil	124	403,000	451	1,764,000
China (communist)	–	–	247	1,015,000
Japan	171	617,000	199	983,000
West Germany	131	616,000	115	909,000
Other countries	510	1,663,000	349	1,884,000
Total	3,288	10,963,000	3,649	16,234,000
Imports				
Nickel in ores, concentrates and scrap				
Australia	4,407	6,408,000	11,913	29,495,000
United States	2,823	4,655,000	8,635	17,138,000
French Oceania	1,861	2,808,000	4,293	2,545,000
Britain	1,201	776,000	1,823	1,338,000
Belgium and Luxembourg	–	–	75	82,000
Other countries	99	182,000	2,940	5,000
Total	10,391	14,829,000	29,679	50,603,000
Nickel anodes, cathodes, ingots, rods				
Norway	12,388	28,403,000	11,787	32,402,000
United States	91	559,000	39	150,000
Other countries	122	806,000	–	–
Total	12,601	29,768,000	11,826	32,552,000
Nickel alloy ingots, blocks, rods and wire bars				
United States	509	1,945,000	463	1,815,000
Britain	–	–	9	45,000
West Germany	11	47,000	–	–
Total	520	1,992,000	472	1,860,000
Nickel and alloy plates, sheet, strip and flat products				
United States	2,605	9,315,000	1,246	4,865,000
West Germany	38	100,000	30	67,000
Other countries	97	330,000	10	52,000
Total	2,740	9,745,000	1,286	4,984,000
Nickel and nickel alloy pipe and tubing				
United States	258	1,148,000	345	1,460,000
West Germany	181	1,048,000	188	1,155,000
Other countries	16	70,000	1	9,000
Total	455	2,266,000	534	2,624,000

TABLE 1 (Cont'd)

	1969		1970[p]	
	Short Tons	$	Short Tons	$
Nickel and alloy fabricated material, n.e.s.				
United States	422	2,455,000	276	1,782,000
Britain	60	246,000	47	249,000
Other countries	20	84,000	7	40,000
Total	502	2,785,000	330	2,071,000
Consumption[3]	12,094		11,794	

Source: Statistics Canada.
[1]Refined nickel and nickel in oxides and salts produced plus recoverable nickel in matte and concentrates exported. [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; n.e.s. Not elsewhere specified.

TABLE 2

Nickel – Production, Trade and Consumption, 1961-70
(short tons)

		Exports					
	Production[1]	In Matte etc.	In Oxide Sinter	Refined Metal	Total	Imports[2]	Consumption[3]
1961	232,991	92,938	18,022	133,504	244,464	4,304	4,935
1962	232,242	77,410	11,120	121,712	210,242	7,494	5,322
1963	217,030	83,392	15,208	109,156	207,756	10,973	5,866
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[r]
1969	213,611	76,976	29,009	104,243	210,228	12,601	12,094
1970[p]	308,042	96,659	43,895	153,203	293,757	11,826	11,794

Source: Statistics Canada.
[1]Refined metal and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates exported. [2]1961 to 1963 incl., nickel, semi-fabricated, comprising nickel and nickel alloys in ingots, blocks, bars, rods, strip, sheet, etc.; 1961 and subsequent years, 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; [r]Revised; . .Not available.

TABLE 3

Principal Canadian Nickel Mines 1970 and (1969)

Company and Location	Mill or Mine Capacity* (tons ore/day)	Grade of Ore Nickel (%)	Grade of Ore Copper (%)	Ore Produced (tons)	Contained Nickel Produced (tons)	Remarks
QUEBEC						
Renzy Mines Limited, Hainault Township	1,000 (800)	0.46 (0.54)	0.51 (0.57)	324,015 (88,049)	957 (335)	
ONTARIO						
Consolidated Canadian Faraday Limited, Werner Lake Division, Gordon Lake	1,100 (1,200)	.. (0.82)	.. (0.39)	105,504 (177,726)	627 (987)	Mills ore from Dumbarton mine.
Falconbridge Nickel Mines Limited, East, Falconbridge, Fecunis, Hardy, Longvack South, North, Onaping, and Strathcona Mines, Falconbridge	6,000 (Strathcona) 3,000 (Falconbridge)	.. ..	.. ..	4,631,000 (3,118,000)	42,071** (40,324)**	Considering a nickel refinery in Canada. Tune-up on the iron-nickel refinery at Falconbridge was started at year-end.
The International Nickel Company of Canada, Limited, Clarabelle, Copper Cliff North, Crean Hill, Creighton, Frood-Stobie, Garson, Kirkwood, Levack, MacLennan, Murray and Totten mines, Copper Cliff	30,000 (Copper Cliff) 22,500 (Frood-Stobie) 12,000 (Creighton) 6,000 (Levack)	.. ..	.. ..	22,996,100 (14,578,700)	259,435*** (191,085)***	The new Clarabelle concentrator, with a capacity of 35,000 tons of ore a day, is to be operational by the end of 1971. The new refinery, using Inco's Pressure Carbonyl process, is being constructed at Copper Cliff. Capacity will be 50,000 tons of nickel pellets and 12,500 tons of nickel powders annually, to be completed in 1972. Expansion of the iron ore recovery plant has been deferred.
MANITOBA						
Dumbarton Mines Limited, Bird River	700 (700)	.. (0.77)	.. (0.26)	252,552 (66,395)	1,710 (411)	Trucked to Consolidated Canadian Faraday mill. Mine started production in September, 1969.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity* (tons ore/day)	Grade of Ore: Nickel (%)	Grade of Ore: Copper (%)	Ore Produced (tons)	Contained Nickel Produced (tons)	Remarks
The International Nickel Company of Canada, Limited,	12,000 (12,000)	.. ..	.. ..	3,861,700 (4,225,000)^{e}	259,435*** (191,085)***	Concentrator and smelter expansion at Thompson, begun in 1966, was completed at year-end.
Birchtree and Thompson mines, Thompson						
Sherritt Gordon Mines, Limited, Lynn Lake	3,500 (3,500)	0.77 ..	0.51 ..	1,090,000 (1,258,193)	6,472 (6,532)	All open-pit ore has been milled. The Farley mine is being deepened from the 3,000 foot level to the 3,600 foot level to mine deeper ore. Reserves remain unchanged from the previous year.
BRITISH COLUMBIA						
Giant Mascot Mines Limited, Hope	1,500 (1,300)	0.84 (0.83)	0.43 (0.40)	211,460 (337,056)	1,435 (1,985)	Mill and surface plant destroyed by fire in August. Ore reserves have been increased by extensions to the 2200, 2663, 4400, 4600 and Chinaman Zones and the discovery of the Climax No. 1 zone.
NORTHWEST TERRITORIES						
Copper Pass Mines Ltd., Great Slave Lake	–	(..)	(..)	(..)	(..)	Hand-cobbed ore shipped to European smelter.
Jason Explorers Ltd., Blanchet Island, Great Slave Lake	–	10.00	(..)	(..)	(..)	300 tons of nickel-cobalt hand-cobbed ore shipped to Marseilles, France.

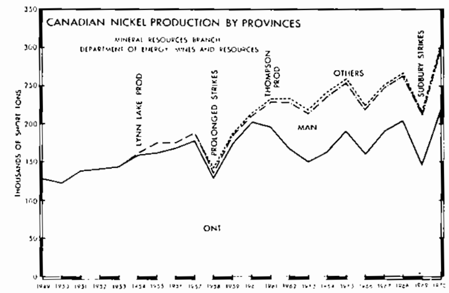
*Mill capacity in tons of ore a day; **Nickel deliveries; ***Ontario and Manitoba nickel deliveries.

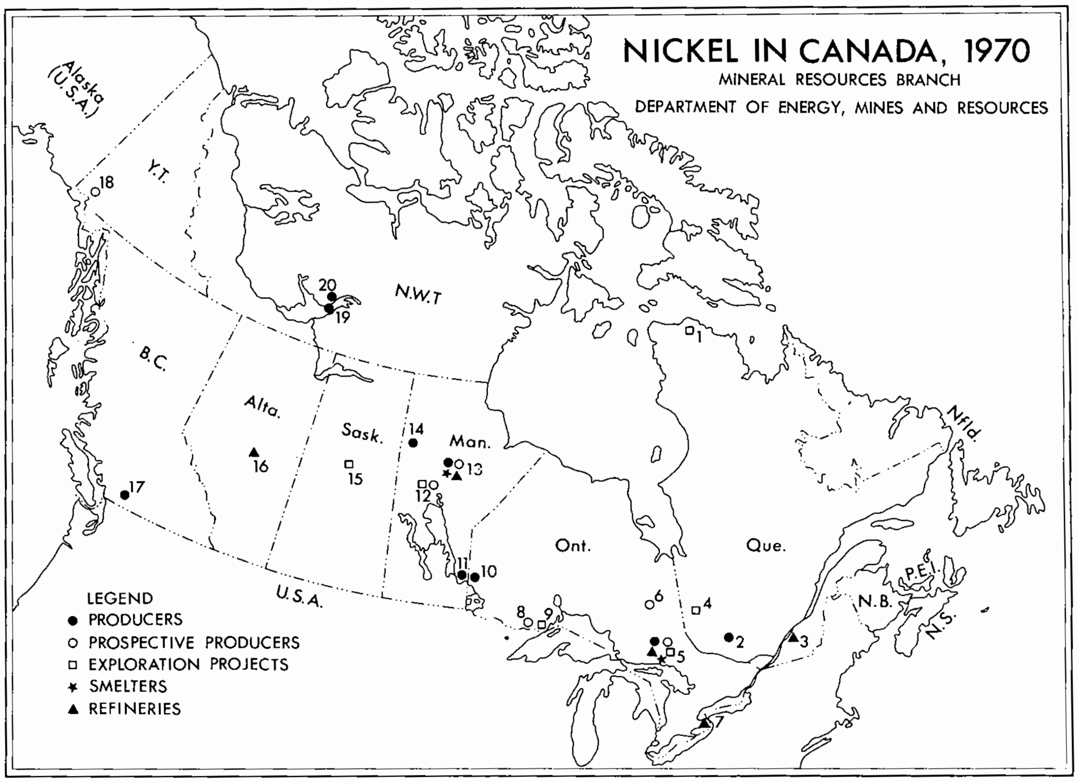
..Not available; –Nil; ^{e}Estimated.

concentrators and a smelter at Sudbury, Ontario. Two mines are being developed in the Sudbury area, and one mine and a concentrator at Wabowden in Manitoba. The company ships its nickel-copper matte to Norway for refining, but is constructing a refinery at Becancour in Quebec to treat part of its production. Completion of this refinery is scheduled for 1974. It will be designed to turn out 15,000 tons of nickel, 11,000 tons of copper, 7,000 tons of sulphur and 250 tons of cobalt a year from nickel-copper matte from the Falconbridge smelter. Nickel deliveries in 1970 amounted to 42,000 tons. Falconbridge plans to double its Canadian capacity by 1975.

Sherritt Gordon Mines, Limited is the third-largest Canadian producer, operating a nickel mine at Lynn Lake, Manitoba and a hydrometallurgical refinery at Fort Saskatchewan, Alberta. Mine production has been declining for the past few years and Sherritt has been importing concentrates from Australia, both on a purchase basis and for toll refining, to keep its refinery operating at capacity. Production in 1970 from its own ores amounted to 6,500 tons of refined nickel, and a further 11,500 tons from other sources.

Information on all mines producing nickel in Canada can be found in Table 3. Those mines with announced production plans are listed in Table 4, while Table 5 lists a number of nickel properties undergoing exploration.





(numbers refer to numbers on map)

PRODUCERS

2. Renzy Mines Limited (Hainault Township)
5. Falconbridge Nickel Mines Limited (East, Falconbridge, Fecunis, Hardy, Longvac South, North, Onaping and Strathcona mines)
   The International Nickel Company of Canada, Limited (Clarabelle, Copper Cliff North, Crean Hill, Creighton, Frood-Stobie, Garson, Kirkwood, Levack, MacLennan, Murray and Totten mines)
10. Consolidated Canadian Faraday Limited (Gordon Lake)
11. Dumbarton Mines Limited (Bird River)
13. The International Nickel Company of Canada, Limited (Birchtree and Thompson mines)
14. Sherritt Gordon Mines, Limited (Lynn Lake)
17. Giant Mascot Mines Limited (Hope)
19. Jason Explorers Ltd. (Blanchet Island)
20. Copper Pass Mines Ltd. (Great Slave Lake)

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)
12. Bowden Lake Nickel Mines Limited (Bowden Lake and Bucko Lake mines)
15. National Nickel Ltd. (Nemeiben Lake)

SMELTERS

5. Falconbridge Nickel Mines Limited (Falconbridge)
   The International Nickel Company of Canada, Limited (Coniston)
   The International Nickel Company of Canada, Limited (Copper Cliff)
13. The International Nickel Company of Canada, Limited (Thompson)

PROSPECTIVE PRODUCERS

5. Falconbridge Nickel Mines Limited (Lockerby and Thayer Lindsley mines)
   The International Nickel Company of Canada, Limited (Coleman, Copper Cliff South, Levack West and Little Stobie mines)
6. Noranda Mines Limited (Longmuir mine)
   Texmont Mines Limited (Timmins)
8. The International Nickel Company of Canada, Limited (Shebandowan)
12. Falconbridge Nickel Mines Limited (Manibridge mine)
13. The International Nickel Company of Canada, Limited (Pipe and Soab mines)
18. Hudson-Yukon Mining Co., Limited (Wellgreen mine)

REFINERIES

3. Falconbridge Nickel Mines Limited (Becancour): Production scheduled for 1973-74
5. Falconbridge Nickel Mines Limited (Falconbridge): Nickel-iron refinery. Tune-up in late 1970.
   The International Nickel Company of Canada, Limited (Copper Cliff): Pressure Carbonyl nickel refinery scheduled for completion in 1972.
7. The International Nickel Company of Canada, Limited (Port Colborne)
13. The International Nickel Company of Canada, Limited (Thompson)
16. Sherritt Gordon Mines, Limited (Fort Saskatchewan)

TABLE 4

Prospective* Canadian Nickel Mines

Company and Location	Mill Capacity** and Ore Grade (%)	Year Production Expected	Destination of Nickel Concentrates	Remarks
ONTARIO				
Falconbridge Nickel Mines Limited, Falconbridge				
Lockerby mine	–	1975	Own smelter	Ore will be shipped to Falconbridge mill.
Thayer Lindsley mine	–	1973	Own smelter	" " " " " " "
	Ni (..)			
	Cu (..)			
The International Nickel Company of Canada, Limited, Copper Cliff				
Coleman mine	–	1971	Own smelter	4,000 tons a day to company's mills.
Copper Cliff South mine	–	1971	Own smelter	6,000 " " " " " "
Levack West mine	–	1975	Own smelter	2,500 " " " " " "
Little Stobie mine	–	1971	Own smelter	8,000 " " " " " "
	Ni (..)			
	Cu (..)			
The International Nickel Company of Canada, Limited, Shebandowan	3,000	1972	Own smelter	
	Ni (..)			
	Cu (..)			
Noranda Mines Limited	700			Joint project with Inco.
Langmuir mine	Ni (1.87)	1972	..	
Timmins	Cu (..)			
Texmont Mines Limited	500	1971	..	
Timmins	Ni (1.00)			
	Cu (..)			
MANITOBA				
Falconbridge Nickel Mines Limited,				
Manibridge mine	1,000	1971	Falconbridge	
Wabowden	Ni (2.55)			
	Cu (0.27)			

TABLE 4 (Cont'd)

Company and Location	Mill Capacity** and Ore Grade (%)	Year Production Expected	Destination of Nickel Concentrates	Remarks
The International Nickel Company of Canada, Limited, Thompson,				
Pipe mine	16,000	1971	Own smelter	
Soab mine	4,000	1971	Own smelter	
	Ni (..)			
YUKON TERRITORY				
Hudson-Yukon Mining Co., Limited,	600	1972	Japan	
Wellgreen mine	Ni (2.04)			
Kluane Lake	Cu (1.42)			

*Only mines with announced production plans. **Mill capacity in tons of ore a day.
..Not available; —Nil.

TABLE 5

Nickel Exploration Projects

Company and Location	Indicated Ore Tonnage (tons)	Grade of Ore (%)	Remarks
QUEBEC			
Dumont Nickel Corporation, Launay Township	480,000,000	Ni (0.32)	Surface diamond drilling continuing. Metallurgical examinations under way.
Expo Ungava Mines Limited, Ungava	18,500,000	Ni (0.47) Cu (0.52)	Surface diamond drilling continuing.
New Quebec Raglan Mines Limited, Ungava	16,050,000	Ni (2.58) Cu (0.71)	Feasibility study in progress. Falconbridge is continuing development work on the property.
ONTARIO			
Great Lakes Nickel Limited, Pardee Township	40,000,000	Ni (0.20) Cu (0.40)	Underground and surface exploration continuing.
The International Nickel Company of Canada, Limited, Copper Cliff,			
Cryderman mine	..	Ni (..)	
North Range mine	..	Cu (..)	
Victoria mine	..		
Whistle mine	..		
MANITOBA			
Bowden Lake Nickel Mines Limited, Wabowden,			
Bowden Lake mine	80,000,000	Ni (0.60)	Shaft to be sunk and underground exploration carried out.
Bucko Lake mine	30,000,000	Ni (0.78)	Shaft to be sunk and underground exploration carried out.
SASKATCHEWAN			
National Nickel Ltd., Nemeiben Lake, La Ronge,			
East Zone	5,500,000	Ni (0.34) Cu (0.18)	Surface diamond drilling continuing.
West Zone	8,000,000	Ni (0.23) Cu (0.15)	

TABLE 6

World Production* of Nickel
(short tons)

	1969	1970
Canada	213,611	308,042
New Caledonia	123,460	147,000^e
USSR	115,000^e	120,000^e
Cuba	40,000^e	40,000^e
Australia	12,235	30,860
United States	15,100	15,430
Indonesia	9,810	11,000
Republic of South Africa	9,900	9,800
Greece	6,170	9,300^e
Finland	3,970	5,400
Rhodesia	4,400	4,400
Brazil	1,650	1,650
Poland	1,650	1,650
Other	5,500	5,700
Total	562,456	710,232

Sources: World Metal Statistics, June 1971. For Canada: Statistics Canada.
*Production all forms; ^{e}Estimated.

TABLE 7

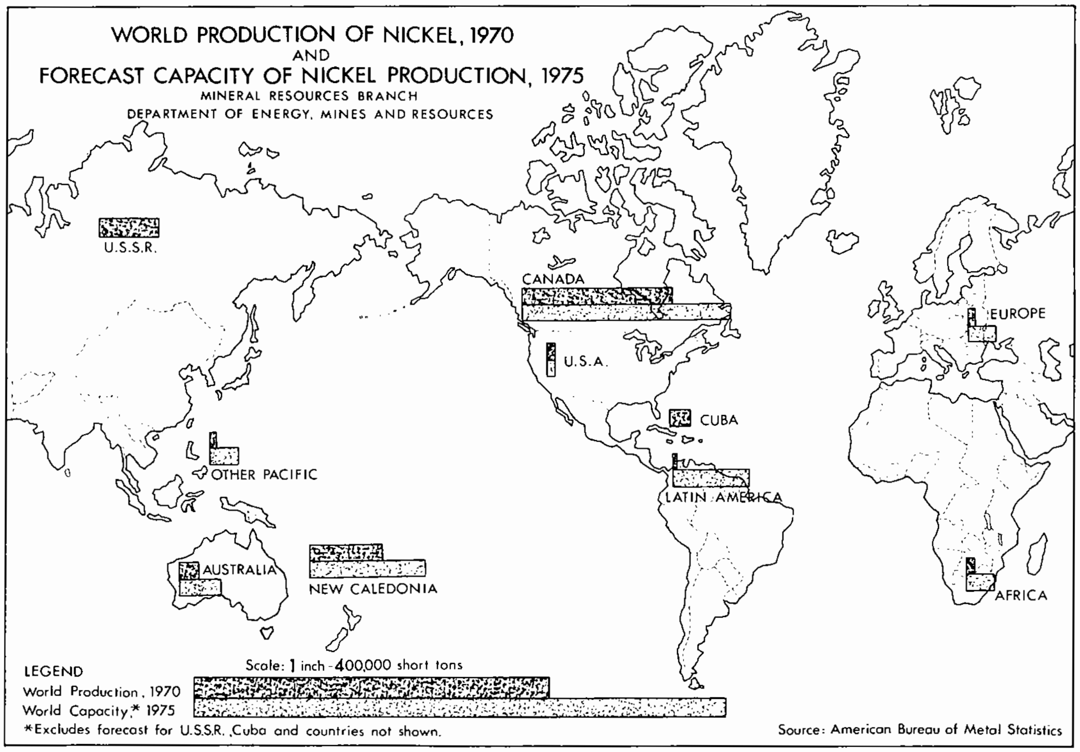
Possible World Nickel Producers

Company	Anticipated Annual Capacity (tons of contained nickel)	Production Could Start	Destination of Concentrates	Remarks
AUSTRALIA				
Freeport of Australia, Inc. and Metals Exploration N.L., Greenvale deposit, Queensland	25,000	. .	. .	
Poseidon N.L., Windarra, Western Australia	30,000	1972	. .	Anglo American Corporation of South Africa supplying finances.
BOTSWANA				
Bamangwato Concessions Ltd., Botswana RST and Foseco Minsep, Selebi-Pikwe	15,000	1973	Port Nickel, Louisiana, USA	
COLOMBIA				
The Hanna Mining Company and Compania Niquel Chevron, Cerro Matoso, Cordoba	18,750	1974	Own smelter	To produce ferronickel.
DOMINICAN REPUBLIC				
Falconbridge Dominicana C. Por A.	35,000	1971	Own smelter	To produce ferronickel.
GREECE				
Intercontinental Mining and Abrasives, Inc. and Southland Mining Company, Lake Ionina	9,000	1974	Own smelter	
GUATEMALA				
Exploraciones y Explotaciones Mineras Izabal, S.A. (Exmibal), The International Nickel Company of Canada, Limited, Lake Izabal	30,000	1975	Own refinery	To produce fire refined nickel.

TABLE 7 (Cont'd)

Company	Anticipated Annual Capacity (tons of contained nickel)	Production Could Start	Destination of Concentrates	Remarks
INDONESIA				
P.T. International Nickel Indonesia, Malili, Sulawesi	50,000	1975	..	
Sulawesi Nickel Development Cooperation Company (Sunideco), Japanese smelting and refining companies, Pomalea, Sulawesi	13,200	1976	Own smelter	To produce ferronickel for export to Japan.
NEW CALEDONIA				
Compagnie Française Industrielle et Minière du Pacifique (Cofimpac), The International Nickel Company of Canada, Limited	50,000	..	Own refinery	Production plans suspended pending financial arrangements.
Penamax G.I.E., Société Minière et Métallurgique de Penarroya, S.A. and American Metal Climax, Inc.	50,000	1975	Own refinery	
New Caledonia Nickel Company, Société Le Nickel and Kaiser Aluminum & Chemical Corporation	49,500	1971	Doniambo refinery	
Société Métallurgique Caledonienne (Someca), Société Le Nickel and The Patino Mining Corporation, Poum	46,000	..	Own smelter	Production plans delayed pending financial arrangements.
REPUBLIC OF THE PHILIPPINES				
Marinduque Mining & Industrial Corporation, Nonoc Island	37,500	Late 1973	Own refinery	Construction Sherritt Gordon-type refinery to produce nickel powder.
Universal Oil Products Company and Rio Tuba Mining Company, Palawan Island	..	..	..	Production being considered.
VENEZUELA				
Universal Nickel Corporation, Loma de Hierro	40,000	1974	Own smelter	
YUGOSLAVIA				
Government Company	12,000	1973	Own smelter	To produce ferronickel.

. . Not available.



WORLD DEVELOPMENTS

World production of nickel rose from 562,456 tons in 1969 to 710,232 tons in 1970. Much of this increase was caused by the resumption of full production in Canada following the strikes at Sudbury in 1969. Most of the remainder came from expanded output from New Caledonia and Australia.

The recent strong growth in the demand for nickel and an increased appreciation of the dependency of world consumers on Canadian supplies have stimulated exploration and development of nickel reserves in other countries. Sulphide deposits are being explored and developed in Africa and Australia but the major activity has been directed to the exploration and development of garnierite and laterite deposits occurring in semi-tropical or tropical areas. Some companies with announced production plans are listed in Table 7. This list is not complete as it does not contain those companies that are expanding their present operations. A summary of expected future production capability from world nickel mines is given in Table 8 below.

These totals may appear small when compared to many other recent forecasts made by various students of the nickel industry, but it must be remembered that the current slow pace of business activity combined with reports of large future overcapacity in nickel production have caused some rethinking to take place on many projects. At the same time, the high cost of borrowing money and the huge amounts of capital needed, not only to build new plants but also to supply the infrastructure (townsites, harbours, transportation) needed in developing countries, makes the possibility of even some of the mines listed in Table 7 coming into production in the year shown somewhat speculative. Production metallurgy raises further questions about the development of certain projects. A lot of money is being invested in plants to treat garnierite and laterite ores using newly developed hydro-metallurgical processes that have been tested only in pilot plants. Bringing some of these plants up to rated capacities will undoubtedly be a slow, painstaking procedure that will make the term "rated capacity" a goal rather than a regular occurrence.

TABLE 8

World* Mine Nickel Production Capacity
(thousands of short tons)

	1971	1972	1973	1974	1975
Canada	336	367	372	402	422
New Caledonia	160	175	175	189	234
Latin America	49	70	73	104	152
Australia	32	41	72	76	82
Europe	17	19	34	50	58
Africa	24	31	43	54	55
Other Pacific	5	7	17	44	54
United States	13	13	14	14	15
Total	636	723	800	933	1,072

Source: Company reports and press clippings.
*Does not include Russia, Poland and other countries as listed in Table 6.

TABLE 9

Free World Nickel Comsumption by Use
(millions of pounds)

	1969^e	1970^e
Stainless steels	320	404
High-nickel alloys	131	135
Nickel plating	115	130
Constructional alloy steels	90	104
Iron and steel castings	74	88
Copper and brass products	24	32
Other	66	92
Total	820	985

Source: The International Nickel Company of Canada, Limited.
^{e}Estimated.

USES

Resistance to corrosion, pleasing appearance, and suitability as an alloying agent are the chief advantages in almost all of the uses of nickel. Stainless steel is the largest single outlet 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, and in architectural applications. High-nickel alloys are used in chemical, marine, electronic, nuclear and aerospace applications.

OUTLOOK

Canadian production of nickel should maintain a steady increase for the next four or five years, although it must be remembered that labour contracts with the major companies at Sudbury come up for renegotiation in 1972. On the world scene, a number of new operations are scheduled for completion through to 1975 and others are waiting to see what shape world economic conditions will take in the short term before large sums of capital are committed. Should business activity in the United States and Japan accelerate appreciably in the near term, production plans for more new mining ventures will be announced.

PRICES

The prices of nickel in its various forms held at the November 1969 level until October 14, 1970 when Inco raised its base price in the United States by approximately 5 cents a pound to $1.33. The effective cost to Canadian customers became $1.36 (Can.). Prices in other markets were adjusted to reflect this increase.

	Canada		United States	
	Jan. 1 – Oct. 13	Oct. 14 – Dec. 31	Jan. 1 – Oct. 13	Oct. 14 – Dec. 31
	(cents a pound)			
Inco, electrolytic, f.o.b. Port Colborne, Ont. and Thompson, Man.	138.0	137.5 (effective 136.0)	128.0	133.0
Falconbridge, electrolytic, f.o.b. Thorold, Ont.	138.0	137.5 (effective 136.0)	128.0	133.0
Sherritt Gordon, briquettes or powder, f.o.b. Niagara Falls, Ont. and Fort Saskatchewan, Alta.	138.0	128.0 (U.S.)	132.0	128.0
Inco, nickel oxide sinter 75	131.5	131.0	122.0	127.0
Inco, nickel oxide sinter 90		132.0	123.0	128.0

TARIFFS

CANADA		British Preferential %	Most Favoured Nation %	General %
Item No.				
35500–1	Nickel, and alloys consisting of 60 per cent or more nickel by weight not otherwise provided for, viz: ingots, blocks and shot; shapes or sections, 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 per cent or more of 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%
35515–1	Metal, alloy strip or tubing, not being steel strip or tubing, consisting of not less than 30 per cent by weight of nickel and 12 per cent by weight of chromium for use in Canadian manufactures	free	free	free
35800–1	Anodes of nickel	free	free	10%
35515–1	Nickel, and alloys containing 60 per cent by weight or more of nickel, in powder form	free	free	free
35520–1	Nickel or nickel alloys, namely: matte, sludges, spent catalysts and scrap, and concentrates other than ores	free	free	free
44643–1	Articles or 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		
601.36	Nickel ore	free
603.60	Nickel matte	free
620.03	Nickel, unwrought	free
620.04	Nickel waste and scrap (duty suspended on or before June 30, 1971)	
	On and after Jan. 1, 1970	0.5¢ per lb
	On and after Jan. 1, 1971	0.2¢ per lb
	On and after Jan. 1, 1972	free
620.30	Nickel flakes	
	On and after Jan. 1, 1970	7¢ per lb
	On and after Jan. 1, 1971	6¢ per lb
	On and after Jan. 1, 1972	5¢ per lb
620.32	Nickel powders	free
620.50	Nickel, electro-plating anodes, wrought or cast, of nickel	
	On and after Jan. 1, 1970	7%
	On and after Jan. 1, 1971	6%
	On and after Jan. 1, 1972	5%

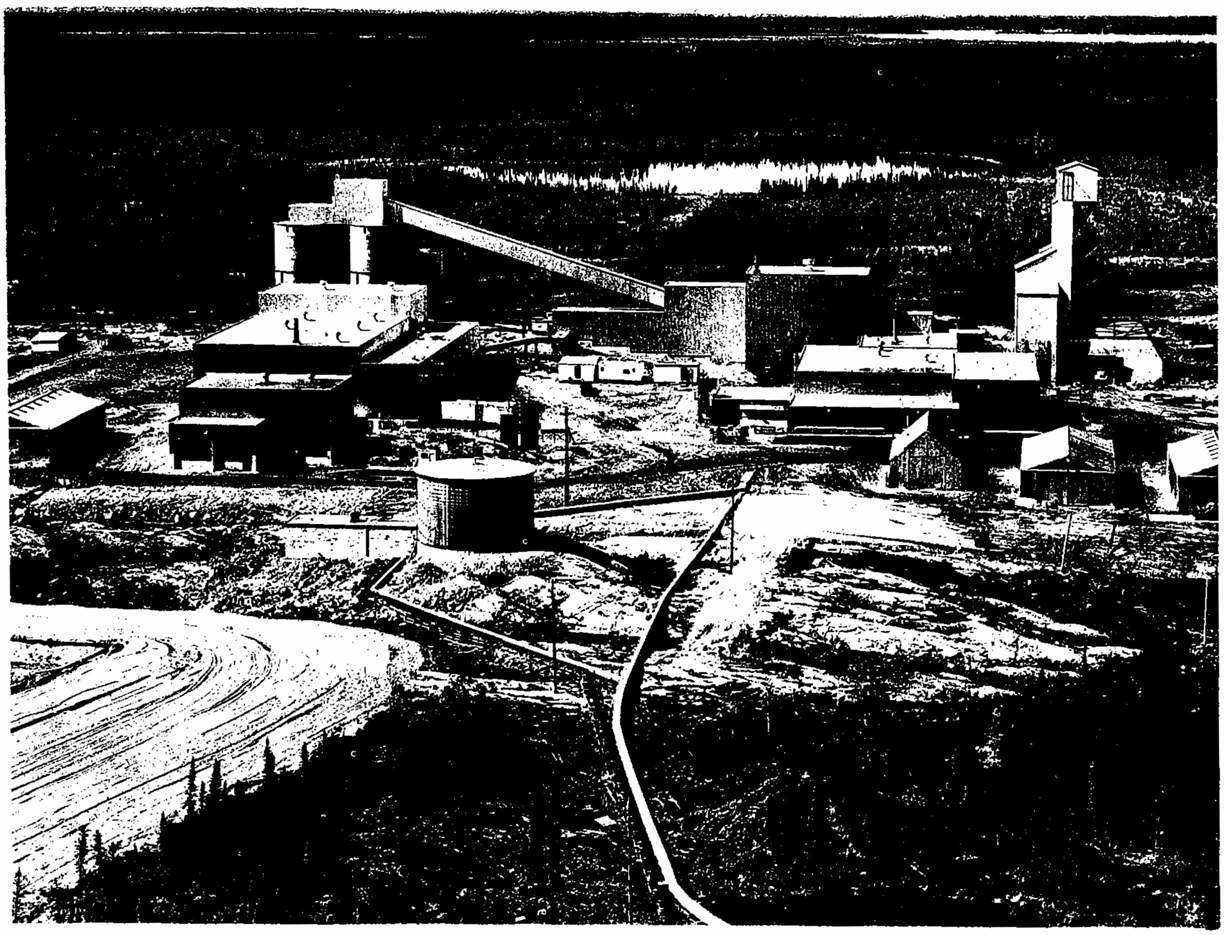
TARIFFS (Cont'd)

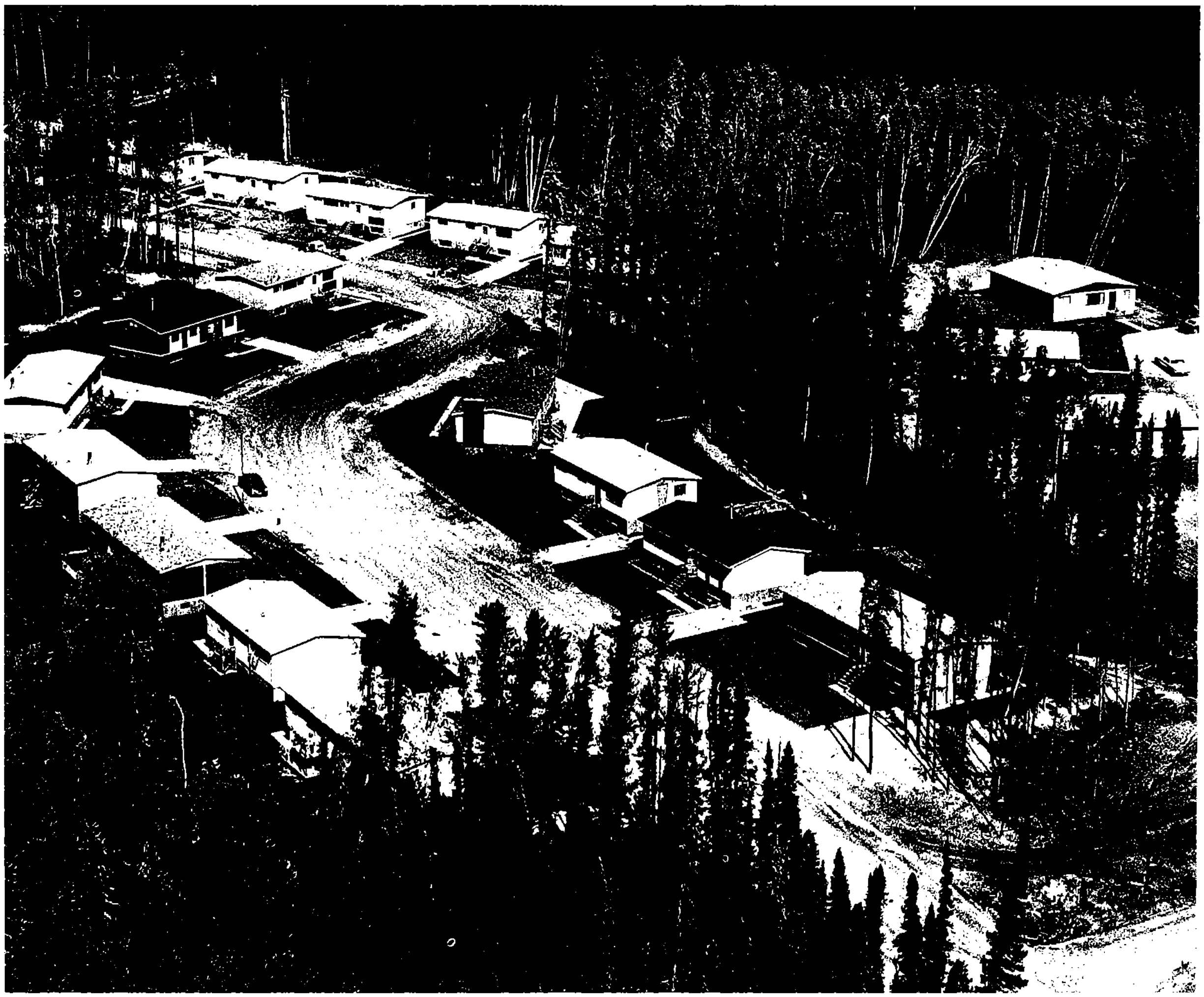
419.72	Nickel oxide	free
607.25	Ferronickel	free
	Note: Various tariffs are in effect on more fabricated forms of nickel and nickel alloys and also on fully manufactured nickel products.	

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 (1970) TC Publication 344.

View of Manibridge mine and concentrator, near Wabowden, Manitoba. (Photo by Hunter)





Townsite, 1 mile south of Manibridge mine, near Wabowden, Manitoba. (Photo by Hunter)

Petroleum

W.G. LUGG*

Three major events in 1970 made the year a favourable one for the Canadian petroleum industry and offered promises for a bright future. First, the producing sector of the oil and gas industry enjoyed one of the most prosperous and productive years in its history, as output of crude oil and natural gas rose to record levels. Revenue from the sale of oil and gas production exceeded $1,637 million. That the industry looked forward with optimism may be judged by the size of the industry expenditures which amounted to $1,435 million in 1970. Second, the expectations for success in Canada's frontier areas began to be realized in 1970 as the tempo of exploration in the Arctic and offshore from eastern Canada quickened. Drilling on the continental margins has not yet produced a commercial discovery but two gas discoveries in the Arctic Islands during 1969 and 1970 are indicative of the future potential of this region. Lastly, consultations between government authorities of the United States and Canada on energy problems continued during 1970 and resulted in the assurance that Canada will increase oil and natural gas liquids exports to the United States in 1971 and subsequent years. Increased access of Canadian crude oil and natural gas liquids to United States markets combined with late-year price increases for crude oil provided additional incentive to explore for and develop Canada's untapped petroleum reserves.

Both pipeline and refinery construction lagged in 1970 but industry activity in these areas is expected to accelerate in 1971. With the prospects for the discovery of large reserves of oil in Canada's remote areas running high, several major pipeline projects from northern areas are under active consideration. In addition, Canada's major pipeline companies will spend a record amount of money in 1971 on new line facilities and in so doing will substantially increase their immediate capability to deliver oil to Canadian and United States markets.

Exports of crude oil and products, all to the United States, increased to 732,000 barrels a day (b/d) and exceeded 1969's daily average by 137,000 barrels. Value of exports of crude oil and products was approximately $732 million. Imports of crude oil and products, at 759,000 b/d continued to exceed exports. However, the gap was narrowed by 108,000 b/d in 1970 from the 1969 level of 135,000 b/d.

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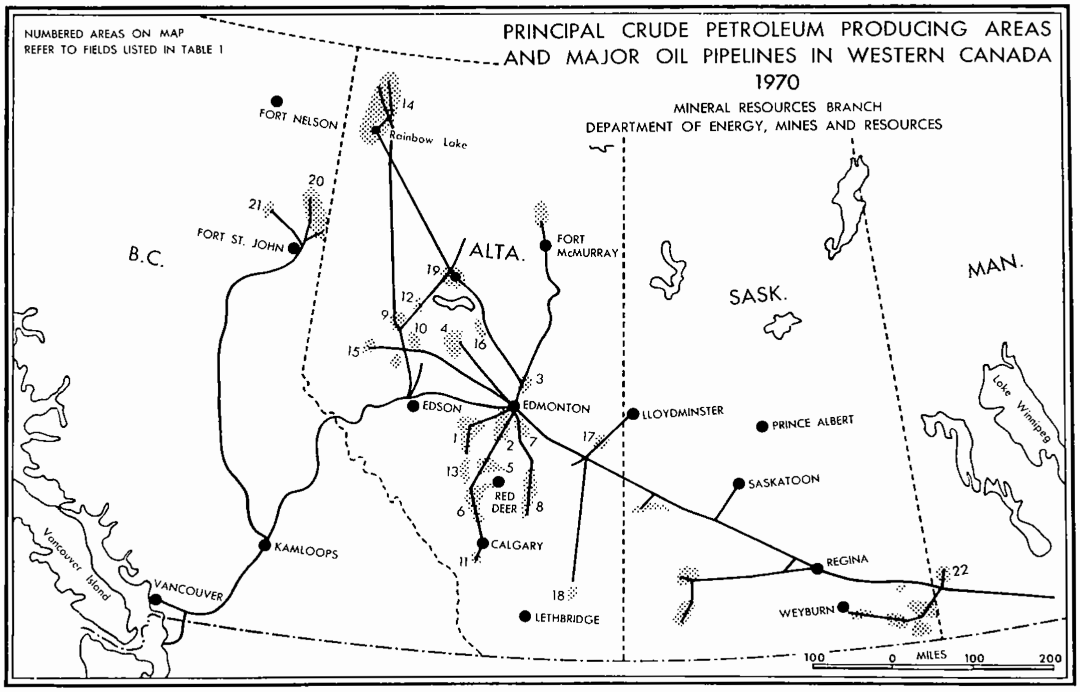


TABLE 1

Production of Crude Oil and Condensate by Province and Field, 1969-70
(number in parentheses gives location of field on the accompanying map)

	1969		1970^p	
	Barrels	Bbl/day	Barrels	Bbl/day
Alberta				
Pembina (1)	43,431,165	118,989	51,069,288	139,916
Swan Hills (4)	26,381,312	72,278	28,086,473	76,949
Rainbow (14)	17,176,446	47,059	22,595,276	61,905
Redwater (3)	18,843,731	51,627	21,159,217	57,969
Judy Creek (4)	13,103,744	35,901	15,842,189	43,403
Golden Spike (2)	14,877,446	40,760	13,617,937	37,309
Bonnie Glen (2)	11,175,105	30,617	13,118,430	36,842
Swan Hills South (4)	10,436,881	28,594	12,555,112	34,396
Mitsue (16)	9,955,408	27,275	11,573,443	31,708
Nipisi (19)	7,110,930	19,482	10,567,624	28,951
Wizard Lake (2)	6,764,094	18,532	10,072,801	27,595
Fenn-Big Valley (8)	6,388,571	17,503	7,147,276	19,582
Leduc-Woodbend	6,132,532	16,801	6,013,875	16,476
Virginia Hills (4)	4,716,629	12,922	5,508,685	15,092
Zama (14)	6,798,233	18,625	5,109,720	13,998
Carson Creek North (4)	3,515,216	9,631	4,774,374	13,080
Willesden Green (13)	3,820,186	10,466	4,405,767	12,071
Sturgeon Lake South	3,698,380	10,133	4,282,954	11,734

TABLE 1 (Cont'd)

	1969		1970[p]	
	Barrels	Bbl/day	Barrels	Bbl/day
Kaybob (10)	3,412,641	9,350	3,987,365	10,924
Virgo (14)	5,563,657	15,243	3,924,825	10,751
Acheson (2)	2,732,605	7,487	3,446,432	9,443
Westerose (2)	2,905,746	7,961	3,441,561	9,427
Rainbow South (14)	2,612,082	7,156	3,025,661	8,289
Bantry (18)	2,313,547	6,338	2,506,655	6,878
Joffre (5)	1,667,185	4,568	2,493,957	6,833
Wainwright (17)	2,273,360	6,228	2,433,744	6,667
Harmattan-East (6)	1,754,277	4,806	2,391,630	6,002
Joarcam (7)	2,061,734	5,649	2,177,209	5,964
Medicine River (13)	1,755,668	4,810	2,096,540	5,744
Innisfail (6)	1,584,094	4,340	2,023,583	5,544
Goose River	1,272,210	3,486	1,746,309	4,783
Clive	1,425,347	3,905	1,680,048	4,602
Kaybob South (10)	1,450,367	3,974	1,908,692	5,229
Gilby (5)	1,370,342	3,754	1,589,341	4,353
Harmattan-Elkton (6)	1,595,436	4,371	1,738,197	4,762
Taber South	1,163,535	3,188	1,462,228	4,005
Red Earth	1,269,786	3,479	1,431,184	3,921
Provost	900,464	2,467	1,380,262	3,782
Simonette (15)	1,269,872	3,479	1,437,830	3,939
Bellshill Lake	659,260	1,806	1,353,158	3,707
Sundre	854,449	2,341	982,862	2,693
Cessford	1,115,027	3,055	1,084,725	2,972
Stettler	1,026,650	2,813	1,078,990	2,956
Turner Valley (11)	1,057,356	2,896	1,079,157	2,957
Other fields and pools	28,618,996	78,408	37,000,655	101,372
Total	290,011,702	794,552	338,403,241	927,132
Total value	$740,435,043		$864,139,002	
Saskatchewan*				
Total	87,413,988	239,490	89,511,262	245,236
Total value	$196,067,467		$201,337,412	
British Columbia				
Boundary Lake (20)	8,914,827	24,424	9,403,953	25,764
Peejay (20)	5,838,825	15,996	5,097,579	13,965
Milligan Creek (20)	3,601,026	9,865	3,912,798	10,719
Inga (21)	2,714,618	7,437	2,504,601	6,861
Other fields and pools	4,317,887	11,831	4,560,042	12,496
Total	25,387,183	69,553	25,478,973	69,805
Total value	$ 58,356,733		$ 58,568,435	
Manitoba				
North Virden-Scallion (22)	2,972,664	8,144	2,895,762	7,934
Virden-Roselea (22)	1,540,576	4,221	1,480,398	4,056
Other fields and pools	1,691,411	4,634	1,533,948	4,202
Total	6,204,651	16,999	5,910,108	16,192
Total value	$ 15,548,929		$ 14,863,684	

TABLE 1 (Cont'd)

	1969		1970P	
	Barrels	Bbl/day	Barrels	Bbl/day
Ontario	1,161,889	3,184	1,048,168	2,871
Total value	$ 3,117,031		$ 2,812,830	
Northwest Territories	801,341†	2,196	846,003†	2,318
Total value	$ 966,898		$ 1,021,170	
New Brunswick	9,176	25	9,303	25
Total value	$ 12,846		$ 12,094	
Total, Canada	410,989,930	1,126,000	461,207,058	1,263,580
Total value	$1,014,570,734		$1,142,754,627	

Sources: Dominion Bureau of Statistics and provincial government reports.
*Saskatchewan lists production by formation rather than by field.
†Net figure after allowing for reinjected products.
PPreliminary.

PRODUCTION

Production of all liquid hydrocarbons–crude oil and natural gas liquids–averaged 1.47 million b/d during 1970, an increase of 168,000 b/d or 12.9 per cent over 1969. Crude oil output alone amounted to 1.26 million b/d, and natural gas liquids reached 217,000 b/d comprised of 121,000 b/d of pentanes plus and condensate, and 96,000 b/d of propane and butane. Alberta production, at 925,000 b/d, which was 17 per cent greater than last year, accounted for 73.2 per cent of the total Canadian crude oil output. Saskatchewan production increased by 6,000 b/d to 244,000 b/d in 1970. Saskatchewan production represented 19.5 per cent of the Canadian total. British Columbia's production remained static at 69,000 b/d and contributed 5.5 per cent to total national production; Manitoba accounted for 1.3 per cent and Ontario, the Northwest Territories and New Brunswick together, 0.5 per cent. All provinces except Alberta were producing crude oil at near capacity. According to the Alberta Oil and Gas Conservation Board, wellhead production capacity in Alberta was 1.6 million b/d which meant that about 58 per cent of the province's productive capability was being utilized at the end of 1970.

Great Canadian Oil Sands Limited's bituminous sands plant at Fort McMurray has been plagued with operating problems since it began to operate in 1967 and this year a maintenance shutdown in August restricted output for three months thereby lowering the annual average production. Nevertheless, in September, production reached a record of 1,560,000 barrels of synthetic crude oil or about 52,000 barrels a day and if this level can be maintained there should be no problem in meeting an authorized annual production of about 16.4 million barrels during 1971. In 1970, average daily production from this plant amounted to 33,000 barrels, well below the allowable production of 45,000 b/d.

Several separate operators of thermal recovery experimental pilot projects in the Cold Lake heavy oil belt suspended operations during 1970. The general consensus of opinion is that although it is technically possible to produce such oil by thermal means, production appears to be uneconomic at the present time. Principal among those suspending operations were Imperial Oil Limited and Great Plains Development Company of Canada, Ltd., two pioneers in thermal recovery research and development in Canada.

RESERVES

In the face of record production levels, Canada's reserves of liquid hydrocarbons declined for the first time since the discovery of oil at Leduc in 1947. The estimates of the Canadian Petroleum Association (CPA) place Canada's reserves of conventional crude oil and natural gas liquids at 10,439 million barrels at the end of 1970. This was comprised of 8,558 million barrels of crude oil and 1,880 million barrels of natural gas liquids. Reserves added in 1970 totalled 440 million barrels and of this amount, 325 million barrels were attributed to revisions, 81 million barrels to extensions of existing fields and only 33 million barrels to new discoveries. Since production exceeded 539 million barrels in 1970, total proven reserves showed a net decline of 99 million barrels for the year. At the 1970 level of production the life index for crude oil and natural gas liquids dropped to 19.3 years

TABLE 2

Production of Natural Gas Liquids by Province, 1969-70

	1969r		1970p	
	Barrels	Bbl/day	Barrels	Bbl/day
Alberta				
Propane	16,758,676	45,914	20,158,510	55,228
Butane	10,994,591	30,122	13,114,578	35,931
Pentanes plus	36,412,082	99,759	41,894,798	114,781
Condensate	722,816	1,980	729,372	1,998
Total	64,888,165	177,775	75,897,258	207,938
Saskatchewan				
Propane	855,041	2,342	796,075	2,181
Butane	347,757	953	351,394	963
Pentanes plus	330,947	907	390,116	1,069
Total	1,533,745	4,202	1,537,585	4,213
British Columbia				
Propane	327,501	897	420,327	1,152
Butane	417,540	1,144	308,664	846
Pentanes plus	944,111	2,587	1,003,138	2,748
Condensate	78,147	214	116,637	320
Total	1,767,299	4,842	1,848,766	5,066
Canada				
Propane	17,941,218	49,154	21,374,912	58,562
Butane	11,759,888	32,219	13,774,636	37,738
Pentanes plus	37,687,140	103,252	43,288,052	118,598
Condensate	800,963	2,194	846,009	2,317
Total	68,189,209	186,819	79,283,609	217,215
Returned to formation	717,699	1,966	671,451	1,840
Total net production	67,471,510	184,853	78,612,158	215,375

Source: Provincial government reports.
pPreliminary; r Revised.

TABLE 3

Value of Natural Gas Liquids by Province, 1969-70 ($ thousands)

	1969	1970p
Alberta	132,224	153,339
Saskatchewan	2,616	2,673
British Columbia	3,079	3,571
Total, Canada	137,919	159,583
Volume (thousand bbl)	66,725	77,595

Source: Dominion Bureau of Statistics.
pPreliminary.

from the indicated 22 year supply in 1969. This is the lowest Canada's reserves life index has been since 1962 when it stood at 19.2 years supply.

The reserve position of all provinces declined, the most notable reduction occurring in Alberta where total reserves dropped by 65 million barrels. The CPA estimated Alberta's remaining recoverable reserves of crude oil at 7,495 million barrels and natural gas liquids at 1,832 million barrels. Together this accounted for about 89 per cent of Canada's proven reserves. Almost all of the additions to reserves recorded in Alberta this year were due to revisions and extensions of existing fields with only minor amounts credited to new discoveries.

Reserve estimates given by the CPA do not include the oil discovered by Imperial Oil Limited at Atkinson

TABLE 4

Crude Oil – Production, Trade and Refinery Receipts, 1960-70
(barrels)

	Production[1]	Imports[2]	Exports[2]	Refinery Receipts[3]		
				Domestic	Imports	Totals
1960	189,534,221	125,559,631	42,234,937	149,259,745	126,824,208	276,083,953
1961	220,848,080	133,249,113	65,222,523	157,182,263	133,225,748	290,408,011
1962	244,115,152	134,517,707	91,580,232	173,606,596	135,364,821	308,971,417
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
1970p	461,207,058	207,633,062	240,893,633	259,252,797	208,335,853	467,588,650

Source: Dominion Bureau of Statistics.

[1]Alberta field condensate is excluded from the statistics for 1960, 1961 and 1962. [2]Trade of Canada (DBS) data. [3] Refinery receipts include condensate and pentanes plus.

pPreliminary.

Point in the Mackenzie Delta as there is insufficient data available to accurately assess the size of this discovery at the present time. Estimates of proved non-conventional reserves were reported as a separate category by the CPA and placed at 6.3 billion barrels. These reserves include only the synthetic crude oil that could be recovered within an "economic radius" of the province's only existing oil sands plant near Fort McMurray, and are based on the concept of the deposits having equivalent or better characteristics than the deposits currently under development. Ultimate recoverable reserves for Athabasca-type oil sands by all known methods of recovery have been estimated by the Alberta Oil and Gas Conservation Board at over 300 billion barrels.

EXPLORATION AND DEVELOPMENT

ALBERTA

Both exploratory and development drilling footages declined in 1970 and this can be attributed to the absence of significant oil discoveries in the province during the past five years and the move to northern areas where drilling is more expensive. Drilling statistics show development drilling declined 12 per cent to 3.3 million feet and exploratory drilling decreased 8 per cent to 4.4 million feet. The reduced rate of exploratory drilling in Alberta during 1970 is significant when it is recalled that these statistics include exploration for gas, which probably enjoyed its most active year. The curtailment in exploratory drilling for oil suggests that the number of new, unexplored structures is declining. Hence it is likely that the rate of provincial reserve growth by new discoveries has reached or is near its peak. However, some discoveries were made.

One of the bright spots in the provincial exploration scene this year was the discovery of the Meekwap D2 (Nisku) field in west-central Alberta. By year-end, five successful wells had been drilled within the designated field boundaries and several other 'step-out' and exploratory wells were being drilled in an attempt to extend the limits of the field. Late in the year, one of these ventures was successful and another D2 discovery was recorded about 4 miles northeast of the field limits. Meekwap was officially designated as an oilfield by the Alberta Oil and Gas Conservation Board in October and at that time, estimated recoverable reserves had been placed at 50 million barrels by industry sources, with prospects of more to come. Another intermediate size discovery appears to be developing 2 miles from the southwestern extremity of the Boundary Lake South field which straddles the British Columbia–Alberta border north of Dawson Creek. At the present time, nine wells have been completed in this area and are unofficially reported to have encountered crude oil in the Boundary Lake sandstone, of Triassic age. Since all of these wells are still on the confidential list, it is still too early to know if this is a separate field or a major southeasterly extension of the Boundary Lake field itself. Nevertheless, in October, the Conservation Board expanded the limits of the Alberta part of the Boundary Lake producing area by an additional 22 sections which included these wells, nearly doubling the previous size of the field. At year-end several

TABLE 5

Year-End Reserves of Crude Oil, 1969-70

Province or Region	1970 (000 barrels)	% of Total 1969	% of Total 1970	Net Change 1970 over 1969 (000 barrels)
Alberta	7,495,567	87.5	87.5	−47,628
Saskatchewan	681,792	8.0	8.0	− 6,417
British Columbia	271,499	3.2	3.2	− 790
Northwest Territories	45,200	0.5	0.5	− 905
Manitoba	59,953	0.7	0.7	− 4,469
Eastern Canada	4,969	0.1	0.1	− 616
Total	8,558,980	100.0	100.0	−60,825

Source: Canadian Petroleum Association.

TABLE 6

Reserves of Liquid Hydrocarbons at End of 1970

	Natural Gas Liquids (000 barrels)	Crude Oil Plus Natural Gas Liquids (000 barrels)	Per Cent of Total
Alberta	1,832,064	9,327,631	89.4
Saskatchewan	10,657	692,449	6.6
British Columbia	37,329	308,828	3.0
Other areas	–	110,122	1.0
Total	1,880,050	10,439,030	100.0

Source: Canadian Petroleum Association.
– Nil.

development projects were under way, many of which were within the expanded boundaries of the field.

In northwestern Alberta, a Devonian Keg River oil discovery was made at Shekilie River, 10 miles northwest of production in the Zama oil field. By the end of the year, drilling of two 'step-outs' had started in an attempt to evaluate the extent of the find. During the past three years several other exploratory wells encountered limited success in the Middle Devonian Muskeg, Keg River, Zama and Bistcho oil and gas-bearing horizons in this region and exploration efforts are expected to be maintained at a moderate level. Elsewhere in the same area, several successful wells have been completed within designated field boundaries, particularly within the Virgo-Zama fields. Most of these discoveries are in small Devonian pinnacle reefs which often turn out to be one-well pools.

In southern Alberta, as in previous years, exploratory drilling continued at a brisk pace and several small Cretaceous sandstone oil reservoirs were discovered. Two discoveries were made in the Glauconitic Zone and follow-up drilling is proceeding in an attempt to extend the limits of these discoveries.

Although most of the development drilling in the province remained concentrated in the Rainbow-Zama area of northwestern Alberta, a considerable amount of development drilling was done in some of the larger fields throughout the province. Much infill drilling was carried out in the Pembina Cardium field and in addition, several wells drilled along the northwest edge of this field encountered commercial production. In west-central Alberta, the Ferrier Cardium oilfield continued to be enlarged as several successful development wells were drilled. In the heavy oil belt which straddles the Alberta–Saskatchewan border, several more successful wells were completed within the Lloydminster and South Chauvin field boundaries and added substantially to their proven reserves.

Several new enhanced recovery schemes were introduced in Alberta during 1970; most of these were waterflood projects. In December of 1970, the Alberta Oil and Gas Conservation Board approved a major integrated sequential waterflood, solvent bank and gas injection enhanced recovery project in the Zama and Virgo oilfields. The scheme covers 25 pools and the injection solvent will consist mainly of methane, ethane, propane and hydrogen sulphide. A gas processing plant will now be built at Zama to supply the gas and miscible flood material for the enhanced recovery schemes. Late in the year, the Board considered an application for another integrated sequential waterflood enhanced recovery scheme in the Zama-Virgo oilfields. This project would cover 15 pools and the system planned would require conversion of depleted wells to injector wells and the return of original injectors to production under a rotation plan.

SASKATCHEWAN

There was little to report about industry activity in Saskatchewan during 1970 as there has not been a

TABLE 7

Wells Completed and Footage Drilled

	1955		1960		1969		1970	
	No.	Footage	No.	Footage	No.	Footage	No.	Footage
WESTERN CANADA								
Westcoast–Offshore								
New field wildcats	–	–	–	–	4	36,923	–	–
Hudson Bay–Offshore								
New field wildcats	–	–	–	–	2	5,143	–	–
British Columbia								
New field wildcats	34	194,014	60	365,818	41	244,009	43	252,896
Other exploratory	2	13,020	11	55,749	34	182,448	53	245,985
Development	–	–	72	331,740	31	421,426	81	401,051
	36	207,034	143	753,307	166	847,883	177	899,932
Alberta								
New field wildcats	307	1,773,980	338	2,078,876	421	2,202,319	282	1,625,921
Other exploratory	105	436,941	223	1,171,079	581	2,656,533	740	2,825,799
Development	1,208	6,219,810	1,131	7,125,856	841	3,737,169	802	3,325,273
	1,620	8,430,731	1,692	10,375,811	1,843	8,596,021	1,824	7,776,993
Saskatchewan								
New field wildcats	312	1,182,727	113	468,507	231	772,464	110	308,474
Other exploratory	50	179,511	28	99,203	393	1,151,190	285	772,530
Development	550	1,873,040	461	1,795,968	538	1,728,425	538	1,398,639
	912	3,235,278	602	2,363,678	1,162	3,652,079	933	2,479,643
Manitoba								
New field wildcats	59	174,313	10	30,505	15	39,627	12	37,365
Other exploratory	10	23,743	3	6,370	41	43,002	2	5,344
Development	292	647,379	54	110,073	26	63,318	5	12,017
	361	845,435	67	146,948	82	145,947	19	54,726
Territories								
New field wildcats	9	12,266	32	105,969	56	274,401	69	355,383
Other exploratory	–	–	–	–	–	–	1	6,327
Development	–	–	–	–	–	–	–	–
	9	12,266	32	105,969	56	274,401	70	361,710

TABLE 7 (Cont'd)

	1955		1960		1969		1970	
	No.	Footage	No.	Footage	No.	Footage	No.	Footage
Total, Western Canada								
New field wildcats	718	3,337,300	553	3,049,675	770	3,574,886	516	2,580,039
Other exploratory	167	653,215	265	1,332,401	1,049	4,033,173	1,023	3,855,985
Development	2,050	8,740,229	1,718	9,363,637	1,496	5,950,338	1,484	5,136,980
	2,935	12,730,744	2,536	13,745,713	3,315	13,558,397	3,023	11,573,004
EASTERN CANADA								
Eastcoast–Offshore	–	–	–	–	1	13,085	14	149,220
New field wildcats	–	–	–	–	1	13,085	–	–
Ontario								
New field wildcats	64	112,246	39	68,393	128	275,074	61	132,739
Other exploratory	57	92,536	55	109,839	26	42,495	10	14,413
Development	266	271,191	213	228,190	64	86,437	98	160,990
	387	475,973	307	406,422	218	404,006	169	308,142
Quebec								
New field wildcats	9	10,226	5	4,287	3	21,023	4	35,757
Other exploratory	–	–	–	–	–	–	–	–
Development	–	–	1	240	–	–	–	–
	9	10,226	6	4,527	3	21,023	4	35,757
New Brunswick								
New field wildcats	1	3,414	2	13,023	–	–	–	–
Other exploratory	–	–	–	–	–	–	–	–
Development	7	21,143	–	–	–	–	–	–
	8	24,557	2	13,023	–	–	–	–
Nova Scotia								
New field wildcats	–	–	1	9,840	–	–	–	–
Other exploratory	–	–	–	–	–	–	–	–
Development	–	–	–	–	–	–	–	–
	–	–	1	9,840	–	–	–	–
Newfoundland								
New field wildcats	1	1,381	–	–	–	–	–	–
Other exploratory	–	–	–	–	–	–	–	–
Development	–	–	–	–	–	–	–	–
	1	1,381	–	–	–	–	–	–
Total, Eastern Canada								
New field wildcats	75	127,267	47	95,543	132	309,182	79	317,716
Other exploratory	57	92,536	55	109,839	26	42,495	10	14,413
Development	273	292,334	214	228,430	64	86,437	98	160,990
	405	512,137	316	433,812	222	438,114	187	493,119
Total, Canada								
New field wildcats	793	3,464,567	600	3,145,218	902	3,884,068	595	2,897,755
Other exploratory	224	745,751	320	1,442,240	1,075	4,075,668	1,092	3,870,398
Development	2,323	9,032,563	1,932	9,592,067	1,560	6,036,775	1,582	5,297,970
Total	3,340	13,242,881	2,852	14,179,525	3,537	13,996,511	3,210	12,066,123

Source: Canadian Petroleum Association.

– Nil.

TABLE 8

Canada, Wells Drilled, by Province, 1969-70

	Oil		Gas		Dry*		Total	
	1969	1970	1969	1970	1969	1970	1969	1970
Western Canada								
Alberta	464	304	437	617	942	903	1,843	1,824
Saskatchewan	528	469	42	63	592	401	1,162	933
British Columbia	42	36	43	50	81	91	166	177
Manitoba	15	2	–	–	67	17	82	19
Yukon and N.W.T.	–	1	2	1	54	68	56	70
Westcoast-offshore	–	–	–	–	4	–	4	–
Hudson Bay-offshore	–	–	–	–	2	–	2	–
Sub-total	1,049	812	524	731	1,742	1,480	3,315	3,023
Eastern Canada								
Ontario	5	10	49	63	164	96	218	169
Quebec	–	–	–	–	3	4	3	4
Atlantic Provinces	–	–	–	–	–	–	–	–
Eastcoast–offshore	–	–	–	–	1	14	1	14
Sub-total	5	10	49	63	168	114	222	187
Canada	1,054	822	573	794	1,910	1,594	3,537	3,210

Source: Canadian Petroleum Association.

*Includes suspended wells.

– Nil.

significant oil discovery made in Saskatchewan for several years. As a result, not only development drilling but exploratory drilling is beginning to show an accelerated rate of decline. In 1970, only minor oil accumulations were discovered around the peripheries of established fields, particularly in the southwestern corner of the province where drilling activity has remained relatively stable. The most noteworthy of these was a Jurassic oil discovery made in the vicinity of Gardenhead, 2½ miles west of the Butte field. The size and extent of this find has not yet been determined.

Development in the Plato, Viking sandstone pool in western Saskatchewan is still proceeding but at a subdued rate. The thinness of pay and unpredictable distribution of porosity in the producing formation have necessitated a 'go-slow' approach in the development of this field. Nevertheless, a few wells have encountered commercial production at the extremities of the established producing area.

After the discovery of Middle Devonian oil at Rainbow Lake in Alberta in 1965 a revitalized exploration program in Saskatchewan was undertaken with the Middle Devonian Winnipegosis reefs being the primary targets. After five years of extensive exploratory drilling, companies have failed to find any indications of commercial oil or gas. The lack of success in exploring this deep prospect contributed to the sharp, 44 per cent decline in exploratory drilling in Saskatchewan, during 1970 as the industry believes that the Winnipegosis is the last major formation that warranted industry-wide interest in this region.

Most of the development drilling was confined to western Saskatchewan where fields in the heavy oil belts of Lloydminster and Rapdan are still being actively expanded. In the Lloydminster area of northwestern Saskatchewan, the Dulwich, Silverdale, and Big Gully fields in particular were enlarged by development drilling while the Butte and Gull Lake fields in the Jurassic trend of southwestern Saskatchewan had some minor extensions.

MANITOBA

Both development and exploratory drilling declined to the lowest level since the province's initial oil discovery was made in the early 1950's. Aggregate drilling totalled 55,000 feet compared to 146,000 feet in 1969. In Manitoba as in Saskatchewan, the lack of success in finding reserves in pre-Mississippian rocks has contributed to a steadily declining discovery rate in the past 15 years. All of the province's oil reserves are contained in Mississippian formations which form the northeasterly extremity of the Williston Basin. The only remaining unexplored area with a potential for significant accumulations of oil and gas is located in the northeastern corner of the province on the west flank of the Hudson Bay Basin. A core hole was scheduled to be drilled in the vicinity of York Factory early in 1971 to evaluate a fairly thick sequence of Lower Palaeozoic rocks that outcrop in this area. The results of this test have not yet been released.

BRITISH COLUMBIA

Drilling footage increased slightly in 1970 from the previous year but this was due mainly to exploration and development of the province's natural gas resources encouraged by the growing export and domestic markets for this commodity. There has not been a significant oil discovery in British Columbia for over three years and as a result oilfield development drilling has declined to a negligible amount, being restricted to the existing fields which have already reached a near maximum degree of development. However, early in 1971, unofficial industry reports indicate that a significant Triassic oil discovery has been made in the Flatrock area of northeastern British Columbia. No details as to discovery zones or pay thicknesses have been released. A test well drilled in the Bowser Basin of the northwestern interior of British Columbia was fully evaluated and abandoned in 1970 after encountering non-commercial indications of gas. In the offshore area of western Canada, Shell Canada Limited completed its drilling program in 1969 and since that time industry interest in this area has not been revived.

YUKON TERRITORY, NORTHWEST TERRITORIES AND ARCTIC ISLANDS

The shift in exploration activity from the Prairie Provinces to the North become more prominent in 1970–sparked by two spectacular discoveries; one being oil at Atkinson Point on the mainland and the other gas on King Christian Island. Neither of these discoveries are likely to have an immediate effect on development drilling or production but they do point up the future potential of this region. Aggregate drilling, all exploratory in northern regions increased by 32 per cent to 362,000 feet in 1971 and is a measure of the increased interest in this region. The Atkinson Point discovery was made in early 1970, in a formation of Cretaceous age. Subsequent step-out drilling was unsuccessful indicating that the discovery was not of major proportions, but details as to reservoir thickness and potential reserves have not yet been made public by the operating company. Nine other wells were drilled in the Mackenzie River Delta area during 1970, all of which were unsuccessful. However, by year-end, drilling had begun on five new exploratory wells with several more scheduled, the results of which could have a very significant bearing on the future trend of exploratory drilling in this area.

Farther north, Panarctic Oils Ltd. is now in its third season of the costly search for oil and gas in the Arctic Islands. Panarctic is an industry-government company consisting of 20 companies in partnership with the federal government, which holds a 45 per cent financial interest in the organization. To the end of 1970, about $50 million had been spent on exploration programs which had yielded two large gas discoveries–the first on Melville Island in 1969 and the second late in 1970 on King Christian Island. A 'blow-out' and subsequent fire occurred during drilling operations on the King Christian well. It took three months in time and a large investment in men and equipment to bring the wild well under control. The original rig was completely destroyed and a new rig had to be flown into the site to drill the relief well necessary to bring the well under control. Plans call for deepening the relief well in order to quickly evaluate the gas bearing sand and when this is done, bring in a larger rig to drill to the original projected depth of 10,000 feet. Although it is too early to estimate the magnitude of the discovery, industry officials say that it could be one of the largest natural gas reservoirs discovered in Canada. Five other wells drilled in the Arctic Islands during 1970 were dry and abandoned. By the end of 1970 four drilling projects were under way, including a joint venture on Bathurst Island on land leased from Panarctic, and a well on Mackenzie King Island being drilled by Elf Oil Exploration and Production Canada Ltd. Two other 'wildcats', one by Panarctic and the second a Sun Oil Company–King Resources Company joint venture, have commenced drilling on Amund Ringnes and Melville Islands respectively. The current level of exploratory activity in the Arctic Islands is expected to increase in tempo with plans being finalized for several more drilling ventures later in 1971.

EASTERN CANADA

In Ontario, total footage drilled amounted to 308,000 feet–a 24 per cent decrease over 1969. Exploratory drilling accounted for 47 per cent of the total, down 53 per cent from the previous year. The decrease in drilling is partially attributable to the recent ban placed by the Ontario government on drilling for and producing oil in Lake Erie. Three unevaluated oil discoveries had been made in Lake Erie before the restrictions were enforced and are now shut-in. Elsewhere in Ontario, a fairly significant oil discovery was made in Essex County where a well drilled there encountered commercial production in the Ordovician dolomites of the Trenton formation. A follow-up well to this success was drilling at the end of the year.

In Quebec, four exploratory wells were drilled, one on Anticosti Island and the others on the Gaspé Peninsula. All were dry and abandoned. Late in 1970 Husky Oil Ltd. announced its intention to drill two tests in the Trois-Rivières region.

In 1970 the Quebec government incorporated its own oil and gas company, La Société Québécoise d'Initiatives Pétrolières (SOQUIP). The company has embarked on an exploration program in eastern

TABLE 9

Oil Wells in Western Canada at End of Year 1969-70

	Producing Wells		Wells Capable of Production	
	1969	1970	1969	1970
Alberta	9,381	9,383	13,897	13,971
Saskatchewan	6,200	6,175	7,095	7,287
Manitoba	745	730	923	904
British Columbia	515	529	614	620
Northwest Territories	33	44	66	63
Total	16,874	16,861	22,595	22,845

Sources: Provincial and federal government reports.

Canada with an allocated budget of $15 million to be spread over the next ten years. It is intended that SOQUIP's program will encourage exploratory interest in both the Gaspé and Gulf of St. Lawrence areas.

In the Maritimes region, Shell Canada Limited completed the 13th well in its extensive offshore drilling program in the Atlantic off Nova Scotia and at year-end was drilling its 14th and 15th. However, none of the wells have made a commercial discovery. In 1970, Shell used two semi-submersible rigs in their two-year drilling program, one of which was constructed in Halifax shipyards. In 1971, the Amoco Canada Petroleum Company Ltd.–Imperial Oil Limited team will start a two-year drilling program on a large block of Amoco acreage on the Grand Banks off Newfoundland, using the Sedco I semi-submersible rig recently built in the Halifax shipyards. At least four other companies are tentatively committed to drilling programs in this area in 1971, if they can obtain suitable drilling rigs. Tenneco Oil and Minerals, Ltd. plan a two-well program on their acreage in the waters off the Labrador coast. Mobil Oil Canada, Ltd. is understood to have two tests scheduled for 1971, one a well on Sable Island and the other in the offshore area about 100 miles northwest of Sable Island. The second well will be drilled by one of the rigs now under contract to Shell. In addition, Hudson's Bay Oil and Gas Company Limited and Canadian Fina Oil Limited which completed one well off Prince Edward Island in 1970 and suspended a second test, may continue their program in 1971. With all this activity, and because of the favourable geology, it would seem probable that it is only a question of time before a commercial discovery is made in this offshore area of eastern Canada.

TRANSPORTATION

Oil and product pipeline construction again lagged in 1970 as only 583 miles of new pipeline were added to the pipeline system. Most of the large diameter pipeline construction this year was restricted to natural gas transmission. However, Interprovincial Pipe Line Company expanded the capacity of its main trunk line by 135,000 b/d but most of this increase was accomplished by the installation of several intermediate pumping stations. In addition, 20 miles of 20-inch parallel pipeline was added to the Ontario section of the line between Sarnia and Port Credit, Ontario.

TABLE 10

Mileage in Canada of Pipelines for Crude Oil Natural Gas Liquids and Products

Year-end	Miles	Year-end	Miles*
1956	6,051	1963	10,607
1957	6,873	1964	11,744
1958	7,148	1965	12,315
1959	7,945	1966	15,705
1960	8,435	1967	16,863
1961	9,554	1968	17,550
1962	10,037	1969	18,055
		1970p	18,588

Source: Dominion Bureau of Statistics.

*Includes producers' gathering lines for years 1966 to 1970.

pPreliminary.

Probably the most significant oil pipeline construction in 1970 was the twin line built for Murphy Oil Company Ltd. from Lone Rock in the Lloydminster field to Kerrobert, Saskatchewan on the Interprovincial trunk line. A 4-inch line carries the condensate from the Interprovincial pipeline at Kerrobert, Saskatchewan to Lone Rock where it is blended with the heavy crude oil from the Lloydminster field to make it lighter and capable of being transported by pipeline. A 10-inch line returns the blend to Kerrobert pumping station where it enters the Interprovincial main line for transport east. The right-of-way distance is 100 miles and the system is similar to the one Husky developed from 1963 to 1969 to ship its Lloydminster crude oil, except the connection with Interprovincial is at Hardisty, Alberta.

TABLE 11

Deliveries of Crude Oil and Propane
by Company and Destination, 1969-70
(millions of barrels)

Company and Destination	1969	1970
Interprovincial Pipe Line		
Western Canada	40.7	42.5
United States	114.3	147.4
Ontario	128.2	138.9
Total	283.2	328.8
Trans Mountain Oil Pipe Line		
British Columbia	30.6	35.6
State of Washington	78.7	81.8
Westridge Terminal	3.3	4.2
Total	112.6	121.6

Source: Company annual reports.

Construction of Gulf Oil Canada Limited's major products pipeline system in Alberta was completed in 1970. This 10-inch pipeline is 193 miles long and will carry finished products from Gulf's new 80,000 b/d Edmonton refinery southward to terminals in Red Deer and Calgary. The refinery is scheduled for completion in mid-1971. The remainder of the refinery's products slated for other Prairie centres will be shipped via Interprovincial pipeline to terminals along the route. In this connection, Interprovincial will convert its original 20-inch line out of Edmonton exclusively to products and gas liquids, using the larger lines for crude oil. Pembina Pipe Line Ltd. completed 26 miles of 16-inch loop between Calmar and Aleske to raise the capacity of its main crude oil pipeline from the Pembina field to Edmonton. Late in the year, Imperial Oil Limited completed 37 miles of 6-inch line to carry condensate and liquid petroleum gases from the Quirk Creek gas processing plant to the Dome Petroleum Limited pipeline terminal at Cochrane. Several new field gathering lines and extensions to existing systems were completed this year. Sixty miles of 4.5-inch pipeline were added late last year to the Federated pipeline system to link the Meekwap field to the main line system.

The location of possible large resources in the frontier areas of the country far removed from potential markets has created problems for the transportation sector of the industry. The extent to which these problems will be resolved in the next decade will largely determine the degree to which future development will take place. The challenge has been readily accepted by both industry and government with the result that transportation research is being steadily accelerated both for Arctic and offshore regions. Mackenzie Valley Pipe Line Research Limited, comprised of several oil and pipeline companies, was formed to investigate problems unique to pipeline construction in Arctic regions. A 2,000 foot section of 48-inch pipeline was laid in an area near Inuvik, Northwest Territories during 1969 and tests are still being carried out and additional associated studies will be undertaken. One of the principal problems in Arctic areas relates to the permafrost that exists in the north and although research has been done to demonstrate that technically, pipelines can be built without unduly disturbing the permafrost, there is still more investigation required to ensure that the financial and environmental aspects can be accommodated. Cost of this research project is expected to reach $15 million. A similar research project was initiated by Trans-Canada Pipe Lines Limited and five United States companies when they formed the Northwest Project Study Group to conduct a $12 million study on the feasibility of building a 2,500 mile gas pipeline from the Prudhoe Bay area in Alaska to connect with existing pipelines on the Canada–United States border near Emerson, Manitoba. In anticipation of accelerated pipeline construction activity in Canada's northern areas, the Government of Canada announced guidelines in August for companies engaged in planning these new enterprises. Seven preliminary guides governing pipeline construction and operations in northern areas were outlined and cover questions of ownership, operation and ecological safeguards. Initially only one oil trunk line and one gas trunk line will be approved with the government specifying the corridor through which they may be built.

With respect to pipeline tariffs, Bow River Pipe Lines Ltd. increased rates on the main line movement of oils between Fincastle Station and Hardisty terminal amounting to 3 cents a barrel. On the other hand, gathering rate for many of the fields served by Bow River was reduced 2 cents a barrel.

Westspur Pipe Line Company introduced new tariff changes effective July 1, 1970. The trunk line tariff to Cromer from Midale and Steelman terminals was increased by ½ to 1 cent a barrel. In addition, many of the tariff areas in its gathering system received reduction of ½ to 3½ cents a barrel–a few had tariffs increased.

PETROLEUM REFINING

Crude oil refining capacity of Canada's 40 operating refineries totalled 1,352,250 b/d in 1970,

TABLE 12

Crude Oil Refining Capacity by Regions

	1969		1970	
	Bbl/day	%	Bbl/day	%
Atlantic Provinces	132,600	10.2	135,100	9.9
Quebec	449,600	34.6	460,600	34.1
Ontario	367,000	28.3	389,200	28.8
Prairies and Northwest Territories	236,950	18.3	241,550	17.9
British Columbia	111,700	8.6	125,800	9.3
Total	1,297,850	100.0	1,352,250	100.0

Source: Department of Energy, Mines and Resources, Petroleum Refineries in Canada (Operator's List 5), January 1970.

an increase of 54,400 b/d over 1969. This represents a gain of about 4 per cent over 1969 in the industry's capability to refine crude oil, and is 2 per cent less than the overall increase in demand for petroleum products during the year.

Although refinery capacity increase was small in 1970, major projects nearing completion and future prospects for new refinery construction have assured significant growth in plant capacity during the next few years. In the Atlantic Provinces, the 60,000 b/d refinery that Gulf Oil Canada Limited is building at Point Tupper, Nova Scotia came on stream late in the year and is expected to be fully operational early in 1971. This plant is of relatively basic design, being intended to serve the local market for residual and light fuel oils in addition to the export market for high octane gasoline and jet fuel. In New Brunswick, it is anticipated that the expansion program at Irving Refining Limited's Saint John refinery should be completed by the end of 1971. Capacity will be increased by 45,000 b/d to 100,000 b/d. Newfoundland Refining Company Limited's proposed 100,000 b/d plant at Come-by-Chance is not scheduled for completion before 1973. Financial arrangements have been completed and the federal government has agreed to build a $16 million deep water terminal at the refinery site capable of handling vessels of up to 350,000 tons. The plant is expected to use Middle East crude oil for feedstock and the principle product will be jet fuels for delivery by smaller product tankers to eastern United States aviation centres where it will be sold in bond to international air carriers.

Construction is now well advanced on Golden Eagle Canada Limited's 100,000 b/d refinery near Quebec City. The refinery is scheduled to start-up by the middle of 1971 and Venezuela and Libya will provide most of the feedstock. At the present time, the 1,600-foot causeway being constructed for docking purposes is almost complete and will receive its first cargo of crude oil in April.

When all of these projects come on stream in Quebec and the Maritimes, total capacity of refineries using imported oil will amount to 900,000 b/d.

On the Prairies, Gulf Oil Canada Limited is well advanced in the major reorganization of its refinery operation started in 1969 when it closed its 3,600 b/d Brandon, Manitoba plant. Their Saskatchewan refinery is scheduled to be closed in the third quarter of 1971 and the Moose Jaw and Calgary refineries will be converted to asphalt plants shortly afterwards. Capacities of these three plants total about 30,000 b/d and they will be replaced by an 80,000 b/d refinery now under construction at Edmonton which is scheduled to go on stream in 1971. When this new plant is completed, the existing 12,600 b/d Gulf refinery at Edmonton will also be closed down. The new refinery is designed to be the supply source for Gulf's prairie marketing network and will produce mainly gasoline and other light oil products. Products will be transported east from Edmonton by Interprovincial Pipe Line Company and south to the Calgary area by a new 10-inch product pipeline completed recently.

Imperial Oil Enterprises Ltd. remained the largest refiner in Canada. The company's nine refineries comprise 33 per cent of Canadian refinery capacity. Shell Canada Limited's six plants constitute 18 per cent of Canadian refinery capacity and Gulf Oil Canada Limited, third largest refiner, operates nine refineries which account for 15 per cent of the total.

TABLE 13

Canada, Crude Oil Received at Refineries, 1969 and 1970p
(barrels)

Location of Refineries	Year	Canada	Middle East	Trinidad	Venezuela	Africa	Colombia	U.S.A.	Total Received
		COUNTRY OF ORIGIN							
Atlantic Provinces	1969	–	14,127,172	–	31,469,117	–	–	–	45,596,289
	1970p	590	13,926,789	–	36,035,231	–	233,113	–	50,195,723
Quebec	1969		36,995,222	2,531,778	94,458,226	8,396,719	1,871,763	207,513	144,461,221
	1970p		35,792,591	220,370	96,596,608	17,782,046	7,290,509	–	157,682,124
Ontario	1969	124,396,543	–	–	421,571	–	–	–	124,818,114
	1970p	135,178,201	–	–	458,596	–	–	–	135,636,797
Prairies	1969	78,036,523	–	–	–	–	–	–	78,036,523
	1970p	79,278,406	–	–	–	–	–	–	79,278,406
British Columbia	1969	38,847,588	–	–	–	–	–	–	38,847,588
	1970p	43,903,051	–	–	–	–	–	–	43,903,051
Northwest and Yukon Territories	1969	754,090	–	–	–	–	–	–	754,090
	1970p	892,549	–	–	–	–	–	–	892,549
Total	1969	242,034,744	51,122,394	2,531,778	126,348,914	8,396,719	1,871,763	207,513	432,513,825
	1970p	259,252,797	49,719,380	220,370	133,090,435	17,782,046	7,523,622	–	467,588,650

Source: Dominion Bureau of Statistics, Refined Petroleum Products.
pPreliminary; – Nil.

TABLE 14

Regional Consumption of Petroleum Products by Province, 1970
(thousand barrels)

	Motor Gasoline	Kerosene Stove Oil Tractor Fuel	Diesel Fuel Oil	Light Fuel Oils Nos. 2 and 3	Heavy Fuel Oils Nos. 4, 5 and 6
Newfoundland	2,348	1,321	2,410	2,577	6,121
Maritimes	10,863	3,316	4,257	10,647	17,420
Quebec	42,168	6,349	8,124	39,417	47,024
Ontario	60,401	3,475	10,773	38,322	28,739
Manitoba	7,796	1,155	2,873	1,924	1,059
Saskatchewan	9,862	1,170	4,102	1,592	499
Alberta	16,594	550	6,202	891	509
British Columbia	16,598	1,637	7,690	5,950	8,365
Northwest and Yukon Territories	324	101	882	271	115
Total	167,314	19,074	47,313	101,591	109,851

Source: Dominion Bureau of Statistics, Refined Petroleum Products monthly reports, 1970.

MARKETING AND TRADE

Crude oil consumption by Canadian refineries totalled 1,279,000 b/d in 1970 or 8 per cent more than in 1969. Domestic crude oil made up 55.4 per cent of the total crude received at refineries, about 7 per cent more than the daily average in 1969. Most of the increased demand for domestic production by Canadian refineries occurred in Ontario and British Columbia. Refinery receipts of domestic crude oil in Ontario amounted to 371,000 b/d, more than half of all the domestic crude oil consumed in Canada and about 9 per cent greater than last year's consumption. British Columbia's consumption of crude oil rose 13 per cent to 120,000 b/d. Prairie consumption increased by less than 3 per cent to 217,000 b/d.

Imports of crude oil averaged 568,000 b/d in 1970, up 7.2 per cent from 1969. Venezuela was again the

TABLE 15

Exports and Imports of Refined Petroleum Products, 1969-70
(millions of barrels)

	Exports		Imports	
	1969	1970p	1969	1970p
Propane and butane	15.88	20.88	0.77	0.33
Aviation gasoline	0.01	0.01	0.19	0.12
Motor gasoline	0.70	0.87	6.02	5.08
Aviation turbo fuel	0.07	0.20	4.73	3.65
Kerosene, stove oil and tractor fuel	0.09	0.13	2.28	1.54
Diesel fuel oil	0.50	0.67	5.15	7.63
Light fuel oil (Nos 2 and 3)	1.56	2.62	13.09	10.86
Heavy fuel oils (Nos 4, 5 and 6)	0.43	0.50	33.24	34.71
Asphalt	0.16	0.16	0.37	0.46
Petroleum coke	0.01	0.03	3.38	3.74
Lubricating oils	–	–	1.68	1.14
Other products	0.55	0.55	2.17	0.89
Total all products	20.00	26.62	73.07	70.15

Source: Dominion Bureau of Statistics.

pPreliminary.

TABLE 16

Supply and Demand of Oils, 1969-70
(thousand barrels)

	1969r	1970p
SUPPLY		
Production		
Crude oil and condensate	410,990	461,207
Other natural gas liquids	66,725	77,941
Net production	477,715	539,148
Imports		
Crude oil	193,125	207,633
Products	73,074	70,148
Total imports	266,199	277,781
Change in stocks		
Crude and natural gas liquids	−3,499	−3,675
Refined petroleum products	−1,545	−2,679
Total change	−5,044	−6,354
Oils not accounted for	−2,933	+2,351
Total supply	735,937	812,926
DEMAND		
Exports		
Crude oil	197,341	240,894
Products	20,008	26,619
Total	217,349	267,513
Domestic sales		
Motor gasoline	157,983	166,146
Middle distillates	169,983	175,954
Heavy fuel oil	102,110	106,283
Other products	53,247	59,448
Total	483,323	507,831
Uses and losses		
Refining	33,118	35,253
Field, land and pipeline	2,147	2,329
Total	35,265	37,582
Total demand	735,937	812,926

Sources: Dominion Bureau of Statistics, and provincial government reports.

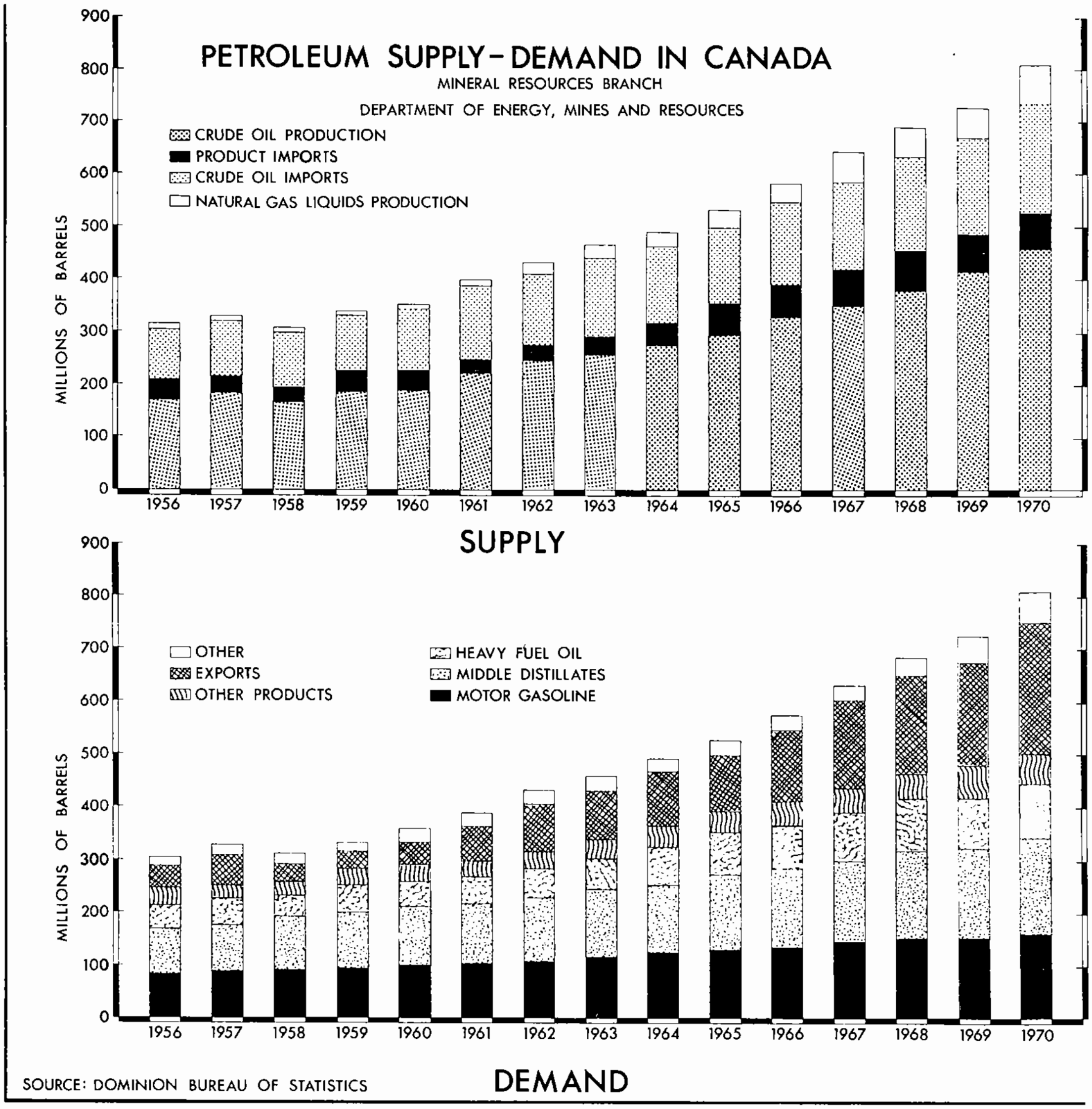
rRevised; pPreliminary.

main source of imported crude, increasing its exports to Canada by 5.5 per cent to 365,000 b/d. Nigeria continued to expand its market growth in this country, almost doubling its 1969 exports of crude oil to Canada to 49,000 b/d. This was anticipated following the cessation of the internal conflict which disrupted the oil industry in that country. A significant advance in exports to this country was attained by Columbia which increased its exports to Canada to over 21,000 b/d. Several recent discoveries combined with the construction of new pipeline facilities have significantly improved that country's productive capabilities.

Although large volumes of petroleum products continued to be imported by Canada, the volume declined in 1971 to 192,000 b/d from last year's total of over 200,000 b/d. The imported product mix has not changed much in the last decade, indeed imports of light and heavy fuel oils in 1960 constituted 63 per cent, the same percentage made-up in 1970; however, the absolute volumes have more than doubled. As in previous years most of the imported products came from Venezuela and the Netherlands Antilles and were consumed in Ontario and Quebec. It is expected that much of the market for imported petroleum products will revert to domestic refineries when the major refinery projects currently under construction in Quebec and the Maritimes come on stream in the next few years.

Early in 1971, major producers in the Organization of Petroleum Exporting Countries (OPEC), including Venezuela and Persian Gulf countries received significant gains in reference prices and tax payments for crude oil production. The agreements with the companies operating in these countries essentially guarantee that the producing nations will receive about 30-38 cents per barrel more for oil in 1971, escalating each year to 1975 when state income will be about 53 cents per barrel higher than pre-agreement rates. In early April, 1971, Libya was also negotiating with the major international oil companies operating within their boundaries for further increases in crude oil prices and tax payments. With higher production rates taken into account, the extra revenue accruing to these large oil-producing states over the life of the 5-year contract have been estimated at $10 billion. The higher costs will likely be passed on to the consumer and if so will add significantly to the price of imported crude oil entering eastern Canada.

Demand for Canadian crude oil in the United States increased to 660,000 b/d, a gain of 22 per cent over 1969. Canadian exports to the United States west coast region via Trans Mountain Oil Pipe Line Company average 224,000 b/d, a gain of 8,500 b/d from the 1969 average. Because of changing United States import policies, exports of Canadian crude oil to markets in the northern states east of the Rocky Mountains (Districts 1-4) fluctuated to a considerable degree during 1970. However, average daily shipments to this area increased by 111,000 barrels to 436,000 barrels. In March of 1970, the United States government limited imports of western Canadian crude oil to 395,000 barrels daily in an effort to curb the rapid rise in exports into its mid-continent northern states. Prior to this reduction, deliveries to this region



from Canada had been running between 550,000 and 600,000 barrels daily. Later in 1970, the United States government raised the 1971 import quota for Canadian crude oil to Districts one to four to 450,000 b/d, up from the 1970 quota target of 395,000 barrels. Also, natural gas liquids were exempted from the quota which effectively raised the level of Canadian crude oil exports into this area by another 40,000 b/d.

In addition, United States importers, who were unable to use their quotas for offshore foreign oil were permitted to apply them to imports from Canada. With all of these incremental increases taken into account, Canada could theoretically expect to export at least an additional 100,000 b/d of crude oil to United States Districts one to four in 1971. None of these rulings apply to west coast United States refineries .

This year most of Canada's producing companies increased the wellhead price of crude oil by about 25 cents per barrel. The price increase was the first for Canadian crude oil in eight years and is in line with recent price increases in the United States.

Exports of petroleum products increased by 33 per cent to 73,000 b/d in 1970. The main commodities exported were butane and propane. Export of propane to Japan increased by 2,000 barrels to 11,000 barrels daily in 1970. The remainder went to the United States.

OUTLOOK

With excellent prospects for major gains in export markets and increased wellhead prices, the producing sector can anticipate considerable gains on both a volume and financial basis. However, the degree to which future growth continues to be realized will largely depend on the successful exploration for and development of additional petroleum resources. These potential resources include not only conventional reserves but also the huge locked-in reserves of oil in the Athabasca bituminous sands. The efforts of OPEC to gain larger revenues from oil exported from member countries resulting in higher laid-down prices in consuming countries, could have an indirect effect on the attitude of countries which have indigenous production such as Canada and such efforts tend to improve the position of marginally economic resources exemplified by the Athabasca bituminous sands.

The rising tide of optimism that has featured the petroleum industry during the past year, however, should be tempered with the fact that present proven reserves of Canadian oil and natural gas liquids of 10.4 billion barrels are relatively small in terms of total world reserves, although they are adequate for our current market opportunities. The extent to which the reserve picture can be improved will largely determine where the future of the Canadian industry lies—a minor producer with a capability to look after only a part of our own needs, or a major producer capable of meeting all of our own needs from a secure supply as well as exporting quantities necessary to provide the economies of scale to make the supplies as economic as possible.

The dramatic discoveries of oil and natural gas in Canada's northern regions during the past two years has justified the confidence of those who have predicted that part of the future of the country's oil and gas industry lies there. The two recent gas discoveries in the Arctic Islands are clearly major ones and when it is considered that exploration is now in a preliminary stage, only then can the potential of the area in terms of oil and gas reserves be realized. However, before oil and gas resources can be developed in the Arctic regions, there are many problems to be solved. Not the least of these are the high operating costs in the northern areas which requires that to be economic, the fields that are found must be very large and prolific. The problems associated with producing and transporting such oil or gas to markets are technically complex and financially expensive. It has been estimated that during the next decade, industry requirements for exploration and production in the Arctic and offshore regions of Canada will approach $21 billion with an additional $6 billion outlay required for transportation systems, providing, of course, that sufficient reserves of oil and gas can be found. Despite these and other related problems, it is likely that the oil and gas industry will be able to escalate activities in the Arctic and elsewhere and eventually will be successful.

Forecasting production growth in the short term has always been hazardous in the past and this is mainly because of the difficulty of predicting United States import policies from year to year. United States is our only export customer and a large one as well. To indicate, this hazard, export growth rate of oil to the United States, which has averaged over 13 per cent during the past decade to 1970, jumped to 22 per cent in 1970. With the relaxing of United States import curbs on Canadian crude oil entering the United States upper mid-continent region in late 1970, it seems reasonable to assume that in 1971 exports to the United States will again increase and conceivably could match the 1970 growth rate of 22 per cent. Domestic demand for Canadian crude oil will probably increase by about 5 per cent, the same as in 1970.

On the international scene, the emergence of OPEC as a formidable bargaining agency dedicated to increasing producer income will undoubtedly effect the structure of the international oil industry for many year to come and could significantly change the supply patterns of Canada. It is quite likely that these recent developments on the international scene will provide additional markets for Canadian crude oil.

Phosphate

W. E.KOEPKE*

Phosphate rock is not produced commercially in Canada but large quantities are imported, mostly from United States, for use in the manufacture of agricultural and industrial phosphate products sold in domestic and export markets. United States and Britain provide the largest export markets for the finished products, principally phosphorus and phosphate fertilizers.

About four-fifths of the world's phosphate rock consumption is for agricultural purposes, largely to fertilize soils deficient in phosphorus. 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 subsequently. In Canada, a weakening of farm income in the Prairie Provinces resulting from difficulties in selling wheat led to a sharp decrease in the use of phosphate fertilizers in that area from 1968 to 1970. In eastern Canada, fertilizer consumption has continued to increase but at a slower rate and from 1968 to 1970, the industry suffered from chronic oversupply and all plants operated at less than capacity.

PHOSPHATE ROCK

Phosphate is a term used to describe a rock, mineral, or salt containing one or more phosphorus compounds. Phosphate rock, or more correctly phosphorite, is a rock that 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 can be represented by the formula $Ca_5(PO_4)_3$ (F, Cl, OH), is second in importance. The term phosphate rock, in general usage, includes apatite. Other sources of phosphate include guano and a basic slag byproduct of some steel mills. Phosphate rock can be decomposed by using one of 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 as follows: apatite deposits within Precambrian metamorphic rocks in eastern Ontario and southwestern Quebec; apatite deposits of some carbonate-alkaline complexes in Ontario and Quebec; and sedimentary phosphate rock deposits of late Palaeozoic–early Mesozoic age in the southern Rocky Mountains.

*Mineral Resources Branch.

TABLE 1

Canada, Phosphate Rock Imports and Consumption, 1969-70

	1969		1970	
	Short Tons	$	Short Tons	$
Imports				
United States	2,195,866	14,617,000	2,457,854	14,433,000
Netherlands Antilles	5,465	241,000	7,492	376,000
Britain	–	–	4,704	61,000
Total	2,201,331	14,858,000	2,470,050	14,870,000
	1968		1969	
Consumption[1] (available data)				
Fertilizers, stock and poultry feed	2,012,290		1,590,892	
Chemicals	217,364		225,751	
Other[2]	4,605		5,426	
Total	2,234,259		1,822,069	

Source: Dominion Bureau of Statistics.
[1]Breakdown by Mineral Resources Branch; [2]Includes amounts for refractories, food processing, medicinals and pharmaceuticals.
–Nil.

TABLE 2

Canada, Phosphate Rock Imports and Consumption, 1961-70
(short tons)

	Imports	Consumption
1961	1,056,885	976,639
1962	1,155,966	1,116,607
1963	1,297,427	1,166,573
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	. .

Source: Dominion Bureau of Statistics.
. . Not available.

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 Lievre 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.

IMPORTS

Canada's phosphate rock imports in 1970 were 2.5 million tons, up considerably from 2.2 million tons in

1969. Most of the increase is attributed to the demand for phosphate rock in manufacturing elemental phosphorus. About three-fourths came from Florida with most of the remainder from the western states–Idaho, Montana, Utah and Wyoming. Florida rock enters the western Canadian market via water shipment to Vancouver and then inland by rail with potash being back-hauled from Saskatchewan.

TABLE 3

World Production of Phosphate Rock 1968-70
('000 metric tons)

	1968	1969	1970p
United States	37,422	34,220	33,000
USSR*	16,210	17,430	20,650
Morocco	10,503		
Tunisia	3,361	13,690	14,000
Algeria	361		
Togo	1,375	2,670	2,650
Senegal	1,270		
South Africa**	1,087	**	**
Nauru Island	2,254		
Ocean Island	528	3,930	3,750
Christmas Island	1,213		
Egypt	600		
Jordan	1,162	2,810	2,150
Israel	850		
Others	542	1,910	2,000
Total	78,748	76,660	78,200

Source: The Journal of World Phosphorus and Potassium.
*Includes other East European countries. **Included with others 1969-70.
pPreliminary shipments.

CANADIAN PHOSPHATE INDUSTRY

ELEMENTAL PHOSPHORUS

Elemental phosphorus is produced in Canada by the thermal reduction method. Thermal reduction involves the smelting of phosphate rock with carbon (coke) and a siliceous flux; co-products of the process are ferro-phosphorus, carbon monoxide and calcium silicate slag. About 9 tons of phosphate rock grading 66-68 per cent BPL are required to manufacture 1 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.

Electric Reduction Company of Canada, Ltd. (ERCO) uses this process, employing electric furnaces at Varennes, Quebec, and in a newly-built plant at Long Harbour, Newfoundland; the latter came on stream in 1968-69.

PHOSPHATE FERTILIZERS

Phosphate fertilizers are normally produced by decomposing phosphate rock with a strong mineral acid. In Canada, only the two most common acidulants–sulphuric acid and phosphoric 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 co-product of the reaction, calcium sulphate, remains in the mixture. Normal raw material requirements to produce 1 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 fluidic slurry that facilitates removal of calcium sulphate by filtering. Off-stream 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 1 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), which is equivalent to 0.86 ton of sulphur. 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 (see Table 4). The balance of Canada's P_2O_5 productive capacity, amounting to 92,000 tons annually, consists of plants that are capable of producing both single and triple superphosphate.

TABLE 4

Canada, Phosphorus and Phosphate Fertilizer Plants, 1970

Company	Plant Location	Annual Capacity in Short Tons	Principal End-Products	Basis for H_2SO_4 Supply for Fertilizer Plants
Elemental Phosphorus				
Electric Reduction Company of	Varennes, Que.	20,000	el ph	
Canada, Ltd.	Long Harbour, Nfld.	80,000	el ph	
Total, elemental phosphorus		100,000		
Phosphate Fertilizer		(P_2O_5 eq.)		
Belledune Fertilizer Limited	Belledune, N.B.	125,000	am ph	SO_2 smelter gas
Canadian Industries Limited	Beloeil, Que.	28,000	s s	sulphur
	Hamilton, Ont.	28,000	s s	sulphur
	Courtright, Ont.	80,000	am ph	SO_2 pyrrhotite, Copper Cliff
Cominco Ltd.	Kimberley, B.C.	128,000	am ph	SO_2 pyrrhotite
	Trail, B.C.	86,000	am ph	SO_2 smelter gas
Electric Reduction Company of Canada, Ltd.	Port Maitland, Ont.	190,000	H_3PO_4, s s, t s, ca ph	SO_2 smelter gas and sulphur
Green Valley Fertilizer & Chemical Co. Ltd.	North Surrey, B.C.	1,000	s s	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	t s, 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		1,032,000		

el ph – Elemental phosphorus; P_2O_5 eq. – Phosphorus pentoxide equivalent;
am ph – Ammonium phosphates; s s – Single superphosphate; t s – Triple superphosphate;
ca ph – Food supplement calcium phosphate.
. . Not applicable, H_3PO_4 is made elsewhere.

PRODUCTION, TRADE AND CONSUMPTION

Reflecting weaker demand for fertilizers, production of phosphate fertilizers in Canada in the fertilizer year 1969/70 (twelve months ended June 30, 1970) at 496,380 tons P_2O_5 equivalent, was slightly below the levels established in 1966/67 to 1968/69. Canada's phosphate output had expanded at an average annual rate of 15 per cent between 1959/60 and 1966/67. Production levelled off in 1968 when three small phosphate fertilizer plants were closed and then declined in 1969 and 1970 as all plants were operated well below productive capacity, some of them being shut down for several months at a time. For example, Sherritt Gordon Mines, Limited, suspended operations in the phosphate section of its Fort Saskatchewan fertilizer works from May to November 1970. Belledune Fertilizer Limited reported that 1970 sales were only 29 per cent of plant capacity.

Nearly all Canada's trade in phosphate fertilizers is with 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. Exports of phosphate fertilizer materials in the fertilizer year 1969/70 were 208,760 tons P_2O_5 equivalent, up sharply from the previous twelve months and an all time high. Imports of phosphate fertilizer materials in 1968/69 amounted to 11,293 tons P_2O_5 equivalent, down sharply from the previous twelve months and by far the lowest level since World War II. This figure, as well as those shown in Table 7 for earlier years, does not include imports of orthophosphoric acid.

Sales of phosphate fertilizers for consumption in Canada in the fertilizer year 1969/70 were 313,071 tons P_2O_5 equivalent, down 10 per cent from the previous twelve months and well below the peak of 440,093 tons sold in 1967/68. The entire loss in sales occurred in the Prairie Provinces where sales decreased from an all time high of 246,659 tons P_2O_5 equivalent in 1967/68 to 113,505 tons in 1969/70, a reflection of weaker farm incomes resulting from a low level of wheat sales. Phosphate fertilizer sales in the Prairie Provinces had increased at an average annual rate of 23 per cent from 1959/60 to 1967/68. Sales in eastern Canada, amounting to 199,566 tons P_2O_5 equivalent in 1969/70, were slightly higher than the year before.

TABLE 5

Canada, Phosphate Fertilizer Production, Years Ended June 30, 1961-70 (short tons P_2O_5 equivalent)

1961	231,840
1962	261,033
1963	299,453
1964	353,547
1965	374,159
1966	461,608
1967	533,460
1968	538,796
1969	523,934
1970	496,380

Source: Dominion Bureau of Statistics.

TABLE 6

Canada, Trade in Selected Phosphate Products, 1969-70

	1969		1970	
	Short Tons	$	Short Tons	$
Imports				
Calcium phosphate				
United States	19,502	2,042,000	20,943	2,093,000
Japan	1,322	87,000	1,455	89,000
Belgium and Luxembourg	976	48,000	1,085	54,000
Total	21,800	2,177,000	23,483	2,236,000
Fertilizers				
Normal superphosphate, 22% P_2O_5 or less				
United States	5,378	171,000	4,983	100,000
Triple superphosphate, over 22% P_2O_5				
United States	22,422	1,198,000	62,027	2,571,000

TABLE 6 (Cont'd)

	1969		1970	
	Short Tons	$	Short Tons	$
Chemicals				
Potassium phosphates				
United States	1,848	583,000	1,859	592,000
France	–	–	40	14,000
Total	1,848	583,000	1,899	606,000
Sodium phosphate, tribasic				
United States	616	104,000	591	92,000
France	165	12,000	55	4,000
Total	781	116,000	646	96,000
Sodium phosphates, n.e.s.				
United States	5,617	1,229,000	5,857	1,331,000
West Germany	50	12,000	79	19,000
Total	5,667	1,241,000	5,936	1,350,000
Exports				
Nitrogen phosphate fertilizers				
United States	..	27,157,000	558,830	35,862,000
Pakistan	..	1,381,000	10,301	650,000
India	..	–	13,296	577,000
South Korea	..	–	7,149	366,000
Other countries	..	880,000	14,254	811,000
Total	..	29,418,000	603,830	38,266,000

Source: Dominion Bureau of Statistics.
– Nil; n.e.s. Not elsewhere specified; . . Not available.

TABLE 7

Canada, Phosphate Fertilizer Consumption and Trade, Years Ended June 30, 1961-70 (short tons P_2O_5 equivalent)

	Consumption	Imports*	Exports
1961	177,132	46,188	100,166
1962	196,763	47,035	111,182
1963	223,314	44,443	101,890
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	152,907
1970	313,071	11,293	208,760

Source: Dominion Bureau of Statistics.
*Excludes nutrient content of mixtures and of orthophosphoric acid.

PRICES AND TARIFFS

Phosphate rock prices are based upon the BPL content. Maximum limits of moisture, iron and alumina are specified. 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 available phosphoric acid (a.p.a.).

The December 28, 1970, issue of *Oil, Paint and Drug Reporter* listed the following prices (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, Florida land pebble, run-of-mine, washed, dried, unground, bulk, carlots, f.o.b. mines, per short ton:

66-68 per cent BPL $6.50
68-70 per cent BPL $5.84-$7.50
70-72 per cent BPL $6.50-$8.15
74-75 per cent BPL $7.55-$9.20
76-77 per cent BPL $10.20

Defluorinated phosphate, feed grade, 100-lb bags, carlots, f.o.b. Coronet, Fla., freight equalized, 19 per cent P, per short ton: $72.25

Phosphoric acid, agricultural grade, f.o.b. works, per unit-ton, 52-54 per cent a.p.a. $1.10

Superphosphate, run-of-pile, pulverized, bulk, carlots, f.o.b. works, per unit-ton, under 22 per cent a.p.a. $0.80 - $0.85

The price listing for phosphate rock remained essentially unchanged from the previous three years, but phosphoric acid prices were slightly higher than in 1969 and superphosphate prices were slightly lower.

Phosphate rock and phosphate fertilizer materials enter Canada and United States duty free.

Platinum Metals

ROBERT J. SHANK*

The platinum group metals (platinoids) are iridium, osmium, palladium, platinum, rhodium, and ruthenium. Production is obtained in only a few countries, chief of which are USSR, Republic of South Africa, Canada, Colombia, and United States in that order. Minor production is obtained in Japan and Ethiopia. Minerals containing these metals are found in nature associated with basic and ultra-basic rocks, often in conjunction with the sulphide ores of nickel. Platinum has been in short supply throughout the world for the past few years but this condition changed to one of over-supply in 1970. New and expanded production facilities that became operational in South Africa during the year brought about the change in supply. Palladium continued to be in increasing over-supply because of declining demand brought about by the fact that the new touch-tone telephones being introduced do not require palladium-bearing electrical contacts.

Canadian production of the platinoids in 1970 was 461,200 troy ounces valued at $42,696,000 compared with 310,404 ounces valued at $30,881,000 in 1969 and 485,891 ounces valued at $46,199,000 in 1968.

The United States Bureau of Mines estimated that world production of the platinoids in 1970 was 3,910,200 troy ounces as against 3,431,404 ounces in 1969. USSR accounted for 2.2 million ounces of the 1970 production, the Republic of South Africa 1.2 million ounces, Colombia 25,000 ounces, and United States 15,000 ounces.

PRODUCTION

CANADA

Canadian nickel-copper sulphide ores, principally those of the Sudbury area of Ontario, contain most of the platinum metals recovered in Canada. It has been estimated that the Sudbury ores contain about 0.025 troy ounces of platinoids per ton, but there is some indication that the lower-grade nickel ores presently being mined contain less platinum group metals. The platinoids are collected in the nickel-copper sulphide matte from the nickel smelting process. Nickel-copper anodes are purified by electrolysis and the precious metals are collected from the electrolytic tanks as sludge. This sludge is purified, then shipped to refineries in Britain and United States for recovery of the individual platinum metals. Nickel ores containing platinum metals are mined in Ontario, Quebec, Manitoba and British Columbia. Concentrates made from the British Columbia ores are shipped to Japan for treatment and the precious metals are recovered there.

In Ontario, The International Nickel Company of Canada, Limited, (Inco) operated 11 mines in the Sudbury district along with four mills and two smelters. The mills processed an average of 63,000 tons of ore each working day. Nickel-copper matte was refined at the company refinery at Port Colborne, Ontario, and the precious metal sludges shipped to the company refinery at Acton, England, for refining. Inco was developing four more mines, and constructing a fifth mill and a nickel refinery in the Sudbury area. A mine and mill were also being prepared for production at Shebandowan in Ontario. Falconbridge Nickel Mines Limited operated eight mines, four mills, a smelter, a pyrrhotite plant, and a nickel-iron refinery at Sudbury. Nickel-copper matte containing platinoid metals was shipped from the Falconbridge smelter to the company refinery at Christiansand, Norway, for refining. Falconbridge was developing three mines and constructing a mill at Sudbury to further expand production. Consolidated Canadian Faraday Limited shipped nickel-copper concentrates from its Gordon Lake mine to Inco at Sudbury for treatment.

* Mineral Resources Branch.

TABLE 1

Canada–Platinum Metals Production and Trade, 1969-70

	1969		1970P	
	Troy Ounces	$	Troy Ounces	$
Production[1]				
Platinum, palladium, rhodium, ruthenium, iridium	310,404	30,881,016	461,200	42,696,500
Exports				
Platinum metals in ores and concentrates				
Britain	418,832	31,002,000	622,661	40,545,000
Norway	10,108	970,000	15,843	1,485,000
United States	3,157	229,000	–	–
Japan	1,650	131,000	–	–
Total	433,747	32,332,000	638,504	42,030,000
Platinum metals				
United States	21,237	2,059,000	6,887	524,000
West Germany	854	142,000	2,344	338,000
Britain	1,897	295,000	1,951	237,000
Other countries	5,765	478,000	380	45,000
Total	29,753	2,974,000	11,562	1,144,000
Platinum metals in scrap				
Britain	14,447	1,629,000	12,980	1,417,000
United States	15,938	1,911,000	17,282	1,311,000
Japan	5,425	416,000	–	–
Total	35,810	3,956,000	30,262	2,728,000
Re-Exports[2]				
Platinum metals, refined and semi-processed	52,694	5,247,240	20,399	2,365,735
Imports				
Platinum lumps, ingots, powder and sponge				
Britain	9,857	1,355,000	3,254	451,000
United States	8	2,000	50	9,000
Total	9,865	1,357,000	3,304	460,000
Other platinum group metals in lumps, ingots, powder and sponge				
Britain	90,726	7,176,000	30,654	1,612,000
United States	18,355	756,000	13,364	537,000
South Africa	–	–	13,423	514,000
Total	109,081	7,932,000	57,441	2,663,000
Total platinum and platinum group metals				
Britain	100,583	8,542,000	33,908	2,063,000
United States	18,363	758,000	13,414	546,000
South Africa	–	–	13,423	514,000
Total	118,946	9,300,000	60,745	3,123,000

TABLE 1 (Cont'd)

	1969		1970p	
	Troy Ounces	$	Troy Ounces	$
Platinum crucibles				
United States	19,267	2,119,000	15,232	1,863,000
Britain	–	–	5	1,000
Total	19,267	2,119,000	15,237	1,864,000
Platinum metals, fabricated materials, n.e.s.				
Britain	7,594	1,022,000	15,819	2,247,000
United States	11,508	843,000	3,187	189,000
Netherlands	42	3,000	–	–
Total	19,144	1,868,000	19,006	2,436,000

Source: Dominion Bureau of Statistics.
[1] Platinum metals, content of concentrates, residues and matte shipped for export.
[2] Platinum metals, refined and semi processed, imported and re-exported after undergoing no change or alteration.

pPreliminary; – Nil; n.e.s. Not elsewhere specified.

In Quebec, Renzy Mines Limited increased production from its mine and mill. Concentrates are shipped to Falconbridge for smelting. Exploration was continued by Falconbridge at the New Quebec Raglan Mines Limited property in the Ungava area. Falconbridge also announced it would build a nickel refinery at Becancour, Quebec.

Inco operated two mines, a mill, a nickel smelter, and refinery at Thompson in Manitoba. Two other mines are being developed for production to begin in 1971. Dumbarton Mines Limited, located in the Bird River area of Manitoba, shipped ore to the Consolidated Canadian Faraday mill for concentration. Development work and mill construction at the Manibridge mine of Falconbridge, near Wabowden, proceeded on schedule for completion by mid-1971. Concentrates will be shipped to Falconbridge for smelting.

Production of nickel-copper concentrates for export to Japan continued at Giant Mascot Mines Limited near Hope, British Columbia, until August 2, 1970 when the entire surface plant was destroyed by fire. Reconstruction started immediately and production is expected to be resumed early in 1971. Hudson Bay Mining and Smelting Co., Limited announced that its Wellgreen mine on Kluane Lake in the Yukon Territory would begin production in 1972. Nickel-copper concentrates will be treated in Japan.

Sudbury ores are estimated to contain about two parts of platinum to three parts of palladium.

USSR

Platinoids in the USSR were derived mainly from the mining of deposits in the nickel-bearing basic and ultra-basic rocks of the Norilsk region of Siberia. Small amounts of platinum were recovered from the southern Urals. Russian production in 1970 was estimated by the U. S. Bureau of Mines at 2,200,000 ounces compared to 2,100,000 ounces in 1969.

SOUTH AFRICA

The Republic of South Africa is the leading producer of the platinoids in the non-communist world. Three companies operated five mines in the Transvaal district in 1970. Rustenburg Platinum Mines Limited operated three mines, a smelter and a refinery. Impala Platinum Ltd., controlled by Union Corporation Ltd., Industrial Selections Ltd., International Nickel, U. C. Investments Ltd., Marula Platinum (Pty) Ltd., National Selections Ltd. and Hambros Bank Ltd. produced from the Bafokeng mine, mill, smelter, and refinery near Rustenburg. Atok Investments (Pty) Limited, a subsidiary of Anglo-Transvaal Consolidated Investment Company Limited, produced platiniferous concentrates from a mine and mill about 40 miles east of Pieterburg. Rustenburg, the non-communist world's largest producer of platinum, reached an annual production capability of 1,100,000 ounces of platinum and about 450,000 ounces of palladium in

1970. The company was engaged in a major expansion program that would have expanded its production capability to 1,300,000 ounces of platinum by mid-1972, but this program was suspended temporarily because of surplus output. Impala announced in November, 1970, that it had reached a productive rate of 250,000 ounces of platinum (plus an estimated 100,000 ounces of palladium) a year, but was slowing down its expansion plans to bring production more in line with demand. Atok has the capacity to produce 150,000 ounces of platinoids a year. Lonrho Ltd. has announced that it and Falconbridge Nickel Mines Limited would share in the operation of a mine situated on the Merensky Reef near Rustenburg. Production is planned to start early in 1971 and will rise to 430,000 ounces of platinoids a year by 1974 or 1975.

It is estimated that South African ores carry about 2½ ounces of platinum for each ounce of palladium.

UNITED STATES

Mine production of the platinoids in the United States was from placer deposits in the Goodnews Bay area of Alaska. Some primary production was obtained as a byproduct of gold and copper refining.

COLOMBIA

The production in Colombia, amounting to about 25,000 ounces in 1970, was obtained from placers in the Choco district.

USES

Platinum metals are valuable to industry because of their many special properties, the chief of which are catalytic activity, resistance to corrosion, resistance to oxidation at elevated temperatures, high melting points, high strength and high ductility. Platinum and palladium are the principal platinum metals. Iridium, osmium, ruthenium and rhodium are used mainly as alloying elements to modify properties of platinum and palladium. Rhodium is used in plating.

The catalytic action of platinum, palladium, rhodium and ruthenium is utilized in the oil industry for the production of high octane gasoline; in the chemical industry for the production of sulphuric and nitric acids and the hydrogenation of organic chemicals; and in the drug industry for the manufacture of pharmaceuticals, vitamins and antibiotics. A recent development is the use of platinum metal salts and complexes as homogeneous catalysts for the oxidation, isomerisation, hydrogenation and polymerisation of olefins.

The corrosion resistance of the platinum metals is utilized in laboratory utensils to contain corrosive liquids and as protective coatings for vessels used in the melting of materials for laser crystals. Wear resistance of the platinum metals makes them ideal for use as spinnerets for the production of glass, rayon and other synthetic fibres. Plantinum and platinum alloys are used for the cathodic protection of ships' hulls and as inert anodes in electro-deposition. Palladium is used as

TABLE 2

Canada, Platinum Metals Production and Trade 1961-70

	Production[1]	Exports		Imports
	Troy Ozs.	Domestic[2]	Re-Exports[3]	
	$	$	$	$
1961	418,278	26,331,101	9,820,374	11,242,328
1962	470,787	24,340,175	8,644,781	12,925,466
1963	357,651	24,555,816	10,144,484	13,590,575
1964	376,238	20,812,514	20,888,749	17,369,291
1965	463,127	30,103,254	11,389,395	13,461,546
1966	396,059	25,800,000	11,779,822	14,930,000
1967	401,263	29,829,000	9,087,955	13,161,000
1968	485,891	38,068,000	8,254,753	17,077,000
1969	310,404	35,306,000	5,247,240	9,300,000
1970p	461,200	43,174,000	2,739,000	3,123,000

[1]Platinum metals, content of residues, concentrates and matte shipped to Britain and Norway for treatment; [2]Value of platinum metals and platinum concentrates exported for treatment; [3]Re-exports of 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, most of which is re-exported.

p Preliminary.

contacts in automatic electric switching gear and in dentistry. Wear resistance and beauty of finish are the qualities that created a demand for the platinum metals in the manufacture of high-quality jewelry.

Platinum could benefit from the current agitation to remove lead compounds from automobile exhaust gases in two ways: more catalyst, and thus more platinum, will be required to reform gasoline if tetraethyl lead is to be discarded as an anti-knock agent; and platinum catalysts may be used in automobile exhaust control devices. Much research is being carried out along these lines but the effect on platinum consumption is as yet unmeasurable.

TABLE 3

World Production of Platinum Group Metals
(troy ounces)

	1968	1969	1970
USSR	2,000,000	2,100,000	2,200,000
Republic of South Africa	914,000	964,000	1,200,000
Canada	485,891	310,404	461,200
Colombia	15,076	28,000	25,000
United States	14,793	22,000	15,000
Other countries	7,056	7,000	9,000
Total	3,436,816	3,431,404	3,910,200

Sources: U.S. Bureau of Mines Minerals Yearbook, Preprint, 1968; U.S. Bureau of Mines, Commodity Data Summaries, January 1971.

OUTLOOK

The outlook for the platinoids is one of uncertain medium-term demand in the face of rising production. The uncertain demand is caused by conflicting views of what part the platinoids will play in the trend towards cleaner exhaust gases from internal combustion engines. Efficient catalysts using less of the platinoids are being developed both for gasoline reforming plants and for exhaust scrubbers. The expanded use of these has somewhat blunted the forecasts of rapidly rising demand being made a year ago. At the same time, productive capability is expanding in South Africa and Canada. As a result, adequate supplies appear to be available for the near-term and probably also for the medium-term.

In Canada, production of the platinoids is dependent on the production of nickel and cannot be adjusted easily to meet demand. Output should increase during the next few years but the mining of lower grade ores will probably keep the increase below what might be expected in light of the ore tonnages involved.

PRICES

The prices of the platinoids were characterized either by stability or changes on the downside during 1970, reflecting adequate supply. The greatest change occurred in the dealers quotations for platinum, which opened the year at a high of $179 U.S. a troy ounce and dropped to the $120 range near the year-end, some $10 below the producers price. Price changes for the platinoids are listed below. It should be noted that the producers price is that quoted by Engelhard Industries, Inc. and Johnson, Matthey & Co., Limited, while the dealers price is a free market price quoted by merchant dealers and the agents selling for the USSR.

Price in $ U.S. a troy ounce	Producers	Dealers
Iridium		
Jan. 1 – Feb. 8	160 – 165	160 – 162
Feb. 9 – Sept. 6	155 – 160	152 – 157
Sept. 7 – Dec. 31	150 – 155	145 – 152
Osmium		
Jan. 1 – Dec. 31	200 – 225	200 – 225
Palladium		
Jan. 1 – May 31	37 – 39	35.50 – 36.50
June 1 – Dec. 31	36 – 38	35.00 – 36.50
Platinum		
Jan. 1 – Dec. 31	130 – 135	120 – 179
Rhodium		
Jan. 1 – Feb. 8	220 – 225	215 – 220
Feb. 9 – May 31	215 – 220	212 – 215
June 1 – Sept. 6	210 – 215	210 – 213
Sept. 7 – Dec. 31	205 – 210	202 – 208
Ruthenium		
Jan. 1 – Dec. 31	50 – 55	45

Source: *Metals Week*.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General
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
48900-1	Crucibles of platinum, rhodium and iridium, and covers, therefore	free	free	15%

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

UNITED STATES

601.39	Precious metal ores	free
605.02	Platinum metals, unwrought not less than 90% platinum	free
605.03	Other platinum metals, unwrought	
	On and after Jan. 1, 1970	28 %
	" " " Jan. 1, 1971	24 %
	" " " Jan. 1, 1972	20 %
605.05	Alloys of platinum, semi-manufactured, gold-plated	
	On and after Jan. 1, 1970	35 %
	" " " Jan. 1, 1971	30 %
	" " " Jan. 1, 1972	25 %
605.06	Alloys of platinum, semi-manufactured, silver-plated	
	On and after Jan. 1, 1970	16.5%
	" " " Jan. 1, 1971	14 %
	" " " Jan. 1, 1972	12 %
605.08	Other platinum metals, semi-manufactured, including alloys of platinum	
	On and after Jan. 1, 1970	28 %
	" " " Jan. 1, 1971	24 %
	" " " Jan. 1, 1972	20 %

Source: Tariff Schedules of the United States, Annotated (1970) TC Publication 304.

Potash

W.E. KOEPKE*

World demand for potash was strong in 1970 but for the fifth consecutive year, productive capability far exceeded market requirements. Canada's potash industry, located in the Province of Saskatchewan, shouldered much of the burden of excess world capacity. World consumption of potash fertilizers increased sharply during the mid-1960's and many companies turned to the rich potash deposits in Saskatchewan as one of the few sources to meet rising North American and world needs. Permanent production of potash began in Saskatchewan in 1962; by 1966 the industry had become an important market force in world potash trade but in that year North American prices began to weaken. By the end of 1969, there were nine potash mines operating in Saskatchewan with designed capacities totalling 7.6 million tons of K_2O equivalent annually, and a tenth mine was brought on stream in 1970.

Sales did not keep pace with the increased output in Saskatchewan and stocks mounted while North American prices deteriorated to the point where, in 1969, they were at the lowest level on record; the value of Canada's potash shipments in 1969 averaged \$19.87 a ton of K_2O equivalent (19.87¢ per unit K_2O equivalent, a unit being 20 lbs) compared with \$37.53 a ton in 1965. The uncertain market conditions prompted the Government of the Province of Saskatchewan to promulgate production and marketing controls, effective January 1, 1970, in an effort to restore order to the marketing of potash in North America and in other parts of the world and to prevent a possible shutdown of any of the newly-opened mines in the province.

POTASH REGULATIONS

The controls, known as The Potash Conservation Regulations, 1969, were introduced on November 19, 1969, under The Mineral Resources Act and are administered, through the Minister of Mineral Resources, by a three-member board. Under the Regulations as introduced, the potash producers were required to obtain from the province, potash producing licences and potash disposal licences, effective January 1, 1970. On November 25, 1969, the Minister of Mineral Resources posted a ministerial notice declaring that a fair and reasonable price to the producer of potash, free on board, at the potash plant in Saskatchewan shall be not less than thirty-three and three quarter cents (33.75¢) Canadian per unit of potassium oxide equivalent. For the lowest grades produced in Saskatchewan, (that is 60 per cent K_2O minimum) the posted price worked out to \$20.25 (Cdn) or about \$18.75 (US) for a ton of potash product with the Canadian dollar pegged at 92.5¢ (US). After the end of May 1970, when the Canadian dollar was allowed to float, the minimum price in terms of US funds rose to about \$19.85. The minimum posted price was applied to all potash produced and sold in Saskatchewan from January 1 to June 30, 1970, but did not apply to stocks, amounting to 863,545 tons K_2O equivalent, that were held over from 1969 and shipped prior to March 31, 1970.

On March 18, 1970, the provincial government amended the Regulations, rescinding the section dealing with disposal licences, effective July 1, 1970. Also beginning July 1st, the province began issuing produc-

* Mineral Resources Branch.

TABLE 1

Canada, Potash Production, Shipments and Trade, 1969-70

	1969		1970P	
	Short Tons	$	Short Tons	$
Production (potassium chloride)				
Gross weight	6,122,000	. .	5,656,000	. .
K_2O equivalent	3,748,000	. .	3,464,000	. .
Shipments (potassium chloride)				
Gross weight	5,687,000	. .	5,580,000[e]	
K_2O equivalent	3,492,001	69,382,516	3,424,000	116,402,000
Imports–Fertilizer potash				
Potassium chloride				
United States	11,184	363,000	23,421	720,000
West Germany	5,192	133,000	2	1,000
Britain	7	2,000	–	–
Total	16,383	498,000	23,423	721,000
Potassium sulphate				
United States	27,773	1,041,000	20,447	880,000
Italy	3,300	147,000	–	–
Britain	2	1,000	–	–
Total	31,075	1,189,000	20,447	880,000
Potash fertilizer, not elsewhere specified				
United States	25,574	505,000	27,205	638,000
Total, potash fertilizer	73,032	2,192,000	71,075	2,239,000
Potash chemicals				
Potassium carbonate	1,001	181,000	1,094	185,000
Potassium hydroxide	1,513	331,000	1,816	368,000
Potassium nitrate	3,836	447,000	2,954	364,000
Potassium phosphates	1,848	583,000	1,899	605,000
Potassium bitartrate	179	119,000	179	113,000
Potassium silicates	1,062	188,000	1,031	217,000
Total, potash chemicals	9,439	1,849,000	8,973	1,852,000
Exports–Fertilizer potash				
Potassium chloride (muriate of potash)				
United States		59,909,000	4,237,567	93,302,000
Japan		12,583,000	605,295	14,030,000
India		697,000	141,340	3,313,000
Netherlands		9,084,000	132,568	3,219,000
New Zealand		1,903,000	106,642	2,132,000
South Korea		1,826,000	78,933	1,411,000
Pakistan		1,151,000	27,711	956,000
Australia		981,000	42,746	874,000
Singapore		521,000	29,357	701,000
Other countries		1,921,000	71,720	1,367,000
Total		90,576,000	5,473,879	121,305,000

Source: Dominion Bureau of Statistics.

P Preliminary;–Nil; . . Not available.

tion licences to cover a term of one year, the yearly production allowables being subject to quarterly maximums and revisions. To administer the Regulations, the board held a public inquiry in Regina each quarter for the purpose of determining:

(a) "the demand for potash or potash products for reasonable current requirements and current consumption or use within and outside the province, together with such amounts as are reasonably necessary for building up or maintaining reasonable storage reserves and working stocks of potash and potash products;
(b) a proportionate share of production, if any, that may be allocated to each potash mining property required to meet the market demand for potash;
(c) such other matters or things that may be considered necessary by the board with a view to prorationing production of potash in Saskatchewan in the interest of sound utilization, development and conservation principles relating to the potash resource of Saskatchewan."

Prior to the public inquiry, each company was required to submit to the Department of Mineral Resources:

(a) "a monthly potash production and disposition report showing the quantity and value of each shipment and to whom and where it was shipped, and a record of production and inventory by grade. (On the basis of these submissions the Department publishes monthly production and shipment statistics).
(b) a statement of its own potash market requirements and the entire demand for Saskatchewan potash for the forthcoming quarter and the following three quarters."

Production was then allocated using a formula that included factors of plant capacity, market requirements and inventory needs. Production allowables for 1970 are shown in Table 4.

PRODUCTION AND DEVELOPMENTS IN CANADA

According to the Saskatchewan Department of Mineral Resources, production of potash in the province in 1970 was 3,497,901 tons K_2O equivalent and sales totalled 3,354,710 tons. Production was down from an estimated 3,748,000 tons in 1969. According to the Dominion Bureau of Statistics, shipments decreased from 3,492,001 tons K_2O equivalent in 1969 to 3,424,000 tons in 1970 while the value of shipments rose from $69.4 million in 1969 to $116.4 million in 1970. The sharp increase in value reflects the minimum prices as set forth by the Government of the Province of Saskatchewan. Potash stocks on hand at the end of 1970 were at an all time high of 959,479 tons K_2O equivalent, a rise of 95,934 tons from the previous year.

As a noun the term potash means potassium oxide (K_2O) equivalent and when used as an adjective it refers to potassium compounds or potassium-bearing materials. There are more than 70 potassium-bearing minerals but only a few of the soluble potash salts found in bedded deposits and lake, sea, or subsurface brines, are of economic significance. Other potash sources include wood ashes, kelp, guano and organic matter. Almost 95 per cent of the world's potash production is for fertilizers. Small quantities are used in the manufacture of soaps, glass, ceramics, textiles, dyes, explosives and numerous chemicals.

Potash minerals and compounds are graded in terms of K_2O equivalent. For example, potassium chloride (KCl), which accounts for over 90 per cent of the world's potash fertilizer consumption, has a K_2O equivalent of 63.2 per cent (KCl $\times$ 0.632 = K_2O and conversely, $K_2O \times 1.58$ = KCl). Fertilizer grades produced in Canada normally range from an accepted minimum of 60 per cent up to 63 per cent K_2O equivalent, the average being 61.2 per cent. Pure potassium chloride contains 52.4 per cent potassium (K).

DEPOSITS AND OCCURRENCES

Underground potash deposits occur in the Prairie Provinces of Manitoba, Saskatchewan, and Alberta, and in the Atlantic Provinces of Newfoundland, Nova Scotia and New Brunswick. Only those in Saskatchewan have attained commercial production. The deposits in Nova Scotia are in the Malagash-Wallace area of Cumberland County; they occur in the Windsor Formation, of Mississippian age, at a depth of nearly 4,000 feet and grade about 5 per cent K_2O equivalent. The Newfoundland deposits also occur in rocks of Mississippian age and are of low grade. The New Brunswick deposits, discovered early in 1971 in the Sussex area of Kings County, were encountered at a depth of 900 to 1,000 feet; bed thicknesses are as much as 32 feet and grades range from 21 to 25.5 per cent K_2O equivalent.

The deposits in western Canada underlie a broad northwesterly trending belt that extends across southern Saskatchewan into the bordering areas of Alberta and Manitoba; they occur within the Prairie Evaporite Formation, which constitutes the upper 50 to 700 feet of the Middle Devonian Elk Point Group. Depths of the Saskatchewan deposits range from 3,000 feet at the northern edge of the beds to 7,000 feet near the International Boundary. Individual potash beds reach 20 feet in thickness. Sylvite (KCl) and halite (NaCl) are the predominant minerals and form a physical mixture known as sylvinite, which is the chief 'ore'. In some areas the potash beds contain up to 3 or 4 per cent carnallite ($KCl \cdot MgCl_2 6H_2O$). In other areas

TABLE 2
Canada, Potash Production and Sales by Grade * and Destination, 1970
(s.t. of K_2O)

	Standard	Special Standard	Coarse	Granular	Soluble	Chemical	Total
Production	919,588	225,046	1,363,161	597,076	327,715	65,315	3,497,901
Sales							
Domestic	48,207	7,871	158,075	10,180	2,710	309	227,352
U.S.A.	649,907	50,350	1,000,058	501,315	177,417	69,183	2,448,230
Australia	4,896	–	8,804	–	–	–	13,700
Belgium	2,490	557	–	–	2,064	–	5,111
England	–	23,595	–	–	–	935	24,530
Germany	–	6,113	–	–	556	–	6,669
Holland	1,367	6,030	–	–	–	–	7,397
India	71,903	–	–	–	9,746	–	81,649
Indonesia	333	–	–	–	–	–	333
Italy	11,322	–	–	–	–	–	11,322
Ireland	8,786	521	–	–	–	–	9,307
Japan	57,780	174,217	9,668	–	109,215	329	351,209
Korea	36,455	–	–	–	–	–	36,455
Malaysia	5,218	–	–	–	4	–	5,222
New Zealand	61,765	–	–	–	–	–	61,765
Pakistan	9,703	–	6,243	–	–	–	15,946
Philippines	12,527	–	–	–	–	–	12,527
Singapore	10,454	–	–	–	20	–	10,474
South Africa	–	–	1,946	–	–	–	1,946
Sweden	4,235	–	–	–	2,185	–	6,420
Switzerland	2,662	–	–	–	–	–	2,662
Taiwan	3,686	6,459	–	–	–	–	10,145
Vietnam	4,340	–	–	–	–	–	4,340
Total offshore	309,922	217,492	26,661	–	123,790	1,264	679,129
Total sales	1,008,036	275,713	1,184,794	511,495	303,917	70,756	3,354,711

Source: Saskatchewan Department of Mineral Resources, Monthly Potash Report.
* 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.

where this mineral is generally lacking, the beds have a higher clay content of up to 6 per cent. The deposits in Saskatchewan grade as high as 35 per cent K_2O equivalent. Potash reserves, grading a minimum of 25 per cent K_2O equivalent, are estimated at 50 billion tons.

MINING AND PROCESSING

Mining is either by underground excavation or by solution extraction. A modified room-and-pillar method is used in underground excavation employing electrically-powered continuous mining machines that cut openings ranging from 7 to 10 feet in height and 18 to 22 feet in width. Mining is on one level and working depths from mine to mine range from 3,100 to 3,500 feet. Shuttle cars and/or portable conveyors transfer broken rock to a main conveyor for haulage to the hoisting shaft. Normally there is some underground primary crushing.

In the surface plant, the rock is further crushed and the sylvite is removed by flotation. The sylvite is then dried and screened to provide as many as four 'grades' of potassium chloride (muriate of potash in common terminology): granular, coarse, standard and special standard. Compactors are used to increase the proportion of the more desirable granular and coarse grades. Chemical or soluble grades are also produced from evaporation and crystallization circuits that are fed with dust and fines collected throughout the plant.

For solution mining, a weak brine is pumped into the potash beds at about 5,200 feet deep through a selected pattern of cased wells. The injected brine dissolves the sylvinite and potash-rich solutions are circulated to surface for refining. Refining involves a sequence of multiple-effect evaporation and crystallization whereby potassium chloride crystals are precipitated, drawn-off, dried and screened. Products resulting from evaporation and crystallization processes have a higher degree of purity than floated potash.

CURRENT OPERATIONS

Although potash permits have been issued in all three Prairie Provinces and extensive drilling has been done in the area around St. Lazare, Manitoba, most exploration work has been concentrated in a belt 120 miles wide that extends southeasterly from just west of Saskatoon to the Manitoba border. This area, covering about 21,000 square miles, is designated and identified by the Province of Saskatchewan as Commercial Potash Area No. 1 under the Oil and Gas Conservation Act. Area No. 2 covers a 936-square mile area around Unity, the site of the first attempt to mine potash in Saskatchewan. In December 1970 there were, outstanding in Saskatchewan, 12 potash leases comprising 904,081 acres, one 99,840-acre lease pending, and 9 permits, totalling 757,472.

TABLE 3

Canada, Potash, Production and Trade,
Years Ended June 30, 1961-70
(short tons K_2O equivalent)

Year Ended June 30	Production	Imports*	Exports
1961	–	101,370	–
1962	–	124,370	–
1963	403,679	75,180	310,633
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

Source: Dominion Bureau of Statistics – Fertilizer Trade.
* Includes potassium chloride, potassium sulphate and sulphate of potash magnesia, except that contained in mixed fertilizers.
–Nil.

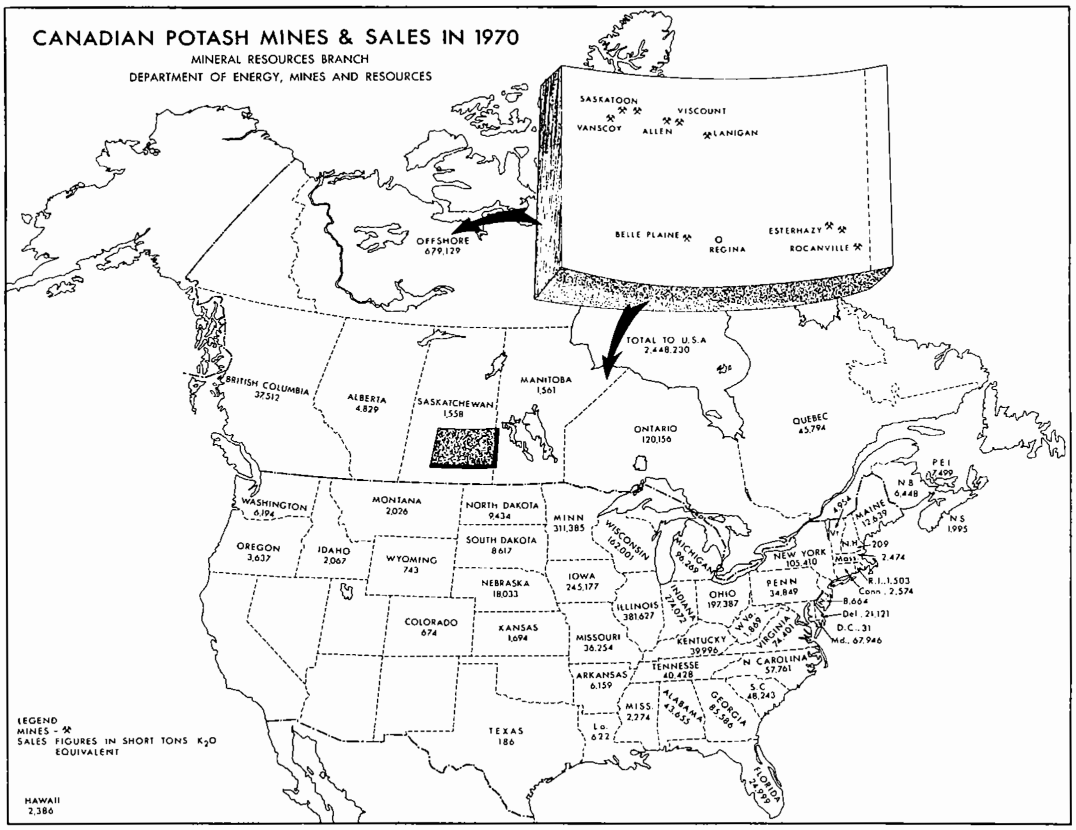


TABLE 4

Canada, Summary of Potash Mines and Their Production Allowables for 1970

Company	Location[1]	Initial Production	Production Capacity short tons yearly: KCl	Production Capacity short tons yearly: K_2O eq.	Production Allowable st K_2Oeq.	Operating Rate (Allowable as % of Capacity)
International Minerals & Chemical Corporation (Canada) Limited	K-1, Esterhazy	1962	2,100,000	1,280,000	1,130,952	48.5
	K-2, Esterhazy	1967	1,720,000	1,050,000		
Kalium Chemicals Limited	Belle Plaine	1964	1,500,000	937,500	383,226	40.9
Potash Company of America	Saskatoon	1965	760,000	460,000	237,644	51.7
APM Operators Ltd.	Allan	1968	1,500,000	912,700	479,699	52.6
Alwinsal Potash of Canada Limited	Lanigan	1968	1,000,000	600,000	235,926	39.3
Duval Corporation of Canada	Saskatoon	1968	1,200,000	732,000	303,664	41.5
Cominco Ltd.	Vanscoy	1969	1,200,000	720,000	317,808	44.1
Central Canada Potash Co. Limited[2]	Viscount	1969	1,500,000	900,000	364,776	40.5
Hudson Bay Mining and Smelting Co., Limited[3]	Rocanville	Sept. 1970	1,200,000	732,000	21,200	..
Totals or average			13,680,000	8,324,200	3,474,895[4]	45.5

[1] All in the Province of Saskatchewan; [2] Productive capability reported by company as 520,562 tons K_2O eq. for 1970; [3] Productive capability reported by company as 21,200 tons K_2O eq. for 1970. Hudson Bay's mine is excluded in the operating rate column; [4] Includes 91,895 tons K_2O eq. for storage purposes.

–Nil.

The conventional shaft mines are concentrated in two regions of Area No. 1: six are in the Saskatoon-Lanigan region, and three are in the Esterhazy-Rocanville region. The solution mine is in the deeper part of the evaporite basin, near Regina; other solution-mining experiments have also been conducted in the Regina region.

As indicated in Table 4, there are 10 potash mines in Saskatchewan with an installed annual productive capacity of 13.68 million tons of potassium chloride (8.32 million tons K_2O equivalent). Noranda Mines Limited officially opened its $89-million potash mine and refinery at Viscount, 45 miles east of Saskatoon, in June 1970. Actual start-up of the 1.5 million-ton-a-year mine began in August 1969. The mine has two shafts, 440 feet apart; the production shaft is completed to a depth of 3,561 feet with the mining zone at 3,351 to 3,361 feet, and a service shaft is completed to a depth of 3,549 feet with the mining zone at 3,339 to 3,349 feet. It was announced in June 1970 that Central Farmers Fertilizers Company, a large Chicago-based co-operative with fertilizer outlets scattered throughout the United States and in Ontario, had exercised its option to acquire a 49-per cent interest in Noranda's mine. The mine is being operated under the name, Central Canada Potash Co. Limited, with Central Farmers taking all or nearly all the output from the mine.

On August 7, 1970, International Minerals & Chemical Corporation (Canada) Limited announced that it was closing down the K-2 mine for shaft repairs that would take almost a year to complete. On August 27th, Cominco Ltd. was forced to suspend mining operations at Vanscoy, because of a serious water inflow that occurred during routine grouting in the ventilation shaft. At year-end, the company was in the process of dewatering the flooded mine, which is expected to re-open in 1972. Cominco has apparently been meeting its market commitments by acquiring potash from Duval Corporation of Canada's neighbouring mine.

Sylvite of Canada Division of Hudson Bay Mining and Smelting Co., Limited began start-up operations in September 1970 at its $70-million potash mine near Rocanville, about 25 miles southeast of Esterhazy. The mine has two 16-foot diameter shafts, 515 feet apart; the production shaft is completed to a depth of 3,350 feet and the service shaft to a depth of 3,250 feet. The potash zone is at 3,150 feet and mining is by room-and-pillar method employing four-rotor, continuous miners. The mine and plant have been designed to produce 1.2 million tons of potash product annually.

CONSUMPTION AND TRADE

Canadian potash consumption is about 8 per cent of its output, the principal consuming areas being the farm communities of southern Ontario, Quebec and British Columbia. Total domestic sales of Saskatchewan potash were 227,352 tons K_2O equivalent in 1970, of which 120,156 tons went to Ontario. Including imports, total deliveries of potash salts for agricultural purposes in Canada in 1970 as reported by the Potash Institute of North America were 202,824 tons K_2O equivalent, consisting of 190,243 tons as potassium chloride supplied almost entirely from Saskatchewan and 12,581 tons as potassium sulphate and potassium magnesium sulphate from the United States.

The United States is Canada's leading export market for potash, followed by Japan. In 1970, 2.45 million tons K_2O equivalent, representing about 73 per cent of Canada's potash sales went to the United States and 351,000 tons representing 10 per cent of sales went to Japan. The higher prices for Saskatchewan potash brought about in conjunction with the Potash Regulations, has had a strong impact on the marketing of Canadian potash in certain areas of the world. Canadian potash began moving into the west European market, particularly Britain, in substantial quantities in 1966 and by 1968 almost 500,000 tons of potassium chloride from Saskatchewan was shipped to the Netherlands for furtherance to British, other European and Scandinavian markets. In 1970, Canadian potash shipments to the Netherlands amounted to 133,000 tons of product. The loss of European markets is not entirely attributed to the increased prices of Saskatchewan potash, but also to increased ocean freight rates. For example, a tramp charter rate for 10,000 tons of potash from Vancouver to Taiwan was $8.50 (US) a long ton in 1968 whereas a rate of $12.00 (US) a long ton for a 16,000-ton cargo was paid in 1970. Although there have been no recent listings for tramp shipments from Vancouver to Rotterdam, Netherlands, the rate is believed to have increased from about $5.00 a long ton in 1968 to $6.00 a long ton in 1970.

TABLE 5

Canada, Consumption of Potash Fertilizers, Years Ended June 30, 1961-70 (short tons K_2O equivalent)

Year Ended June 30	In Materials	In Mixtures	Total
1961	5,404	96,514	101,918
1962	6,558	99,934	106,492
1963	9,704	102,285	111,989
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	40,306	153,843	194,149

Source: Dominion Bureau of Statistics.

TABLE 6
Canada, Potash Deliveries by Product and Area, 1969-70
(short tons K_2O equivalent)

		Agriculture						Industrial
		Potassium Chloride				Potassium Sulphates	Total Agricultural	
		Standard	Coarse	Granular	Soluble			
Atlantic Provinces	1969	5,873	27,910	–	–	1,105	34,888	–
	1970	2,689	20,784	–	–	2,291	25,764	–
Quebec	1969	19,768	38,119	1,994	50	3,197	63,128	273
	1970	12,140	30,699	426	77	2,670	46,012	177
Ontario	1969	16,819	78,797	5,193	4,157	15,634	120,600	4,511
	1970	18,602	86,455	2,515	556	7,195	115,323	2,174
Prairie Provinces	1969	7,767	2,707	2,027	17,702	103	30,306	92
	1970	2,818	4,345	2,801	364	156	10,484	20
British Columbia	1969	4,053	8,153	1,122	374	314	14,016	137
	1970	1,625	2,625	596	126	269	5,241	–
Totals	1969	54,280	155,686	10,336	22,283	20,353	262,938	5,013
	1970	37,874	144,908	6,338	1,123	12,581	202,824	2,371

Source: Potash Institute of North America.
–Nil.

Brazil had become an important market for Saskatchewan potash, having imported about 40,000 tons of potassium chloride from Canada in both 1968 and 1969; there were no Canadian exports of potash to Brazil in 1970. The loss of Brazilian markets, mainly to United States producers, is attributed mainly to the increased prices for Saskatchewan potash.

The increased prices for Saskatchewan potash were also of deep concern to Japanese customers, but the problem seems to have been partially resolved with the conclusion in June 1970, of a medium-term contract between Japanese buyers and the Province of Saskatchewan, the latter apparently acting on behalf of the potash industry. The contract was for 2.75 million tons of potash product to be spread over a five-year period beginning July 1, 1970. Canadian exports to Japan amounted to an estimated 495,000 tons of potash product in 1968, 598,000 tons in 1969 and in 1970 amounted to 605,000 tons.

In October 1970, Canpotex Limited was formed as a marketing and distributing agent for certain offshore outlets; it is backed by most of the Saskatchewan-based producers. The company's charter allows it to deal in potash export trade other than in the United States and to own and/or lease storage and distribution facilities. During the first six months of operation, Canpotex reportedly bid on foreign aid and foreign government tenders only.

As indicated in Table 3, Canada's potash imports have declined sharply from an all-time high of 124,370 tons K_2O equivalent in the fertilizer year 1961/62 to 27,020 tons in 1969/70. Imports during the last few years consisted largely of potassium sulphate, potassium magnesium sulphate and potassium nitrate, none of which are produced in Canada.

TRANSPORTATION AND PRICES

The bulk of Canada's potash exports to the United States are carried by railway directly from the Saskatchewan mines to market outlets in north central and middle Atlantic states or by a truck-railway system. Shipments to the southeastern United States are transported by rail to Vancouver, thence by ocean-going vessels to ports such as Tampa and Pensacola, Florida, and Savannah, Georgia. Occasional shipments to the United States have been carried by rail to the Lakehead and then by boat to Lower Great Lakes ports. Domestic shipments are also carried by rail from mine to market outlets.

Railway transportation rates and the movement of potash by a "uniflo" system have been debated at length since the founding of Canada's potash industry in the early 1960's. The market for potash is seasonal, the months of February, March and April being the peak shipping period. Prices for potash, f.o.b. mine, traditionally reflected the seasonal nature of potash demand; prices were highest during the period February 1st to June 30th, the idea being that customers would be encouraged to buy potash in the off-season and do their own stockpiling thereby easing the burden of storage for the producers and spreading out the shipping season for the railways. Seasonal pricing, was to some extent, abandoned when prices deteriorated, although storage allowances were deducted for shipments in the off-season.

When the industry was founded in Saskatchewan, a competitive freight rate – competitive in the sense that a potash producer located in Saskatchewan would face about the same freight rate when shipping to the port of export as would a producer located in Carlsbad, New Mexico, which was the hub of the United States potash industry – of $9.00 a ton of product was established for shipping potash from the mines some 1,100 railway miles to Vancouver for offshore export. Similarly, competitive railway freight rates were established for shipping Saskatchewan potash to many of the large consuming areas of continental United States. Basic rates to key United States points were established at: $12.62 to Minneapolis, Minn.; $12.98 to Sioux City, Iowa; $13.50 to Chicago, Ill., and St. Louis, Mo.; and $16.49 to Cincinnati, Ohio. On August 19, 1967, the inland rates were boosted by 10¢ a ton and on November 28, 1968, they were increased a further 5 per cent.

High freight rates in the face of depressed marketing conditions were of deep concern to the potash industry and some producers sought alternative shipping methods. In November 1968, International Minerals & Chemical Corporation (Canada) Limited (IMC) inaugurated a system of trucking potash from Esterhazy to a railway loading terminal just south of The International Boundary, a distance of about 150 miles. This system served for IMC's shipments to Minnesota, Wisconsin and Illinois. The industry also negotiated for more favourable freight rates and on November 18, 1969, the railways introduced a $1.10 a ton reduction for maximum carloading for shipments to the mid and midwestern States. The railways also announced a $1.90 a ton "uniflo" reduction for producers who would ship not more than 10 per cent and not less than 6 per cent of annual tonnage to the United States in any one month, to be effective January 1, 1970. However, a number of United States railways objected to the latter proposal and its introduction was disallowed by the U.S. Interstate Commerce Commission.

Also on November 18, 1969, the Canadian railways announced a general 6 per cent increase in freight rates. In the case of potash, an immediate increase was applied for continental shipments while a rise from $9.00 to $9.54 a ton on offshore export shipments through Vancouver was to become effective December 20, 1969. At the request of the Government of the Province of Saskatchewan, introduction of the Vancouver rate was postponed until February 20, 1970, at which time the new schedule became effective. Potash

TABLE 7

World Potash Output and Producer Sales and Inventories, 1965-70
(000 metric tons K_2O equivalent)

	1965		1966		1967		1968		1969		1970[p]	
	Production	Sales	Production	Sales	Production	Sales	Production	Sales	Production	Sales	Production	Sales
USSR	2,368	2,310	2,626	2,435	2,868	2,789	3,120	3,010	3,250	3,194	4,200	3,950
Canada*	1,470[e]	1,353	1,820[e]	1,805	2,340[e]	2,162	2,800[e]	2,647	3,400[e]	3,168	3,173	3,043
United States	2,849	2,659	3,012	2,842	2,993	2,836	2,469	2,643	2,544	2,784	2,452	2,550
Germany, East	1,926	1,856	2,006	1,950	2,206	2,150	2,293	2,220	2,346	2,330	2,400	2,400
Germany, West	2,385	2,295	2,291	2,200	2,131	2,222	2,220	2,290	2,283	2,271	2,310	2,360
France	1,888	1,831	1,782	1,701	1,818	1,907	1,719	1,814	1,794	1,802	1,760	1,770
Spain[r]	364	360	418	387	507	490	543	568	551	550	520	525
Israel	293	220	314	310	300	250	366	310	363	424	540	540
Italy[r]	169	160	182	165	163	160	174	170	175	196	180	180
Congo	–	–	–	–	–	–	–	–	50	30	240	250
Chile[e]	20	20	20	20	20	20	20	20	20	20	20	20
World, Total	13,732	13,064	14,471	13,815	15,346	14,986	15,724	15,692	16,776	16,769	17,795	17,588

Inventories

	1965	1966	1967	1968	1969	1970[p]
USSR[e]	450	600	675	750	775	950
Canada	188[e]	183[e]	365[e]	500[e]	783	870
United States	457	626	783	613	356	412
Germany, East[e]	200	225	250	250	250	250
Germany, West[e]	225	325	225	150	150	100
France	216	292	207	120	115	100[e]
Other[e]	100	125	180	220	150	150
World, Total	1,836	2,376	2,685	2,603	2,579	2,832

Sources: Dominion Bureau of Statistics, Saskatchewan Dept. of Mineral Resources, U.S. Bureau of Mines, and The Journal of World Phosphorus and Potassium.

*Sales figures for Canada for 1965-69 represent shipments.

[p]Preliminary; [e]Estimated; [r]Revised production figures; –Nil.

railway rate negotiations continued throughout the summer of 1970 and in early November an 11 per cent reduction to $8.48 a ton for offshore export shipments through Vancouver was announced in return for greater efficiency in scheduling rail movements. As a means of helping to spread out the shipping season and create greater efficiency for rail movements, producers reverted to the habit of seasonal pricing.

On November 20, 1970, freight rates were further increased by 6 per cent. As of March 1, 1971, the freight rate for shipping potash from Saskatchewan to Ontario markets became $21.78 a ton, a rise of $3.00 a ton in a 15-month period.

The ministerial notice posted by the Minister of Mineral Resources, Province of Saskatchewan, on November 25, 1969, stipulated that a fair and reasonable price to the producer of potash, f.o.b. mine should be not less than 33.75¢ Cdn. per unit K_2O equivalent, for potash produced after January 1, 1970. Producers responded and for the first eight months of 1970, prices were listed as follows:

Muriate of potash, bulk, carload lots, f.o.b. mine, per unit (20 lbs) K_2O

Standard	(60-62% K_2O min.)	33.75¢
Coarse	(60-62% K_2O min.)	37.75¢
Granular	(60-62% K_2O min.)	39.75¢
Soluble	(62% K_2O min.)	35.75¢

In mid-summer, new price lists for the last part of 1970 and the first half of 1971 were issued as follows:

Muriate of potash, bulk, carload lots, f.o.b. mine, per unit (20 lbs) K_2O

		Sept. 1970-Jan. 1971	Feb.-June 1971
Standard	(60-62% K_2O min.)	33.75¢	36¢
Coarse	(60-62% K_2O min.)	40¢	43¢
Granular	(60-62% K_2O min.)	42¢	45¢
Soluble	(62% K_2O min.)	38¢	41¢

WORLD REVIEW

About 95 per cent of the world's potash consumption is as fertilizer, the balance is being used in a host of industrial applications. From 1950 to 1964, world potash output exceeded potash fertilizer consumption by an average of 6 per cent. Over the same period, potash production and consumption experienced an average annual growth rate of 7 per cent but then growth increased sharply with consumption moving up to 10 per cent annually from 1965 to 1967. World potash producers responded to the soaring demands by constructing new mines, with most of the expansion taking place in Canada and the USSR. Potash prices began to weaken in North America in 1966 and in 1967 it spread to other parts of the world. Some producers cutback their 1968-69 production schedules, but inventories remained high as consumption tended to level-off and by 1969, North American potash prices reached their lowest level on record. The Canadian industry bore much of the burden of excess capacity in 1970; the largest increase in output took place in the USSR; other significant increases occurred in Israel and the Congo.

United States potash output peaked in 1966 and 1967, then dropped considerably in 1968 as a result of cutbacks at some Carlsbad, New Mexico mines, the hub of the United States potash industry. In spite of a slight boost in output from the New Mexico mines in 1969 and 1970, total potash output in the United States remained relatively constant in those two years, but sales have been somewhat steadier over the period 1966-70 thereby allowing producers to reduce inventories. United States producer stocks reached an all time high of 783,000 metric tons K_2O equivalent in 1967 and by the end of 1970 they had been reduced to 412,000 metric tons. Great Salt Lake Minerals & Chemical Corporation, a subsidiary of Gulf Resources & Chemical Corporation and a German company, Salzdetfurth A.G., completed the first stage of a $35-million brine recovery plant at Great Salt Lake, Utah, in November 1970. The complex includes a 220,000-ton-a-year potassium sulphate plant. Also at Great Salt Lake, National Lead Company is constructing a complex to produce magnesium metal and about 45,000 tons of co-product potash salts, annually; the complex is scheduled for completion in late 1971. Texas Gulf Sulphur Company announced in mid-1970 that it was converting its Moab, Utah, mine that had come on stream in 1964, from conventional mining methods to a solution mine; conversion was scheduled to be completed by mid-1971.

USSR potash output increased sharply to an estimated 4.2 million metric tons K_2O equivalent in 1970 an increase of almost 30 per cent from 1969. Potash is mined in three widely separated areas of USSR: near the towns of Solikamsk and Berezniki on the west side of the Ural Mountains, about 120 miles north of Perm; near Soligorsk, about 75 miles south of Minsk, Byelorussia; and near the towns of Kalush and Stebnikov in the Carpathian Mountains of Ukrainian SSR. Development of the Soligorsk deposits began in 1958 with the first and second section of No.1 Combine starting operation in 1963 and 1964, respectively. The first and second sections of Soligorsk No. 2 Combine began production in 1965 and 1967 and the first and second sections of No. 3 Combine came on stream in 1969 and late 1970. Annual productive capacity of the three Soligorsk Combines is 3.15 million metric tons K_2O equivalent. At Berezniki, the first and second sections of the No. 2 Combine came on stream in 1969 and 1970 to bring the annual productive capacity of the Ural area to 2.94 million metric tons K_2O equivalent; construction is under way for Berezniki No. 3 and a fourth Combine is being planned. Output from Ukrainian SSR is modest.

Potash output in both France and West Germany remained relatively unchanged in 1970 from the previous few years but appreciably lower than the peaks established in 1965; year-end inventories in both countries were at a six-year low of about 100,000 tons K_2O equivalent. The potash industries in both countries have been undergoing major programs of rationalization and modernization during the past few years in an effort to reduce operating costs and stabilize output. In France, the Marie-Louise plant is being expanded from 300,000 to 900,000 metric tons K_2O equivalent annually; upon completion in 1972-73, three smaller plants are expected to close. Until recently, the West German potash industry consisted of three companies: the Wintershall A.G. group that operated six potash refineries and produced about 54 per cent of that nations output; the Salzdetfurth A.G. group that operated three potash plants and produced about 35 per cent of output; and Kalie Chemie A.G. that operated two potash plants. In mid-1970, Wintershall and Salzdetfurth were amalgamated to become Kali und Salz A.G., which took over all the potash and salt mining assets of the two companies, and also took over marketing, effective January 1971. The new company is controlled by Badische Anilin-und Soda-Fabrik A.G. (BASF), a large integrated chemical-mining company, which also became the parent firm of Alwinsal Potash of Canada Limited.

In East Germany, the potash industry has also been modernized during the past few years and production has been increasing steadily; output in 1970 reached an all time high of 2.4 million metric tons K_2O equivalent. A moderate increase in East German potash output is expected in 1971, followed by a substantial rise in 1972 when production starts from a new potash deposit near Magdeburg, some 85 miles north of Erfurt, the latter being the centre of the East German potash industry. The new Combine is reportedly designed to mine 24,000 tons of potash rock daily, almost equal to one-quarter of East Germany's current mining rate. Poland is apparently supplying a substantial part of the construction services and equipment for the Combine in return for potash shipments.

Poland has also been attempting to establish some potash production of its own: a pilot plant was reported to have begun operation late in 1968 to process some low-grade potash deposits near Klodawa, central Poland. The venture is believed to have proven uneconomic and Poland is now considering exploitation of some deep-lying deposits along the Baltic Sea coastline in the vicinity of Gdansk. Poland is a large consumer of potash; it imported 1.9 million metric tons of potash products in 1969, mostly from East Germany. East Germany has traditionally been Poland's chief supplier, although much of its rising demand for potash in recent years has been met by imports from West Germany, France and Spain. These three countries supplied almost 600,000 metric tons of potash products for Poland in 1969, but much of the Polish market is about to be taken over by shipments from the USSR. In 1963, USSR agreed to supply Poland with up to 600,000 metric tons of K_2O annually, in return for equipment and credits to expand output in the Soligorsk area; deliveries were to begin in 1971.

The Spanish potash industry has been steadily expanding its productive capacity during the past five years and has become a significant supplier of potash for the rest of Europe; substantial increases in output are expected over the next few years. In Italy construction began in 1969 at Carvillo, Sicily, on a 230,000-ton-a-year potassium sulphate plant; the new plant, scheduled for completion in 1971, will boost Italy's potash output by about one-third. In Israel, output rose sharply to 540,000 metric tons K_2O equivalent in 1970, up 50 per cent from the previous year. A further increase is expected in 1971. The Republic of Congo became a significant supplier of world potash in 1970. A 500,000-ton-a-year mine, controlled by the French potash industry, came on stream in 1969 and output in 1970 amounted to an estimated 240,000 metric tons K_2O equivalent. Further increases in output are expected in 1971 and 1972.

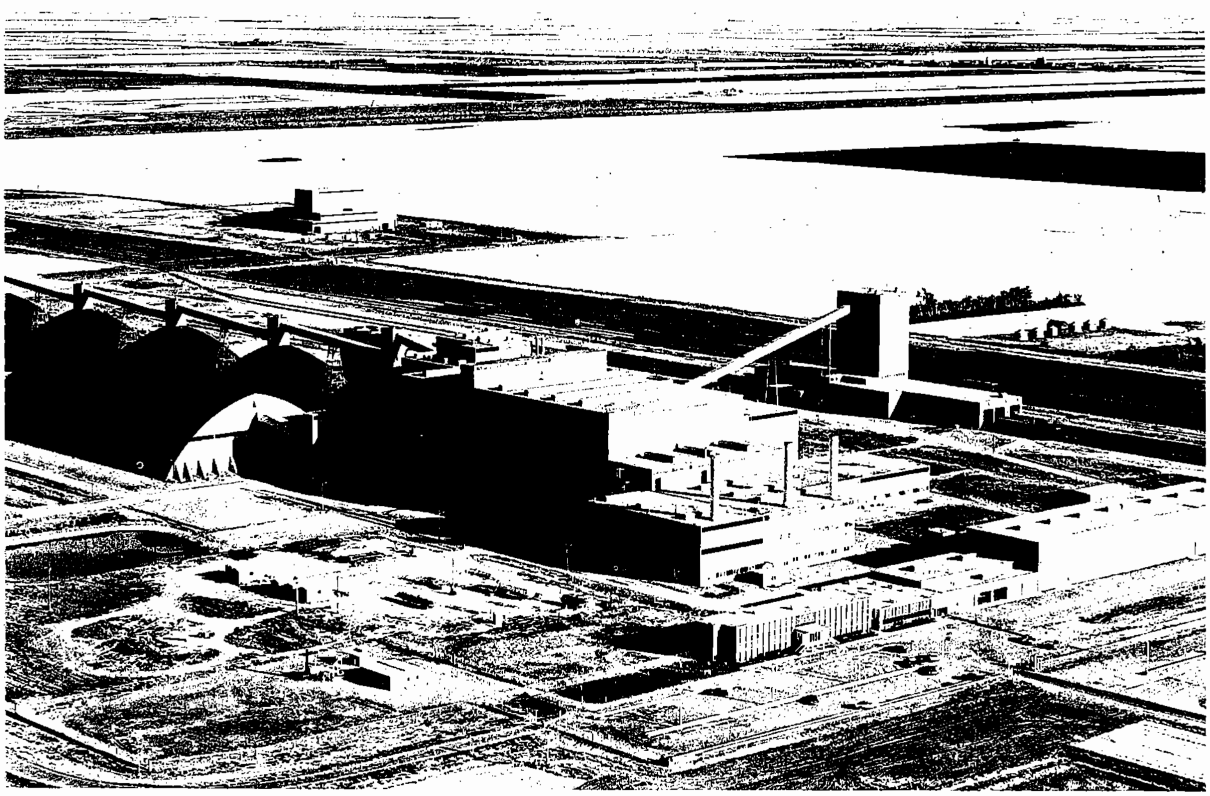
Construction is under way on Britain's first potash mine and there are plans for two more. Cleveland Potash Ltd., a joint venture financed by Charter Consolidated Ltd. and Imperial Chemical Industries Ltd., has started shaft-sinking for a $60-million mine near Staithes, Yorkshire. Production from the 1 million-ton-a-year mine is expected to begin in 1974. Two other companies, Yorkshire Potash Limited and Whitby Potash Ltd. have sought approval from local authorities to develop a second and third mine in the same area; as of early 1971, their plans were being held in abeyance. The Yorkshire deposits occur at a depth of 3,200 to 4,000 feet and grade 26 to 30 per cent K_2O equivalent.

OUTLOOK

The outlook for Canadian potash producers is one of cautious optimism. When the Saskatchewan potash controls came into being in January 1970, prices for Canadian potash in export markets were, in effect, boosted by about $10 a metric ton of product. The majority of United States producers followed but European producers boosted prices by only $3 to $4 a metric ton; likewise prices for Israeli and Congolese potash increased only marginally. The result has been a serious loss in the bargaining position of the Saskatchewan producers, a situation that was further compounded by increased ocean freight rates and by the floating and strengthening of the Canadian dollar in world exchange. Consequently, there has been considerable curtailment in Canadian offshore sales in exchange for higher prices.

Trade reports indicate that the European producers are expected to increase their prices for the 1971/72 fertilizer year. Should these increases bring the price of European potash up to the level of Canadian potash in export markets, Saskatchewan producers will be in a better position to compete for certain markets than they were in 1970. The potential sales of Canadian potash will also depend largely upon the quantity of USSR potash offered for export, and on output in Israel; essentially all of Israel's output is exported. In spite of some short-term optimism for the Saskatchewan producers, the long-term outlook is for continuing oversupply.

Kalium Chemicals Limited's potash complex at Belle Plaine, Saskatchewan. (Photo by Hunter)



Rare Earth Elements

D. PEARSON*

The rare earth elements are a series of 15 chemically similar materials. They are sometimes called the lanthanides having atomic numbers 57 to 71 in Group III B in the periodic table. These elements are listed in Table 1. Scandium and yttrium are similar to the rare earth elements in many respects and are usually classified with them.

TABLE 1

Rare Earth Elements

Atomic No.	Name	Abbreviation	Abundance in Igneous Rocks – parts per million
	Light Rare Earths		
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

*Mineral Resources Branch.

Looking at the abundance column in this table, cerium is more abundant than tin or cobalt and almost three times as abundant as lead. Thulium, the least abundant of the rare earth elements, is less rare than cadmium. These elements are therefore not "rare", neither are they "earths". The term was used by various authors in the eighteenth century to describe a material which today would be classed as an oxide of a metal.

Scandium and yttrium are not in the lanthanide series but are often included with the rare earth elements because they generally occur with and are similar to them. Based on their characteristics, the rare earth elements are divided into two groups, the light and heavy groups along with scandium and yttrium as illustrated in Table 1.

All the rare earths will be present in a particular mineral, but either the light (cerium) group or the heavy (yttrium) group will predominate. In general, granitic rocks are the most favourable for the concentration of the heavy rare earths; alkalic rocks and carbonatites tend to concentrate the cerium group. The relative abundance of the various rare earths in the ores presently being mined has no relationship 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 separated compounds, are available at higher cost. For some compounds, no significant market has yet been found. The problem has been, firstly, to develop markets for those compounds that are available and secondly, to find and develop sources of supply to meet changing industrial requirements.

A substantial increase in demand for products of the rare earth industry has occurred since 1963. Mine production and potential sources of production multiplied along with processing capacity. The main growth in dollar value was in high priced, high purity oxides of yttrium and europium for television phosphors. Oversupply began to affect producers in 1967 when the electronics industry realized that stocks of phosphors were excessive in relation to short-term market projections. Also, technological improvements in phosphor compositions resulted in a lowering of requirements. There was a pyramiding effect back through the supply pipeline so that ore supplies dependent upon the market for phosphors, particularly those containing yttrium, were faced with diminishing markets.

In the same period, lower priced rare earth products showed a marked increase in demand such as for applications in the glass industry and in catalysts for the petroleum refining industry. The availability of high purity compounds of all the rare earths resulted in increased basic research that will lead to future markets.

CANADIAN INDUSTRY

Since 1966, the world's major source of yttrium-bearing concentrate has been the uranium mines in the Elliot Lake district of Ontario. Here the minerals uranite, uranorthite, bannerite and monazite are mined and treated. With the exception of promethium, all the rare earth elements have been detected in these ores. Following the extraction of uranium, the rare earth elements and thorium are recovered from the effluent solution. Today, the market requirements for these elements makes only the yttrium oxide constituent of value. The Elliot Lake ores contain about 0.057 per cent rare earth oxides (REO) of which 20 to 40 per cent is yttrium oxide, 20 per cent cerium oxide and 10 to 20 per cent of neodymium. The other rare earth elements seldom exceed 5 per cent. The concentrates are sent to the United States and elsewhere for refinement.

In 1970, Denison Mines Limited was the only Canadian producer of the rare earth elements but full production was not maintained because demand for yttrium oxide fell during the second half of the year. Shipments of the concentrates for the past five years are summarized in the table below.

Canada–Rare Earth Concentrate Shipments
1966-1970

Year	Y_2O_3 in concentrate – pounds	Value
1970^p	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

Source: Dominion Bureau of Statistics.
^{p}Preliminary.

In addition to the Elliot Lake uranium ores, these elements are also associated with the uranium deposits at Agnew Lake, 40 miles to the east of Elliot Lake. The REO content of these deposits is about twice that of the Elliot Lake ores. Rare earth elements are also found in the Bancroft area of Ontario and in one deposit in British Columbia. The precise REO contents of these ores are not known. Other potential sources of the rare earth elements are phosphorite formations in western Canada and apatite or pyrochlore associated with carbonatite rocks.

Few laboratories are equipped to analyze rare earth samples so that a complete mineralogical description of each sample should be submitted to avoid misleading assays.

WORLD INDUSTRY

Monazite and bastnaesite are the two main mineral sources of the cerium group of rare earth elements. Monazite is the major source of both the lanthanides and thorium and is found in India, Brazil, Malaysia, Australia, Thailand, Malagasy Republic, and the United States. Many sources of the mineral are alluvial and the REO is recovered as a byproduct of the extraction of other minerals such as ilmenite, rutile, zircon and cassiterite. Bastnaesite is found in California but use is limited because it contains no thorium and has to be mined and concentrated. California contains what is probably the world's largest concentration of rare earth minerals in the Mountain Pass deposits of carbonatite which supplied about 55 per cent of the non-communist world's oxide requirement in 1970. The most important rare earth deposits in Europe are in the Kola Peninsula. The two most important minerals found in this area are loparite and apatite.

The Finnish producer Typpi Oy, is the only company that recovers rare earths by solvent extraction as a product of producing phosphate fertilizer from apatite. The source of the apatite is the apatite-nepheline mines in the Kola peninsula of the USSR. Many companies produce fertilizer from this source but do not recover the rare earth content.

Sometimes rare earth elements are obtained as a byproduct of the uranium industry such as in Canada. Other potential sources are Mary Kathleen Uranium Limited and Field Metals and Chemicals Pty. Limited in Australia.

There are processors of rare earth ores and concentrates in eleven countries. In the United States there are American Metallurgical Products Co., Inc., American Potash and Chemical Corporation (Rare Earth Division), W. R. Grace and Company (Davison Chemical Division), Michigan Chemical Corporation, Molybdenum Corporation of America, Ronson Metals Corporation (Cerium Metals and Alloys Division), Nuclear Corporation of America (Research Chemicals Division); in Austria, Treibacher Chemische Werke

Aktiengesellschaft; in France, Produits Chimiques Pechiney St. Gobain, Etablissements Tricot; in West Germany, Th. Goldschmidt A.G., Otavi Minen and Eisbahn Ges.; in Holland, Stemmler-Imex NV; in Finland, Typpi Oy; in Britain, British Rare Earths Limited, London and Scandinavian Metallurgical Company, British Flint and Cerium Manufacturers Limited, Rare Earth Products Limited (a joint venture of Thorium Ltd. and Johnson Matthey Chemicals Limited); in Japan, Shin-Etsu Chemical Industry Company, Nippon Yttrium Company, Ogino Chemical Company, Santoku Metal Industry Company; in India, Indian Rare Earths Limited; in Brazil, Commissao National de Energia Nuclear (Industrias Quimicas Reunidas). Production in the USSR is state controlled and output is sold through Techsnabexport.

Stocks of rare earth oxides stored in the United States government stockpile were declared surplus in March 1970 and 288 short dry tons of contained REO in rare earth sodium sulphate were sold.

Molybdenum Corporation of America announced a successful direct oxide to metal reduction process in October, establishing this company as a major producer of pure cerium and praseodymium metals. This breakthrough could be important to other countries when the demand for these metals improves.

USES

Consumption of rare earth elements is mainly in the form of compounds although occasionally the free metals are used in various technological applications. Probably the largest single use is in petroleum refining where lanthanum, neodymium and praseodymium compounds are used to increase the gasoline yield in the distillation step. The glass industry continues to use these oxides in substantial quantities. Cerium oxide is a very valuable abrasive and has found extensive application for grinding optical lenses. Lanthanum oxide is used in place of silica in camera lenses. In 1970, cerium concentrates were used for the decolourizing and stabilizing of container glass. Glazes, enamels and various refractory articles utilize some REO.

In ferrous and nonferrous metallurgy rare earth oxides are used to improve the quality of steel, copper, aluminum and magnesium alloys. Misch-metal, composed chiefly of cerium, lanthanum and neodymium has a steady outlet for making lighter flints. There is also a steady demand for the compounds in carbon arc electrodes.

A low volume application is in the electronic field where rare earth oxides are used as phosphors in colour television tubes, temperature compensating capacitors and associated circuit components. Yttrium aluminate crystals doped with neodymium are a laser grade material which is said to have exceptional qualities for this application. Samarium-cobalt is already in commercial production for permanent magnet manufacture. These have a strength twice that of the conventional permanent magnet. Also, a high energy magnetic material is made from cobalt-copper-cerium which is excellent for miniatured applications such as fractional direct current motors having added advantage that they do not lose their magnetism at high temperatures. Simulated diamonds are being made from yttrium oxide for the jewelry trade. Cerium oxide is a hydrocarbon catalyst used in modern self-cleaning ovens. Europium doped phosphors are being used to obtain an improved x-ray image with a lower x-ray dosage being required. Promethium combined with silicon in layers shows promise in a cardiac pacemaker. It is anticipated that this cell will operate continously for up to 10 years compared to 18 to 30 months now performed by the standard mercury battery for this device. It was reported that an efficient process for phosphate removal from sewage and waste water is possible using a lanthanum chemical.

Rare earth elements and their compounds have many unusual magnetic, optical and nuclear properties. Research to date has only examined a small portion of the potential for new uses of these materials.

PRICES

Prices for rare earth elements as quoted in the December 28, 1970 issue of *Metals Week* did not alter from those in 1969. Monazite sand c.i.f. United States ports remained at $180 to $200 a long ton. Bastnaesite concentrates, f.o.b. California were quoted at 30 cents a pound for 55 to 60 per cent grade and 35 cents a pound for 68 to 72 per cent grade. Calcined oxide from this source assaying 88 to 92 per cent rare earth oxide was quoted at 45 cents a pound.

Prices of the refined products vary considerably depending upon purity, demand and whether in the oxide or metal state. Some typical prices as quoted in the *American Metal Market* for January 20, 1971 are as follows: 99.9 per cent pure cerium oxide costs $7.50 a pound compared to $1.20 per pound for the commercial grade. Cerium metal was quoted at $50 a pound. Yttrium oxide is $38 a pound and the pure metal costs $160 a pound. The oxides of lanthanum, samarium and thulium are $4.50, $40 and $1,376 a pound respectively compared to $50, $145 and $2,750 a pound for the metals.

Salt

W.E. KOEPKE*

Demand for salt was generally strong in 1970 and the prospects are for continuing strong demand in 1971 and 1972. Markets for salt to control snow and ice on highways and city streets were particularly buoyant in Canada and the northern United States in the winter of 1970 and output increased accordingly. Domestic demand for salt to manufacture caustic soda and chlorine had been unusually strong in the mid-1960's but eased somewhat from 1968-70, partially as a result of some slack in the pulp and paper industry. These two markets–snow and ice control and the manufacture of caustic soda and chlorine–together account for about two thirds of Canada's salt consumption.

Canada's salt industry in 1970 can be summarized as follows: Three rock salt mines were operated at capacity; seven evaporator plants were in operation throughout the year; one evaporator plant was closed; and brining at one caustic soda and chlorine plant was suspended.

PRODUCTION AND DEVELOPMENTS IN CANADA

Canadian salt production falls into three statistical classes: mined rock salt; fine vacuum salt; and salt content of brines used or shipped and salt recovered in chemical operations. Refer to Table 3 for a listing of the various plants; plants described as brining for vacuum pan evaporation are classified as producers of fine vacuum salt, and other two classes being self-explanatory. Total salt production (shipments) in Canada in 1970 was 5,052,000 tons valued at $34.2 million. Both the tonnage and value were considerably higher than in 1969, much of the increase being attributed to the fact that part of the industry had been plagued by labor disputes in 1969. Production of mined rock salt accounted for two thirds of Canada's total salt output and amounted to 3,360,000 tons in 1970 compared with 3,007,256 tons in 1969. Output of fine vacuum salt and salt brines increased only marginally.

DEPOSITS AND OCCURRENCES

Salt occurs in solution in sea-water, in some spring and lake waters, in many subsurface waters, and in solid form in surface and underground deposits. Although sea-waters 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 Quebec and British Columbia. They have also been found in the District of Mackenzie, Northwest Territories, and there is geological evidence that suggests the presence of 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. Small quantities are produced from natural subsurface brines in Manitoba. In past years, salt has been recovered from brine springs in Nova Scotia, New Brunswick, Ontario, Manitoba, Saskatchewan and Alberta. Salt springs are also common to southwestern Newfoundland and in certain parts of British Columbia.

*Mineral Resources Branch.

TABLE 1

Canada, Salt Production and Trade, 1969-70

	1969		1970p	
	Short Tons	$	Short Tons	$
Production (shipments)				
By type				
Mined rock salt	3,007,256	15,307,123	3,360,000e	
Fine vacuum salt	557,028	11,787,841	571,000e	
Salt content of brines used or shipped and salt recovered in chemical operations	1,093,481	3,311,145	1,121,000e	
Total	4,657,765	30,406,109	5,052,000	34,248,000
By province				
Ontario	3,760,042	19,104,176	3,958,000	21,366,000
Nova Scotia	500,965	6,022,912	582,000	7,300,000
Alberta	246,861	2,410,922	250,000	2,039,000
Saskatchewan	107,290	2,137,883	237,000	3,358,000
Manitoba	42,607	730,216	25,000	185,000
Total	4,657,765	30,406,109	5,052,000	34,248,000
Imports				
Total salt and brine				
United States	290,670	2,192,000	291,878	2,153,000
Mexico	321,043	477,000	299,497	550,000
Spain	40,363	159,000	25,121	101,000
West Germany	26	10,000	1,043	17,000
Norway	302	17,000	400	12,000
Portugal	–	–	70	. . .
Other countries	43,234	232,000	12	7,000
Total	695,638	3,087,000	618,021	2,840,000
Exports				
United States	. .	5,050,000	. .	7,131,000
Cuba	. .	1,000	. .	231,000
New Zealand	. .	7,000	. .	22,000
Leeward and Windward Islands	. .	10,000	. .	10,000
Nigeria	. .	–	. .	9,000
Other countries	. .	39,000	. .	27,000
Total	. .	5,107,000	. .	7,430,000

Source: Dominion Bureau of Statistics.
pPreliminary; . . Not available; – Nil; . . . Less than one thousand dollars; eEstimated.

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 Salina Formation of Upper Silurian age and ranging in depths from 900 to 2,700 feet, can be identified and traced from drilling records. Maximum bed thickness is 300 feet with aggregate thicknesses reaching as much as 700 feet. The beds are relatively flat lying and undisturbed thereby permitting easy exploitation.

In 1970, these beds were being exploited through two rock salt mines–one at Goderich and one at Ojibway–and through brining operations at four centres, Goderich, Sarnia, Windsor and Amherstburg.

In mid-year, Domtar Chemicals Limited started work on a second phase of a two-phase expansion program which will boost the productive capacity of

TABLE 2

Canada, Salt Production and Trade, 1956-70
(short tons)

	Production*				Imports	Exports
	Mined Rock	Vacuum	In Brines	Total		$
1956	640,027	428,956	521,821	1,590,804	319,124	2,286,830
1957	786,975	422,977	561,607	1,771,559	367,483	3,241,119
1958	787,032	438,394	1,149,766	2,375,192	340,887	2,917,269
1959	1,221,999	459,857	1,304,081r	2,985,937r	369,967	4,639,522
1960	1,322,856	433,538	1,226,341r	2,982,735r	191,940	3,461,366
1961	1,294,988	446,712	1,210,534r	2,952,234r	199,365	2,829,138
1962	1,845,393	463,093	1,013,896r	3,322,382r	245,836	3,987,668
1963	1,771,242	486,940	1,132,537r	3,390,719r	332,581	3,701,356
1964	1,874,225	537,553	1,225,365r	3,637,143r	405,574	3,618,569
1965	2,399,919	558,346	1,289,796r	4,248,061r	441,601	4,996,509
1966	2,180,671	571,497	1,376,654r	4,128,822r	509,548	3,588,000
1967	3,023,397	554,337	1,417,894r	4,995,628r	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
1970p	3,360,000	571,000	1,121,000	5,052,000	618,021	7,430,000

Source: Dominion Bureau of Statistics.
* Producers' shipments.

p Preliminary; r Revised.

its Goderich salt mine to 2.25 million tons of salt annually by 1972. The first phase involved an $836,000 expenditure to expand storage facilities and hoisting capacity and the second phase involves a $5.8 million expansion of the mill and underground workings. In 1969, New United Salt Mines Limited began plant reconstruction and brine well rehabilitation at an old salt producing property in Warwick Township, Lambton County, about 22 miles east of Sarnia. Plans were for a small plant to supply local markets with flake and fine salt; a small quantity of salt was apparently produced in 1970 and early 1971.

ATLANTIC PROVINCES

Salt deposits occur in isolated sub-basins of a large sedimentary basin that underlies the northern mainland of Nova Scotia, and extends westward under the bordering areas of New Brunswick and northeastward under Cape Breton Island. The sub-basins are as follows: Weldon-Gautreau and Westmorland in New Brunswick; and Cumberland, Minas, Antigonish-Mabou and Sydney in Nova Scotia. The Nova Scotia deposits occur within the Windsor Group of Mississippian age and are generally folded and faulted. The deposits appear to be steeply dipping tabular bodies or domes and brecciated structures of rock salt; depths range from 85 feet to several thousand feet with thicknesses up to 1,500 feet.

The rock salt deposits in Prince Edward Island occur at a depth of over 14,000 feet, and in southeastern Newfoundland, salt has been found in the St. Fintan's area at a depth of about 1,000 feet. The latter deposit occurs within the same rock sequence as those in Nova Scotia and is believed to be of the tabular-dome type.

Exploitation of salt deposits in the Atlantic Provinces in 1970 was confined to one rock salt mine and an associated evaporator plant at Pugwash, Nova Scotia, and a brining operation at Amherst, Nova Scotia. During the last few years, at least three companies conducted further exploration of salt deposits under mainland Nova Scotia and Cape Breton Island. In New Brunswick, the Department of Natural Resources headed a joint federal-provincial exploration program, in which two tests drilled in Kings County early in 1971, encountered thick sections of salt.

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 occur-

TABLE 3

Canada, Summary of Salt Producing and Brining Operations, 1970

Company	Location	Initial Production	Remarks
The Canadian Rock Salt Company Limited	Pugwash, N.S.	1959	Rock salt mining at a depth of 630 feet.
	Pugwash, N.S.	1962	Dissolving rock salt fines for vacuum pan evaporation.
Domtar Chemicals Limited	Amherst, N.S.	1947	Brining for vacuum pan evaporation.
Allied Chemical Canada, Ltd.	Amherstburg, Ont.	1919	Brining to produce soda ash.
The Canadian Rock Salt Company Limited	Ojibway, Ont.	1955	Rock salt mining at a depth of 980 feet.
The Canadian Salt Company Limited	Windsor, Ont.	1892	Brining, vacuum pan evaporation and fusion.
Dome Petroleum Limited	Sarnia, Ont.	1969	Brining to develop storage cavity.
Dow Chemical of Canada, Limited	Sarnia, Ont.	1950	Brining to produce caustic soda and chlorine.
Domtar Chemicals Limited	Goderich, Ont.	1959	Rock salt mining at a depth of 1,760 feet.
	Goderich, Ont.	1880	Brining for vacuum pan evaporation.
The Canadian Salt Company Limited	Neepawa, Man.	1932	Natural brines for vacuum pan evaporation. Ceased operation Jan. 1970
Dryden Chemicals Limited	Brandon, Man.	1968	Pumping natural brines to produce caustic soda and chlorine.
Interprovincial Co-Operatives Limited	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.	1948	Brining, vacuum pan evaporation and fusion.
Chemcell Limited	Two Hills, Alta*	1953	Brining to produce caustic soda and chlorine.
Dow Chemical of Canada, Limited	Ft. 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.

* Brining was suspended in 1970.

TABLE 4

World Salt Production, 1969P
('000 short tons)

United States	44,245
China	16,500
USSR	12,677
Britain	9,484
West Germany	9,213
India	7,033
France	5,346
Canada	4,658
Italy	4,345
Other countries	34,481
Total	147,982

Source: U.S. Bureau of Mines Minerals Yearbook Preprint 1969.

P Preliminary.

ring in Upper Devonian rocks. Depths range from 600 feet at Fort McMurray, 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 are relatively flat lying and undisturbed. The same rock sequence contains a number of potash beds that are being exploited in Saskatchewan.

These rock salt deposits were being exploited at five locations in the Prairie Provinces in 1970–Saskatoon and Unity, Saskatchewan, and Lindbergh, Two Hills, and Ft. Saskatchewan, Alberta. In addition, naturally occurring subsurface salt brines in Manitoba were being used to produce caustic soda and chlorine at Brandon. Natural subsurface brines had also been used to make fine salt at Neepawa until the plant was closed in January 1970, following the start-up in October 1969 of the Canadian Salt Company's new salt processing and packaging plant at Belle Plaine, Saskatchewan. Chemcell Limited suspended brining operations in 1970 at Two Hills, but the decrease in salt output was more than offset by increased production at the nearby Ft. Saskatchewan plant of Dow Chemical.

RECOVERY METHOD

Canadian producers employ three different methods for the recovery of salt from depth for the production of dry salt and for the direct use in 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. Recovery of salt from natural subsurface brines is accomplished in a similar manner.

A third method of recovering salt is as a co-product of potash mining, a practice quite common in Europe. In Canada, this technique is being used on a commercial scale at only one potash mine, the mine being of the solution type, which lends itself to the recovery of a good-quality salt brine; the other potash producers regard the byproduct salt as unmarketable, although occasional shipments have been made for snow and ice control.

A fourth method of producing salt 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 feet to 1,760 feet. Mining is normally by the room-and-pillar method, the room-and-pillar dimensions being dependent upon 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, 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; removal of remaining amounts of these impurities from small proportions of the coarser salt fractions is achieved with the use of electronic sorters.

Most of the mined rock salt in Canada is shipped in bulk via 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 bore hole 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

TABLE 5

Canada, Available Data on Salt Consumption, 1967-70
(short tons)

	1967	1968	1969	1970[e]
Industrial chemicals	1,725,105[r]	1,737,685[r]	1,735,117[r]	1,750,000
Snow and ice control[e]	1,400,000	1,600,000	1,800,000	1,900,000
Slaughtering and meat packing	50,461	51,735	46,609	50,000
Food processing				
Fish products	28,729	17,337	20,559	20,000
Bakeries	20,266	14,656	14,928	15,000
Miscellaneous food preparations	17,991	15,994	17,541	18,000
Fruits and vegetable preparations	21,126	19,742	20,554	21,000
Other food processing	3,320	3,279	3,224	3,300
Breweries	713	643	649	700
Dairy factories and process cheese	9,566	9,015	11,912	12,000
Leather tanneries	5,891	9,437	7,957	9,000
Soaps and cleaning preparations	3,100	2,780	2,812	3,000
Dyeing and finishing textiles	1,434	1,499	1,502	1,500
Artificial ice	129	700	728	700
Pulp and paper mills	61,995	54,542	58,725	60,000
Feed and farm stock	49,103	48,504	48,301	50,000
Flour mills	911	1,662	1,597	1,600
Fishing industry[e]	75,000	75,000	80,000	80,000

Source: Dominion Bureau of Statistics.
[e] Estimated; [r] Revised figures for industrial chemicals in 1967-69 and for the previous three years as follows: 1964 1,543,659 tons; 1965 1,407,363 tons; 1966 1,602,333 tons.

Canada range from 1,100 feet 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 dry 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 producing a fused salt, which is particularly suited 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 in 1970 was 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 1.9 million tons in 1970.

In the 1969 edition of the Canadian Minerals Yearbook it was stated that prior to 1967, Canada's largest consumer of salt was the industrial chemical industry, which used it mainly for the manufacture of caustic soda (sodium hydroxide) and chlorine. On the basis of revised figures, the chemical industry remained the largest consumer until 1969. About 1.6 tons of salt are required to produce 1 ton of caustic soda and a proportionate amount of chlorine. In 1970, 23 caustic soda-chlorine plants with a combined annual productive capacity of about 1 million tons of caustic soda and 860,000 tons of chlorine operated in

Canada. As indicated in Table 3, salt for five caustic soda-chlorine plants is obtained from on-site brining. With the exception of three plants in the west coast area, most of the remaining caustic soda-chlorine manufacturers acquire their salt from domestic suppliers. Production of these two chemicals in Canada in 1970 was 947,639 tons of caustic soda (as 100 per cent NaOH) and 839,726 tons of chlorine compared with 943,639 tons and 834,818 tons, respectively, in 1969. The pulp and paper and petro-chemical industries are large consumers of caustic soda and chlorine. 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 bulk of Canada's salt exports go to United States, mostly in the form of mined rock salt.

Most of Canada's salt imports serve west coast markets and consist of solar salt from the San Francisco Bay area of United States, Mexico and the Bahamas. Solar salt contains 3 to 4 per cent moisture but this presents no problem when being used in chemical manufacture or the fishing industry. Small quantities of the solar salt are dried and processed by Domtar Chemicals at Port Mann, near Vancouver, British Columbia, for sale in west coast markets. Salt imports from Spain are largely for the fishing industry on the east coast. Substantial amounts of mined rock salt are also imported into Ontario and Quebec for snow and ice control.

TARIFFS

The Kennedy Round of the General Agreement on Tariffs and Trade (GATT), that was convened in 1964 to consider reductions in tariffs, submitted its report in 1967. Agreement was reached on a series of tariff reductions on salt with reductions beginning on January 1, 1968. Some of the reductions made by Canada and United States are as follows:

	British Preferential	Most Favoured Nation	General
CANADA			
Common salt (including rock salt)			
Jan. 1, 1970 to Dec. 31, 1970 - per 100 lb	free	1¢	5¢
Jan. 1, 1971 to Dec. 31, 1971 - per 100 lb	free	½¢	5¢
Jan. 1, 1972 to Dec. 31, 1972 - per 100 lb	free	free	5¢
Salt for use of the sea or gulf fisheries	free	free	free
Table salt made by an admixture of other ingredients, when containing not less than 90% of pure salt			
Jan. 1, 1970 to Dec. 31, 1970 - per 100 lb	5%	7%	15%
Jan. 1, 1971 to Dec. 31, 1971 - per 100 lb	5%	6%	15%
Jan. 1, 1972 to Dec. 31, 1972 - per 100 lb	5%	5%	15%
Salt liquors and sea water	free	free	free
UNITED STATES			
Salt, in brine			
Jan. 1, 1970 to Dec. 31, 1970		7%	
Jan. 1, 1971 to Dec. 31, 1971		6%	
Jan. 1, 1972 to Dec. 31, 1972		5%	

TARIFFS (Cont'd)

Salt, in bulk	
Jan. 1, 1970 to Dec. 31, 1970	1.15¢ per 100 lb
Jan. 1, 1971 to Dec. 31, 1971	1 ¢ per 100 lb
Jan. 1, 1972 to Dec. 31, 1972	.8 ¢ per 100 lb
Salt, other	
Jan. 1, 1970 to Dec. 31, 1970	1 ¢ per 100 lb
Jan. 1, 1971 to Dec. 31, 1971	.5 ¢ per 100 lb
Jan. 1, 1972 to Dec. 31, 1972	free

Sand and Gravel

D.H. STONEHOUSE*

Construction activity in Canada, particularly in the heavy – or engineering – construction category, influences and even regulates the production of sand and gravel. The general upward trend in output experienced during the 1960's was sharply peaked during 1966 and 1967 in support of major requirements initiated by the Expo '67 construction surge. The demand decreased during post-Expo years and will tend to stabilize to a more normal annual increment closely related to the volume of construction performed and represented by constant dollars. Work stoppages and labour unrest in the construction industry, combined with the high costs of construction have had a dampening effect on the industry with a resultant decrease in demand for all mineral aggregates.

Total sand and gravel production for 1970 is estimated at 194,100,000 tons valued at $117,400,000. This compares with 201,581,498 tons and $122,159,146 for 1969 and represents about 2 per cent of the total value of Canada's 1970 mineral production.

THE CANADIAN INDUSTRY

Sand and gravel deposits are widespread throughout Canada and large producers have established "permanent" plants as economically close as possible to major consuming centres. Urban expansion has greatly increased the demand for sand and gravel in support of major construction. Paradoxically the urban spread has not only tended to overrun operating pits and quarries but has extended at times over areas containing these mineral 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. They must locate industry such that the environmental effects of plant operations will be minimal. Also provision must be made for rehabilitation of pit and quarry sites in order to ensure the best sequential land use – a profitable operation in many instances.

Besides 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 a small and local, continuing market. These are usually operated on a seasonal or part-time basis. Many larger operations are short-term, serving as a supply arm of a heavy construction company and providing material for a given project. Departments of highways operate regional or divisional quarries to supply roadbed material for new and repair work.

The frequency with which small quarries and pits materialize to supply short-lived, local demands, and are abandoned, leaving unsightly properties along highways and near expanding towns, has prompted action by municipal and provincial governments to control such activity.

*Mineral Resources Branch.

TABLE 1

Canada–Production (Shipments) Sand and Gravel by Provinces, 1968-1970

	1968		1969		1970p	
	Short Tons	$	Short Tons	$	Short Tons	$
Production (Shipments), by provinces						
Newfoundland	3,812,003	3,632,018	3,957,022	3,742,412	3,500,000	3,200,000
Prince Edward Island	383,165	563,142	902,218	451,500	900,000	500,000
Nova Scotia	9,380,262	8,078,650	9,167,109	8,913,502	9,000,000	8,500,000
New Brunswick	6,361,658	2,139,790	3,993,628	1,391,158	7,000,000	1,900,000
Quebec	42,955,933	17,613,824	41,500,000	17,222,000	35,000,000	13,500,000
Ontario	84,095,642	55,094,706	82,657,386	46,245,525	85,000,000	48,400,000
Manitoba	9,563,927	5,951,628	8,142,268	5,053,794	9,500,000	6,500,000
Saskatchewan	9,167,702	5,149,600	7,673,225	3,369,132	7,700,000	3,400,000
Alberta	13,600,098	10,739,614	14,903,937	10,530,148	14,000,000	10,000,000
British Columbia	25,914,119	20,537,581	28,684,705	25,239,975	22,500,000	21,500,000
Canada	205,234,509	129,500,553	201,581,498	122,159,146	194,100,000	117,400,000

Source: Dominion Bureau of Statistics.
pPreliminary.

TABLE 2

Canada–Production (Shipments) Sand and Gravel by Uses, 1968-69

	1968		1969	
	Short Tons	$	Short Tons	$
Sand and gravel				
Fill	14,110,524	5,915,268	14,433,573	5,543,649
Back fill for mines	1,995,806	456,593	1,281,412	526,917
For roads (road bed surfaces)	86,586,882	33,881,908	75,038,464	28,842,047
Concrete aggregate – sand	16,359,620	15,325,652	13,249,370	11,286,845
– gravel	6,317,359	6,901,283	4,790,541	4,492,021
Asphalt aggregate – sand	3,834,475	3,300,981	2,691,917	2,090,912
– gravel	5,896,180	3,528,608	1,445,056	977,337
Railroad ballast	1,639,379	656,709	1,638,942	562,848
Mortar sand	1,641,656	1,827,081	1,866,398	1,822,932
Other uses	970,380	1,251,388	979,101	1,574,481
Total	139,352,261	73,045,471	117,414,774	57,719,989
Crushed gravel				
Back fill for mines	25,482	19,419	–	–
Roads – (road bed, surface)	53,612,714	43,134,903	71,897,792	52,107,585
Concrete aggregate	5,639,014	6,262,018	5,741,182	5,680,331
Asphalt aggregate	2,796,427	3,142,546	2,476,872	2,596,054
Railroad ballast	1,412,112	1,278,888	1,548,603	1,413,714
Other uses	2,396,499	2,617,308	2,502,275	2,641,473
Total	65,882,248	56,455,082	84,166,724	64,439,157
Total Sand and Gravel	205,234,509	129,500,553	201,581,498	122,159,146

Source: Dominion Bureau of Statistics.

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 cost, making it necessary to utilize close-in reserves and influencing the scope of exploration for new deposits. The cost of transportation can be determined and can be used to calculate the value of the resource and hence assist in land valuation.

MARKETS AND OUTLOOK

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 cut-off between commercial sand and gravel. Material finer than 200-mesh is called silt or clay depending on the particle size. Sand and gravel have accumulated as river deposits, beach deposits or glacial deposits.

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 analyses, 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.

TABLE 3

Production (Shipments) Sand and Gravel, by Uses, by Area, 1968,1969
(short tons)

		Atlantic Prov.	Quebec	Ontario	Western Prov.	Canada
Fill	1968	821,393	1,264,629	7,579,681	4,444,821	14,110,524
	1969	244,788	1,255,605	7,125,675	5,807,505	14,433,573
Back fill for mines	1968	222,241	151,186	1,647,861	–	2,021,288
	1969	190,050	2,474	1,067,748	21,140	1,281,412
For roads (road bed, surface)	1968	16,828,219	37,587,989	51,491,874	34,291,514	140,199,596
	1969	14,995,269	35,106,330	57,582,405	39,252,252	146,936,256
Concrete aggregate	1968	1,142,200	2,942,443	15,218,359	9,012,991	28,315,993
	1969	1,116,192	3,569,195	10,308,408	8,787,298	23,781,093
Asphalt aggregate	1968	572,611	507,633	4,314,479	7,132,359	12,527,082
	1969	1,161,171	945,622	2,792,411	1,714,641	6,613,845
Railroad ballast	1968	209,241	12,775	564,480	2,264,995	3,051,491
	1969	207,924	267,711	828,864	1,883,046	3,187,545
Mortar sand	1968	41,483	81,674	1,282,603	235,896	1,641,656
	1969	21,342	195,672	1,422,331	227,053	1,866,398
Other uses	1968	99,700	407,604	1,996,305	863,270	3,366,879
	1969	83,241	157,391	1,529,544	1,711,200	3,481,376
Total	1968	19,937,088	42,955,933	84,095,642	58,245,846	205,234,509
	1969	18,019,977	41,500,000	82,657,386	59,404,135	201,581,498

Source: Dominion Bureau of Statistics.
– Nil.

TABLE 4

Canada–Exports and Imports of Sand and Gravel, 1968-1970

	1968		1969		1970	
	Short Tons	$	Short Tons	$	Short Tons	$
Exports						
Sand and gravel						
United States	496,230	535,000	457,760	625,000	1,239,692	1,936,000
West Germany	220	1,000	55	11,000	440	2,000
Guyana	4	...	10	1,000	15	1,000
Other countries	71	2,000	93	3,000	45	1,000
Total	496,525	538,000	457,918	640,000	1,240,192	1,940,000
Imports						
Sand and gravel n.e.s.						
United States	683,490	642,000	859,898	737,000	502,425	537,000
Netherlands	–	–	–	–	314	1,000
Total	683,490	642,000	859,898	737,000	502,739	538,000

Source: Dominion Bureau of Statistics.
– Nil; ... Less than one thousand dollars; n.e.s. Not elsewhere stated.

TABLE 5

Canada–Sand and Gravel, Production (Shipments) and Trade 1960 - 70
(short tons)

	Production	Imports	Exports
1960	192,074,498	885,604	209,172
1961	170,750,947	537,972	389,495
1962	181,245,762	838,894	354,107
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	194,100,000	502,739	1,240,192

Source: Dominion Bureau of Statistics.

Even the common products such as sand and gravel require a sales and distribution effort which depends upon forecast data supplied by monitoring relevant 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, schools, etc. 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 of 5 cents a ton-mile and more can become so large in total that alternate 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. The possibility of using a unit train and a distribution terminal served by trucks is being considered by some operators.

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 being tested.

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.

Selenium and Tellurium

ROBERT J. SHANK*

SELENIUM

Selenium occurs sparsely disseminated throughout the earth's crust in a wide variety of selenium-bearing minerals. None of these minerals occurs in sufficient concentration to allow commercial exploitation for their selenium content alone and production is derived as a byproduct of copper and lead refining.

Production of selenium in all forms in Canada in 1970 amounted to 604,300 pounds valued at $5,160,600, while refined production, from anode slimes and stockpiled material, was 852,452 pounds. Comparable production for 1969 was restated to be 599,415 pounds in all forms worth $3,428,653, with refined output being 820,277 pounds. Comparison of these results with statistics reported for previous years is meaningless because some selenium recovered from imported material was erroneously reported as Canadian production for those years. Domestic consumption amounted to 15,730 pounds compared with 15,572 pounds in 1969. The remainder of the refined production was exported, principally to the United States and Britain.

In the non-communist world, about 70 per cent of production is obtained from the treatment of ores mined in North America. United States, Canada, Japan, Sweden, Zambia, Belgium and Luxembourg, Australia, Finland, Mexico, and Peru are the main producing countries. There is also output from the USSR and other communist countries. Selenium supply is dependent upon copper production and, because of this, it is difficult to adjust supply to demand. There is limited recovery of selenium from secondary sources.

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 and 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 great variety of metallic and organic selenium compounds. Annual capacity is 450,000 pounds of selenium in metals and salts.

The 270,000-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%).

*Mineral Resources Branch.

TABLE 1

Canada – Selenium Production, Exports and Consumption, 1969-70

	1969		1970p	
	Pounds	$	Pounds	$
Production				
All forms[1]				
Quebec	403,370	2,307,276	338,800	2,880,000
Ontario	84,000	480,480	130,500	1,119,600
Manitoba	71,650	409,838	81,000	696,600
Saskatchewan	40,395	231,059	54,000	464,400
Total	599,415	3,428,653	604,300	5,160,600
Refined[2]	820,277		852,452	
Exports (metal)				
United States	525,800	3,469,000	450,400	4,416,000
Britain	266,900	1,525,000	203,900	1,603,000
Belgium and Luxembourg	–	–	10,000	49,000
Brazil	10,000	51,000	6,900	65,000
South Africa	19,600	10,000	3,000	37,000
Colombia	–	–	2,400	17,000
Netherlands	–	–	2,000	10,000
Other countries	50,000	360,000	7,500	63,000
Total	872,300	5,415,000	686,100	6,260,000
Consumption[3] (Selenium content)	15,572		15,730	

Source: Dominion Bureau of Statistics.
[1]Recoverable selenium content of blister copper treated at domestic refineries, plus refined selenium from domestic primary materials. [2]Refinery output from all sources. [3]Consumption of selenium products (metal, metal powder, oxide) selenium content, as reported by consumers.
pPreliminary; – Nil.

CONSUMPTION AND USES

Selenium is used in the glass, rubber, chemical, plastics, steel, and electronics industries and for xerography. Development of the dry-plate rectifier during World War II brought about a sharp increase in the demand for selenium that persisted into the post-war period. Selenium prices rose to such an extent that substitution in all applications took place and subsequently the demand and price for selenium declined. Stable supply and the efforts of the Selenium and Tellurium Development Association have gradually developed new markets and recaptured some of the lost markets. One of the fastest growing uses for selenium is in the plastics industry where selenium and cadmium sulphide are used to produce orange to maroon colours stable at high temperatures. These pigments are also used in the ceramic and paint industries and as colouring inks for printing on glass containers.

Selenium is used in glassmaking both as a decolorizer and as a colouring agent. Small quantities of selenium added to the glass batch help to neutralize the green colour imparted by iron in the glass sand. The brilliant red, ruby glass used in stop lights, signal lights, automotive taillights, marine equipment and decorative tableware, is produced by adding larger quantities of selenium to the glass batch. Selenium is also used in the production of glare-free glass. However, partial substitution of selenium by cerium oxide in the manufacture of glass was in evidence on a small scale during the year.

The chemical industry uses selenium as a catalyst in the manufacture of cortisone and nicotinic acid. Selenium and selenium compounds are used in the preparation of various proprietary medicines for the control of dermatitis in humans and animals, and for the correction of dietary deficiencies in animals.

TABLE 2

Canada–Selenium Production, Exports and Consumption, 1961-70 (pounds)

	Production		Exports	
	All Forms[1]	Refined[2]	Metals and Salts[3]	Consumption[4]
1961	430,612	422,955	345,800	13,160
1962	487,066	466,654	325,600	12,587
1963	468,772	462,385	445,700	12,424
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[p]	604,300	852,452	686,100	15,730

Source: Dominion Bureau of Statistics.
[1]Recoverable selenium content of blister copper treated at domestic refineries, plus refined selenium from domestic primary material. [2]Refinery output from all sources. [3]Exports of selenium metal, metal powder, shot, etc. [4]Consumption (selenium content), as reported by consumers.
[p]Preliminary.

TABLE 3

Non-Communist World Production of Selenium, 1968-70 (pounds)

	1968	1969	1970[e]
United States	633,000	1,229,000	1,000,000
Canada	635,510	599,415	604,300
Japan	399,000	435,000	450,000
Sweden	176,000	176,000	170,000
Zambia[e]	57,000	57,000	..
Belgium and Luxembourg	54,000	55,000	55,000
Other countries	57,000	96,000	125,000
Total	2,011,510	2,647,415	2,404,300

Sources: For Canada, Dominion Bureau of Statistics. For other countries U.S. Bureau of Mines Minerals Yearbook, Preprint 1969, for 1968 and 1969, and U.S. Bureau of Mines, Commodity Data Summaries, January 1971, for 1970.
[e]Estimated; . . Not available.

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 ageing and mechanical properties of sulphurless and low-sulphur rubber stocks. Selenac acts as an accelerator in butyl rubber.

Selenium, in proportions from 0.20 to 0.35 per cent improves the porosity of stainless steel castings. Ferroselenium (55 to 57 per cent Se) is added to stainless and lead-recarburized steels to improve their machineability and other properties.

TABLE 4

Canada – Industrial Use of Selenium, 1968-70 (pounds of contained Selenium)

	1968	1969	1970
By end-use			
Glass	10,787	12,624	12,089
Other*	10,653	2,948	3,641
Total	21,440	15,572	15,730

Source: Dominion Bureau of Statistics-Consumers' reports.
* Electronics, rubber, steel, pharmaceuticals.

OUTLOOK

There has been a persistent increase in the world consumption of selenium since 1968. The limitation on supply because of selenium's byproduct origin, has brought about competition for supplies between the major consuming areas. Producers' stocks have been reduced to low levels and supply will be only that which is available from copper and lead output as well as that available from scrap sources.

It is reasonable to assume that demand will exceed supply until resulting price increases induce sufficient substitution to bring supply and demand into balance.

PRICES

According to *Metals Week*, United States selenium prices throughout 1970, were as follows:

	Commercial Grade (per lb)	High Purity (per lb)
	$	$
Jan. 1 to Sept. 30	8.00	9.50
Oct. 1 to Dec. 31	9.00	10.50

TARIFFS

CANADA		British Preferential	Most Favoured Nation	General
Item No.				
92804-4	Selenium	5%	10%	15%
UNITED STATES				
632.40	Selenium metal, unwrought, waste and scrap		free	
632.84	Selenium and metal			
633.00	alloys, unwrought			
	On and after Jan. 1, 1970		12.5%	
	On and after Jan. 1, 1971		10.5%	
	On and after Jan. 1, 1972		9.0%	
420.50	Selenium dioxide		free	
420.52	Selenium salts		free	
420.54	Other compounds of selenium		5%	

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, T.C. Publication 304

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, Canadian Copper Refiners Limited at Montreal East, Quebec, and The International Nickel Company of Canada, Limited at Copper Cliff, Ontario. Canadian production of tellurium in all forms in 1970 was 58,900 pounds and refined tellurium production was 58,659 pounds. Comparable statistics for 1969 have been restated to be 62,048 pounds in all forms, and 72,644 pounds in refined form. Comparison with previous years is meaningless because tellurium recovered from imported material was erroneously reported as Canadian production for those years.

TABLE 5

Canada–Tellurium – Production and Consumption, 1969-70

	1969		1970p	
	Pounds	$	Pounds	$
Production				
All forms[1]				
Quebec	45,397	293,264	40,200	241,000
Ontario	5,610	36,241	7,400	44,600
Manitoba	7,065	45,640	6,800	42,600
Saskatchewan	3,976	25,685	4,500	28,200
Total	62,048	400,830	58,900	356,400
Refined[2]	72,644		66,634	
Consumption[3] (refined)	3,532		. .	

Source: Dominion Bureau of Statistics.
[1]Recoverable tellurium content of blister copper treated, plus refined tellurium from domestic primary material.
[2] Refinery output from all sources. [3]Consumption reported by consumers.
pPreliminary; . . Not available for publication.

TABLE 6

Canada–Production and Consumption of Tellurium, 1961-70
(pounds)

	Production		Consumption
	All Forms[1]	Refined[2]	Refined[3]
1961	77,609	81,050	4,843
1962	58,725	57,630	4,306
1963	76,842	79,640	1,853
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[p]	58,900	66,634	..

Source: Dominion Bureau of Statistics.
[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; [3]Consumption as reported by consumers.
[p]Preliminary; .. Not available for publication.

TABLE 7

Non-Communist World Production of Tellurium
(pounds)

	1968	1969	1970[e]
United States	121,000	234,000	200,000
Canada	70,991	62,048	58,900
Japan	31,000	51,000	50,000
Peru	35,000	38,000	40,000
Total	257,991	385,048	348,900

Sources: For Canada, Dominion Bureau of Statistics. For other countries, U.S. Bureau of Mines, Minerals Yearbook, Preprint 1969, for 1968 and 1969, and U.S. Bureau of Mines Commodity Data Summaries, January 1971, for 1970.
[e]Estimated.

CONSUMPTION AND USES

Tellurium is recovered from the same sources as selenium and therefore its production and growth of consumption are governed by the same factors. 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.

The metallurgical industry consumes a large part of the tellurium produced as a carbide stabilizing agent in the production of white cast iron, and as an additive to low carbon steel, free machining stainless steel, and cast iron.

Tellurium powder is added to molten iron to control the depth of chill in grey-iron castings. A 99.5 per cent copper and 0.5 per cent tellurium alloy is used in the manufacture of welding tips and in radio and communications equipment because it can be extensively cold-worked, has good hot-working properties, and high thermal and electric conductivity. Up to 0.1 per cent tellurium in lead forms a corrosion-resistant alloy used to sheath marine cables and to line tanks subject to chemical corrosion.

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. Although these devices have received increased attention, the amount of tellurium used in these applications has not risen as fast as was expected.

Rubber containing tellurium is resistant to heat and abrasion. Its principal use is for the jacketing of portable electric cables used in mining, dredging, welding, etc. Tellurium is added to sulphurless or low-sulphur stocks of natural and synthetic rubber in powder form or as tellurium diethyldithiocarbamate to improve the rubber's ageing and mechanical properties. The diethyldithiocarbamate compound also helps to reduce the porosity of thick rubber sections and, in combinations with mercaptobenzothiazol, is one of the fastest known accelerators for butyl rubber.

OUTLOOK

The growth in industrial uses of tellurium will be dependent on available supplies of the metal. Production should increase in proportion to increases in the production of refined copper.

PRICES

According to *Metals Week*, United States tellurium prices, throughout 1970 were as follows:

Powder, 100 lb lots
$6 per lb
Slab, 150 lb lots
$6 per lb

These prices prevailed, unchanged, throughout 1970.

TARIFFS

CANADA		British Preferential	Most Favoured Nation	General
Item No.				
92804-5	Tellurium	5%	10%	15%
UNITED STATES				
632.48	Tellurium metal, unwrought, waste and scrap			
	On and after Jan. 1, 1970		5.5%	
	On and after Jan. 1, 1971		4.5%	
	On and after Jan. 1, 1972		4.0%	
	Duty on waste and scrap suspended on or before 30 June 1972			
421-90	Tellurium compounds			
	On and after Jan. 1, 1970		7%	
	On and after Jan. 1, 1971		6%	
	On and after Jan. 1, 1972		5%	
427-12	Tellurium salts			
	On and after Jan. 1, 1970		7%	
	On and after Jan. 1, 1971		6%	
	On and after Jan. 1, 1972		5%	

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, T.C. Publication 304

Silica

P.R. COTE*

Production of silica in Canada in 1970 increased markedly over 1969 to reach 2.9 million tons valued at $8.6 million. In part, this increase was due to production from Indusmin Limited's new silica processing plant at Midland, Ontario. As in previous years, the majority of production was low-unit-value lump silica and silica sand used as metallurgical flux.

High-quality silicas sand suitable for the manufacture of glass is produced by two companies in Canada. Indusmin Limited, the largest, operates beneficiation plants in Ontario and Quebec. The Winnipeg Supply and Fuel Company, Limited quarries high-grade silica sandstone from a deposit on Black Island in Lake Winnipeg and processes the material at the company's plant located at Selkirk, Manitoba.

Canada imports high-grade silica sand for use in glass manufacture along with substantial quantities of sand suitable for foundry castings. In 1970, imports increased slightly over 1969 to reach 1.3 million tons valued at $5.3 million. Virtually all imports are from the United States. In 1970, some 9,000 tons of glass-grade silica sand was imported from Belgium to supply a new glass-container plant in New Brunswick.

Silica (SiO_2) in commercial quantities occurs in the earth's crust as the mineral quartz in unconsolidated sands, sandstones, quartzites and as vein quartz. The mineral is very abundant but it rarely occurs in sufficient tonnage and purity to be extracted profitably. Further, because of its low unit value, an economically viable deposit should be minable by low-cost, open-pit methods and be located close to consuming areas in order to minimize transportation costs. Principal consuming industries and uses for silica include: glass manufacture; metallurgical works, where silica is utilized as a flux; abrasives manufacture, where silica is used to produce ferrosilicon and silicon carbide; sand blasting; manufacture of silicon; foundry sands for metal castings; and filler materials in tile, asbestos pipe, cement blocks and bricks.

PRINCIPAL PRODUCERS AND DEVELOPMENTS

NEWFOUNDLAND

Newland 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 Electric Reduction Company of Canada, Ltd. (ERCO). 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 the company's 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 some 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; silica flour for use as a filler in tiles, asbestos pipe, cement 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.

*Mineral Resources Branch.

TABLE 1

Canada – Silica, Production and Trade 1969-70

	1969		1970	
	Short Tons	$	Short Tons	$
Production, quartz and silica sand[1]				
By province				
Ontario	865,384	427,163	1,522,000	2,766,000
Quebec	663,960	4,001,727	610,000	4,208,000
Manitoba	460,698	1,213,764	498,000	1,139,000
Saskatchewan	167,936	175,000	169,000	170,000
British Columbia	30,126	150,000	33,000	150,000
Newfoundland	104,887	263,261	. .	165,000
Nova Scotia	7,383	48,877	. .	12,000
Total	2,300,374	6,279,792	2,902,000	8,610,000
By use				
Flux	1,498,105	1,532,231		
Ferrosilicon	257,139	1,101,025		
Silicon carbide[2]	. .	. .		
Glass	257,875	2,211,748		
Other uses[3]	287,255	1,434,788		
Total	2,300,374	6,279,792		
Imports				
Silica sand				
United States	1,263,035	4,856,000	1,279,677	5,231,000
Norway	17,214	42,000	5,071	76,000
Belgium and Luxembourg	–	–	9,033	23,000
Finland	–	–	2,756	7,000
Sweden	4,968	88,000	–	–
West Germany	11	. . .	–	–
Total	1,285,228	4,986,000	1,296,537	5,337,000
Silex and crystallized quartz				
United States	33	67,000	200	86,000
Brazil	2	30,000	5	41,000
Britain	. . . .	6,000	. . . .	1,000
Total	35	103,000	205	128,000
	Thousands	$	Thousands	$
Firebrick and similar shapes, silica				
United States	935	876,000	2,010	1,849,000
West Germany	14	4,000	10	13,000
Total	949	880,000	2,020	1,862,000
	Short Tons	$	Short Tons	$
Exports				
Quartzite				
United States	81,471	222,000	64,945	149,000
Dominican Republic	17	. . .	–	–
Total	81,488	222,000	64,945	149,000

Source: Dominion Bureau of Statistics.

[1]Producers' shipments, including crude and crushed quartz, crushed sandstone and quartzite, and natural silica sand. [2]Confidential, included under "other". [3]Includes foundry uses, sand blasting, silica brick, concrete products, chemical manufacture, building products, and silicon carbide.

[p]Preliminary; – Nil; . . Not available for publication; . . . Less than one thousand dollars; . . . . Less than one ton.

TABLE 2

Canada – Silica – Production and Trade, 1961-70

(short tons)

	Production	Imports			Exports	Consumption
	Quartz and Silica Sand[1]	Silica Sand	Silex or Crystallized Quartz	Flint and Ground Flintstones	Quartzite	Quartz and Silica Sand
1961	2,194,054	693,210	10,327	1,339	26,774	2,648,265
1962	2,085,620	765,431	8,960	1,193	156,205	2,316,316
1963	1,836,612	787,157	11,887	1,812	47,437	2,413,498
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[r]
1969	2,300,374	1,285,228	35	..	81,488	3,526,264[r]
1970[p]	2,832,000	1,296,537	205	..	64,945	

Source: Dominion Bureau of Statistics.
[1] Includes silica to make silica brick.
[p] Preliminary; .. Not available; [r] Revised.

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.

E. Montpetit et Fils Ltée quarries sandstone in the Melocheville area for use by Chromium Mining & Smelting Corporation, Limited, in the manufacture of ferrosilicon, also in Beauharnois.

Baskatong Quartz Products produces lump silica and crushed quartz from a deposit on the southwestern 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.

ONTARIO

In mid-1968, Indusmin Limited announced plans to construct a silica grinding and processing plant at Midland, Ontario with feed material coming from a high-grade silica deposit on Badgeley Island, about 120 miles north of Midland, across Georgian Bay. The Badgeley Island deposit consists of very pure Precambrian Lorraine quartzite. The primary crushing plant located at the deposit was completed early in 1970 and the first shipment to Midland was made in May. The Midland plant was completed late in the second quarter of 1970 and start-up operations were initiated. Some difficulties were experienced with the sand classification circuit but by December a satisfactory product was being obtained and trial shipments were delivered to potential consumers. The Badgeley Island operation will have an initial capacity of approximately 3,000 tons a day of washed lump and fine material, while the Midland processing plant will have an estimated output of 500,000 tons of silica a year. Primary products from the crushing plant on Badgeley Island will be shipped either, directly to manufacturers of ferrosilicon and silicon metal, or to the Midland grinding plant for further processing. Products from the Midland plant will go to the glass, ceramic, chemical and other industries in Ontario. Capital expenditure on the total project at the end of 1970 stood at $5.8 million.

MANITOBA

The Winnipeg Supply and Fuel Company, Limited quarries friable sandstone of the Winnipeg formation at Black Island in Lake Winnipeg. The sandstone is then barged across Lake Winnipeg 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 while 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 use as metallurgical flux for The International Nickel Company of Canada, Limited's smelter at Thompson, Manitoba.

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.

TABLE 3

Canada, Available Statistics on Consumption of Silica by Industries, 1968 and 1969

	1968	1969
	Short Tons	Short Tons
Smelter flux*	1,961,094	1,498,105
Glass manufacture (incl. glass fibre)	366,484	580,019
Foundry sand	746,161[r]	818,796
Artificial abrasives	169,849	168,633
Ferrosilicon	147,495	173,580
Metallurgical use	87,195	88,292
Concrete products	23,738	28,985
Gypsum products	32,431	23,906
Asbestos products	38,614	36,525
Chemicals	21,925	19,876
Fertilizers, stock, poultry feed	30,488	20,950
Other	58,950[r]	68,597
Total	3,684,424[r]	3,526,264

Source: Dominion Bureau of Statistics for source data. Classification by Mineral Resources Branch.

*Producers' shipments of quartz and silica for flux purposes.

[r]Revised.

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

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 as they act as powerful colourants. For example, chromium should not exceed six parts per million; 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 in order 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 the crushing of friable sandstones 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 this 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 as round grains allow maximum permeability of the mould and maximum escape of gases 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 for the manufacture of sandpaper. Various grades of sand are used in water-treatment plants, as filtering media. Silica is also required in portland cement manufacture where there is insufficient silica in either 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 finding increased use in autoclave-cured concrete products such as building blocks and panels, in which case, approximately 45 pounds of silica flour is used for each 100 pounds of portland cement consumed.

QUARTZ CRYSTAL

Quartz crystal with desirable piezoelectric properties is used in radio-frequency control apparatus, 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 2 inches in length and 1 inch or more in diameter. Most of the world's crystal requirement is met by natural crystal from Brazil; however, natural crystal is being replaced by excellent quality, synthetic crystal grown in the laboratory from quartz 'seed'. Artificial quartz crystals come already oriented for the cutter. Purity of these crystals results in final product yields at least four times that of natural quartz crystal.

There is only a small demand for quartz crystal in Canada and no production. Domestic requirements are met largely by imports chiefly from Brazil and the United States. Quartz Crystals Mines Limited, Toronto, has produced minor tonnages from an occurrence near Lyndhurst, Ontario, however, there has been no production from this mine during the past few years.

PRICES

The price of the various grades of silica varies greatly, because it depends upon such factors as location of deposit, the purity and degree of beneficiation required, and market conditions. High-quality silica sand, in carload lots, sells for approximately $8 to $10 per ton in Montreal and Toronto.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General
29500-1	Ganister and sand	free	free	free
29700-1	Silex or crystallized quartz, ground or unground	free	free	free

UNITED STATES

513.11	Sand containing 95% or more silica, and not more than 0.6% of oxide of iron	
	On and after Jan. 1, 1970	35¢ per long ton
	On and after Jan. 1, 1971	30¢ per long ton
	On and after Jan. 1, 1972	25¢ per long ton
513.14	Sand, other	free
514.91	Quartzite, whether or not manufactured	free
523.11	Silica, not specially provided for	free

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, T.C. Publication 304

Silicon, Ferrosilicon, and Silicon Carbide

G.P. WIGLE*

Silica is the resource mineral from which silicon, ferrosilicon, and silicon carbide are made; silica† is also an important raw material in making other industrial products and is used in many industrial in-plant processes.

Canada's utilization of its silica resources is principally in the mining of silica as quartz, quartzite, sandstone, and silica sand, with beneficiation to sized and graded products. The products are used as metallurgical flux, in construction materials, in glass manufacture, in foundry and abrasive cleaning sands, in making ferrosilicon, silicon carbide and other abrasive products, and in the manufacture of various silicon alloys for domestic and export markets. The more important silicon alloy exports in 1970 were: 105,996 tons of silicon carbide valued at $15,976,000 and 49,984 tons of ferrosilicon valued at $8,284,000.

Elemental silicon always occurs combined with oxygen as silica or in the form of silicates with other mineral elements. In these forms it accounts for about 25 per cent of the earth's crust. Silicon is second only to oxygen in order of abundance in the earth's crust. The mineral source of silica (SiO_2) for use in the metallurgical production of silicon and silicon alloys is usually quartz, quartzite, sandstone, or silica sand containing about 98 per cent silica. Silicon is not a metal in the usual association of the term because it lacks ductility and electrical conductivity. It is solid, hard, and has a grey metallic luster but is brittle rather than ductile and its conductivity is intermediate between that of conductors and insulators, exhibiting the property of semiconduction important to its electronic applications.

Silicon in the forms of ferrosilicon alloys and metallurgical silicon metal is the most extensively used deoxidizer in steelmaking. Silicon is used in alloys of iron and steel, aluminum, and copper, and in the preparation of silicones, silicates and other chemical products.

High-purity silicon crystal "doped" with traces of elements such as boron or phosphorus, is one of the most important semi-conductors for use in transistors, diodes, and rectifiers.

SILICON IN STEEL AND IRON

Silicon, intruduced in the form of ferrosilicon into the molten steel, is used as an alloying agent to a lesser extent than, for example, manganese or chromium but steels containing more than 0.5 per cent silicon are important alloy steels. Electric steels (sheet), containing from 0.5 to 5 per cent silicon, used in the construction of transformers, generators and electric motors are probably the most important silicon-containing alloy steels. Steel for leaf springs has a silicon content ranging from 0.5 to 2 per cent. Manganese is also used in spring steel and the ferroalloy silicomanganese can be used to introduce both elements at the same time.

The silicon content of the iron is second only to its carbon content in regard to its effectiveness in controlling the properties of iron castings. It is generally held to amounts of between 0.5 and 3.0 per cent because machinability may be adversely affected above 2 per cent and as it is increased above 3.5 per cent it makes the iron matrix more and more brittle,

*Mineral Resources Branch.
†See Silica, No. (41 in 1970) Preprint Series of Mineral Reviews.

TABLE 1

Canada, Ferrosilicon, Silicon Carbide, and Some Other Ferroalloys*, Exports and Imports, 1969-70

	1969		1970	
	Short Tons	$	Short Tons	$
Exports				
Ferrosilicon				
Britain	28,170	3,266,000	26,281	4,336,000
United States	18,394	1,756,000	13,527	1,551,000
Australia	394	70,000	2,839	659,000
Japan	–	–	2,542	578,000
Philippines	248	31,000	1,669	387,000
Netherlands	–	–	1,134	369,000
Other countries	1,293	134,000	1,992	404,000
Total	48,499	5,257,000	49,984	8,284,000
Silicon carbides, crude and grains				
United States	103,501	14,974,000	103,022	15,377,000
Norway	–	–	2,953	595,000
Other countries	–	–	21	4,000
Total	103,501	14,974,000	105,996	15,976,000
Ferroalloys, n.e.s.				
Britain	554	138,000	640	2,139,000
India	7	5,000	180	847,000
United States	2,176	587,000	1,129	819,000
Netherlands	–	–	1,449	160,000
Other countries	483	135,000	697	285,000
Total	3,220	865,000	4,095	4,250,000
Imports				
Ferrosilicon				
United States	7,994	1,770,000	9,509	2,145,000
Norway	920	213,000	813	196,000
France	2	1,000	97	39,000
South Africa	106	20,000	22	4,000
Britain	28	6,000	5	2,000
Total	9,050	2,010,000	10,446	2,386,000
Silicomanganese, incl. Silico spiegel				
United States	120	35,000	316	81,000
Norway	920	139,000	372	72,000
South Africa	3,519	545,000	387	67,000
Total	4,559	719,000	1,075	220,000
Ferroalloys n.e.s.				
United States	2,860	2,279,000	4,905	2,062,000
Britain	147	354,000	1,564	1,356,000
France	771	232,000	717	294,000
Brazil	11	34,000	71	225,000
West Germany	660	210,000	83	34,000
Norway	30	10,000	–	–
Total	4,479	3,119,000	7,340	3,971,000

Source: Dominion Bureau of Statistics.

*Important other ferroalloys are discussed in the mineral reviews of the respective metals, e.g. those of manganese, nickel, titanium, etc.

n.e.s. Not elsewhere specified; – Nil.

forming silvery iron. However, silicon from 1.5 to 4.5 per cent increases the resistance of iron to atmospheric and acid corrosion; more than 10 per cent greatly protects the metal from oxidation and chemical attack. Silicon is introduced into cast iron in the cupola charge as silvery pig iron or as ferrosilicon. Another popular additive is ferrosilicon in briquette form.

Among the elements used in steelmaking, silicon is a stronger deoxidant than chromium or manganese and is cheaper than aluminum or titanium. These facts and the need for a small silicon content in many types of steel makes silicon, in the form of ferrosilicon, the deoxidizing agent most widely used in the steel industry.

The amount of gases, chiefly oxygen, dissolved in liquid steel and the amount of gases released during solidification determine the types of ingots: semi-killed, capped and rimmed. The amount of oxygen dissolved in molten steel is dependent upon 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 sufficiently for it to lie perfectly quiet when poured into an ingot mould. The amount of silicon added to a killed steel will be from about 0.1 to 0.5 per cent. The other three types require lesser amounts, down to nil or 0.05 per cent in a rimmed steel which evolves considerable gas in the ingot mould as the remaining oxygen reacts with carbon.

TABLE 2

Ferrosilicon Consumption and Steel Production in Canada, 1960-70

	Crude Steel Production (short tons)	Ferrosilicon Consumption (pounds/ton Steel)
1960	5,809,000	4.0
1961	6,488,000	3.5
1962	7,173,000	3.6
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	9,694,000	3.8
1968	11,251,000	4.2
1969	10,307,000	4.9
1970	12,346,000	..

Source: Dominion Bureau of Statistics.
.. Not available.

FERROSILICON

Ferrosilicon is an effective and economical deoxidizer and is used to refine most grades of carbon and alloy steels. It reduces metal oxides in the slag and permits the recovery of desirable alloying elements such as chromium, in the steel. The silicon content of silvery pig iron and ferrosilicon ranges from 6 to 95 per cent. Silicon ferroalloys with above 15 per cent silicon content are usually produced in submerged-arc electric furnaces. Most of the alloys with lower silicon content are made in blast furnaces.

Silvery pig iron, containing 5-20 per cent silicon, is used primarily as a steel furnace "block" added in lump form for the initial deoxidation of the steel. 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 the steel. The most extensively used silicon alloy is the 50 per cent ferrosilicon. 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.

SILICON CARBIDE

The initial, and still prime importance of silicon carbide is its use as an abrasive. Silicon carbide is harder and sharper-grained but more brittle than the other major manufactured abrasive, aluminum oxide; silicon carbide grains fracture readily and maintain sharp cutting edges. Sized, graded grains are used for lapping, grinding and to form abrasive pastes or sticks; bonded with other materials to form wheels and shapes that are then baked and cured; adhered to or incorporated with paper or cloth they form abrasive sheets, discs, or belts. The hardness and wear resistance of silicon carbide is important to its use in brake linings, floor or stair treads, terrazzo tile, and in some deck paints.

General chemical and physical stability, low coefficient of expansion, and high thermal conductivity make silicon carbide an important material for refractory use. Suitable silicon carbide refractory shapes are used in boiler furnace walls, muffles, and kilns.

Electric heating elements are made by extruding a mixture of silicon carbide grain in a temporary binder, heating to set the mixture, then firing in an electric furnace to burn out the binder and recrystallize the grain. Such heating elements are used in furnaces operating up to about 1,600 degrees centigrade, as a source of infrared radiation for drying operations, and as a light source for mineral determinations.

Silicon carbide is also used in ferrous metallurgy. When added to molten steel the vigorous exothermic reaction results in a hotter melt; the silicon carbide

TABLE 3

Canada, Consumption, Exports and Imports of Ferrosilicon, 1961-70

	Consumption	Exports		Imports	
	Short Tons	Short Tons	$	Short Tons	$
1961	19,030	48,948	4,891,566	4,359	1,357,762
1962	20,106	43,249	4,184,149	6,119	1,354,297
1963	24,182	36,736	3,705,201	3,826	1,159,414
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	..	49,984	8,284,000	10,446	2,386,000

Source: Dominion Bureau of Statistics.
.. Not available.

TABLE 4

Canada, Ferrosilicon Consumption in the Steel Industry, 1960-70
(short tons)

	High Silicon (over 55% Si)	Medium Silicon	Low Silicon (under 45% Si)	Sil-X	Total
1960	1,028	10,130	400	67	11,625
1961	1,311	9,783	189	57	11,340
1962	1,691	11,222	44	54	13,011
1963	2,009	12,587	65	62	14,725
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

Source: Dominion Bureau of Statistics annual report, Iron and Steel Mills.

decomposes to deoxidize and cleanse the metal and to promote fluidity. It produces a more random dispersion of graphite flakes to give a more machinable product. It may be added as granules to molten steel or as briquettes to the cupola charge in producing cast iron.

Silicon carbide has a wide range of other uses that include high-density self-bonded shapes for mould liners, spray nozzles, and orifices for handling hot gases or abrasive and corrosive materials. It may be used as pebbles for pebble-bed heaters or fluidized bed reactors, as in gas chlorination apparatus.

The semi-conducting properties of silicon carbide have made it useful in thermistors, varistors, and in diodes, rectifiers and transistors for use at temperatures above the range of silicon or germanium.

Silicon carbide has a relatively low neutron absorption cross section and good resistance to radiation damage making it useful in some nuclear reactor applications.

TABLE 5

Canada, Ferrosilicon Production*, 1962-69
(short tons)

	Ferrous Industry	Other Industries**	Total
1962	60,883	20,574	81,457
1963	71,332	13,263	84,595
1964	86,548	12,660	99,208
1965	81,114	14,907	96,021
1966	76,943	16,547	93,490
1967	82,354	12,609	94,963
1968	82,710	10,392	93,102
1969	104,890	12,599	117,489

Source: Dominion Bureau of Statistics.
*Producers' shipments.
**Principally abrasives industry byproducts.

TABLE 6

Canada, Manufacturers Shipments of Silicon Carbide, 1959-69

	Crude Silicon Carbide	
	Short Tons	$
1959	86,248	12,660,000
1960	84,611	13,026,000
1961	79,188	12,478,000
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

Source: Dominion Bureau of Statistics.

THE MAKING OF SILICON CARBIDE

Silicon carbide is an important artificial abrasive and refractory. Its hardness is 9.5 to 9.75 in Moh's scale, being between diamond (10) and corundum (9). Silicon carbide, or carborundum, is made from a mixture of high-grade silica sand and crushed coke with small proportions of sawdust and common salt. The mixture is loaded into an open-top rectangular electric resistance furnace and heated intensively for about 36 hours. The commercial resistance furnace may be 60 feet long, 10 feet wide, and built as a rectangular trough with walls of brick set in cast-iron frames which can be removed, section by section. During the loading of the charge a core of loose graphite or graphite rods is placed at the centre of the load and leading from the electrodes in one end to those in the other end. Heat is applied to raise the temperature at the core to a maximum of about 2,595 degrees centigrade then falls off to a nearly constant 2,040 degrees. The production rate is about 0.35 pound of product per kilowatt hour.

After about a day and a half the power is shut off and the furnace allowed to cool. The sidewalls are removed and the charge is found to consist of an outer layer of unconverted or partly converted material, an inner zone of intergrown silicon carbide crystals, and a core containing considerable graphite and voids. The outer layer is removed and may be reused in another charge. The masses of carbide crystals are broken up, crushed, cleaned by acid or alkali treatment, washed, and dried. This crude grain is further crushed, size-classified and magnetically treated to remove any iron contamination from the crushing equipment. The grain is then ready for use or for fabrication into shapes.

Developments in the preparation of silicon carbide include the use of anthracite coal in place of some or all of the coke, the introduction of chlorine gas into the reaction zone to remove impurities from the product, and the addition of small amounts of boron, titanium or zircon to the charge so that refractories made from the silicon carbide may have improved resistance to oxidation.

TABLE 7

Canada, Exports of Silicon Carbide, 1960-70

	Short Tons	$
1960	82,558	11,928,750
1961	84,326	12,795,554
1962	62,765	9,343,177
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

Source: Dominion Bureau of Statistics.

OTHER SILICON ALLOYS

The increase in production of miscellaneous silicon alloys in recent years is because of changing steelmaking practice and the demand for high-performance iron and steel products. Specialized ferrosilicon additives contain, in addition to iron and silicon, one or more of the following elements: aluminum, barium, boron, calcium, cerium, magnesium, manganese, titanium, zirconium. Some of the more important commercial grades of silicon-bearing alloys are:

Alloy Name	Alloy Composition
Calcium-silicon	33-33% Ca, 60-65% Si, 1.5-3% Fe
Calcium-manganese-silicon	16-20% Ca, 14-18% Mn, 53-59% Si
Ferrochrome silicon	35-50% Cr, 30-50% Si, 0.05 to 1.25% C
Magnesium ferrosilicon	44-48% Si, 8-10% Mg, 1.0-1.5% Ca, 0.5% Ce
Silicomanganese	65-68% Mn, 12.5-18.5% Si, 1.5-3% C, balance Fe
Simanal	20% Si, 20% Mn, 20% Al, balance Fe
SMZ alloy	60-65% Si, 5-7% Zr, 5-7% Mn, 3-4% Ca, balance Fe

Silicon-aluminum alloys with 10 to 50 per cent silicon, 10 to 20 per cent aluminum and the remainder, one or more, of iron, manganese, chromium or zirconium are made by carbon reduction of the oxides in electric furnaces. These alloys are used to control the grain size of steel and reduce the harmful effects of nitrogen.

Manganese silicides containing varying amounts of iron and carbon are made by carbon reduction of manganese ore and/or manganese-bearing slag with silica in the electric furnace. Silicomanganese is suitable for adding manganese to low-carbon steel; it also acts as a deoxidizer and cleanser of the steel.

Boron silicides (BSi), usually combined with ferrosilicon (FeSi), are made by carbon or silicon reduction of oxides in an electric furnace. Very small amounts of boron are needed to increase the hardness of steel and may be used to replace, to some extent, larger amounts of more expensive ferroalloys.

Calcium-silicon and calcium-manganese-silicon are efficient and effective deoxidizers and degassifiers of steel. The manganese assists in obtaining a pearlitic matrix and improves strength and machinability of castings. These additives are made by carbon reduction of lime, silica, and various manganese-bearing materials in submerged-arc electric furnaces.

Ferrochrome-silicon alloys are made in electric furnaces in the same way as ferrosilicon. The higher carbon grades are used in low-alloy steels. The silicon content makes them readily soluble in iron and reduces metal oxides while the chromium dissolves in the metal. The low carbon grades are used in producing stainless, and heat and corrosion resistant steels with low carbon specifications.

Magnesium silicides in alloy combinations with iron, manganese, copper, nickel and rare-earth elements are used in the production of ductile or nodular cast iron. The more commonly used of such alloys are: nickel-iron-silicon-magnesium, iron-silicon-magnesium, and iron-silicon-magnesium-rare earths. The rare-earth content usually ranges from 0.1 to 1.5 per cent, and the magnesium content from 5 to 10 per cent but for special uses it may be 50 per cent or more. One of the better known uses of nodular iron is in the making of automotive crankshafts where uniform, machinable castings are required. Rare-earth silicides in ferroalloy form are, in some cases, more economic additive agents than mischmetal which is an alloy of cerium and other rare earths.

Titanium silicide may be made by adding titanium scrap to molten silicon metal. The use of titanium silicide is similar to others in that it can be an economical means of adding titanium when silicon is needed for slag reduction and its addition to the steel is not objectionable.

Vanadium silicides made by reduction of vanadium ores or concentrates in the electric furnace can be similarly used, in some cases, as an economical means of adding vanadium to steel.

Silicon-zirconium alloys containing 30 to 65 per cent silicon and 5 to 40 per cent zirconium are made by carbon reduction of the oxides in the electric furnace. These alloys are used as deoxidizers and scavengers. Zirconium combines readily with excess oxygen, nitrogen, and sulphur, forming inclusions that float out of the molten bath or are rendered least harmful.

Silicon "metal", containing approximately 98 per cent silicon, is made by carbon reduction of nearly pure silica in the electric furnace. It is used by the nonferrous metal industry in the production of aluminum and copper alloys. In aluminum alloys it is used in amounts of from 5 to 22 per cent silicon. Silicon is added as an alloying agent to copper in producing the silicon bronzes.

Commercial silicon metal (0.55-0.65 per cent Fe, 0.35-0.45 per cent Al, 0.20-0.30 per cent Ca) is used by the chemical industry in the production of a thousand or more silicones now available for use in industry, in medicine and surgery, and for household use.

Canada, Ferroalloy Producers

Canadian Carborundum Company, Limited	Niagara Falls, Ontario
Chicoutimi Silicon Ltd.	Chicoutimi, Quebec
Chromium Mining & Smelting Corporation, Limited	Beauharnois, Quebec
Electro Refractories & Abrasives Canada Ltd.	Cap de la Madeleine, Quebec
The Exolon Company of Canada, Ltd.	Thorold, Ontario
Lionite Abrasive, Limited	Niagara Falls, Ontario
Norton Company	Chippawa, Ontario
Union Carbide Canada Limited	Beauharnois, Quebec
	Welland, Ontario
Wallace-Murray Canada Limited	Arvida, Quebec

PRICES

Prices published by *Metals Week*, in United States currency, in December 1969 and 1970 were:

Ferrosilicon: Pound contained silicon f.o.b. shipping point, freight equalized to nearest main producer, carload lots, lump bulk.

		1969	1970
High-purity	75% Si	17.3¢	19.6¢
	85% Si	18.0¢	20.3¢
	90% Si	18.6¢	20.3¢
Regular	50% Si	14.1¢	16.0¢

Silicon Metal: Pound contained silicon, f.o.b. shipping point, freight equalized to near main producer, carload lots, lump bulk.

0.35% max. Fe, 0.07% max. Ca	20.55¢	25.4¢
0.50% " " "	18.85¢	23.7¢
1.00% " " "	17.65¢	21.5¢
Magnesium Ferrosilicon 44/48 Si:		
9% Mg	20.9¢	29.95¢
9% Mg 0.5% Ce	23.2¢	26.25¢
5% Mg 0.5% Ce	17.25¢	19.80¢
12-15 zirconium silicon	10.90¢	12.35¢
35-40 " "	31.95¢	33.75¢
Silicon Metal: per pound, f.o.b. producer,		
Semi-conductor grade	$130-$355	$130-$355
Solar grade	$ 70	$ 70

Prices published by *American Metal Market*, in United States currency, in December 1969 and 1970 were:

	1969	1970
SMZ Alloy: 60-65% Si, 5-7% Mn, 5-7% Zr, 15 ton lots, per pound of alloy	20.8¢	22.3¢
Calcium–Silicon and Calsibar alloy f.o.b. producer, 15 ton lots, per pound	23.75¢	24.0¢
Electric Furnace Silvery Pig Iron		
f.o.b. Niagara Falls, 15% Si, per ton	$82.00	$90.50
" " " 22% Si, per gross ton	$99.00	$105.74

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General
37503-1	Ferrosilicon, being an alloy of iron and silicon containing 8% or more, by weight, of silicon and less than 60% per pound, or fraction therein, effective June 4, 1969	free	free	1.75¢
37504-1	Ferrosilicon, being an alloy of iron and silicon containing 60% or more, by weight, of silicon and less than 90% per pound, or fraction thereof, on the silicon contained therein, effective June 4, 1969	free	0.75¢	2.75¢
37505-1	Ferrosilicon, being an alloy of iron and silicon containing 90% or more, by weight, of silicon per pound, or fraction thereof, on the silicon contained therein, effective June 4, 1969	free	2.50¢	5.50¢

UNITED STATES

Item No.		Effective on and after January 1 1970	1971	1972
607.50	Ferrosilicon containing over 8% but not over 60% by weight of silicon, per pound Si content	0.2¢	0.1¢	free
607.51	Ferrosilicon containing over 60% but not over 80% by weight of silicon, per pound Si content	0.6¢	0.55¢	0.5¢
607.52	Ferrosilicon containing over 80% but not over 90% by weight of silicon, per pound Si content	1.4¢	1.2¢	1.0¢
607.53	Ferrosilicon containing over 90% by weighing of silicon, per pound Si content	2.8¢	2.4¢	2.0¢
607.55	Ferrosilicon chromium	10%	10%	10%
607.57	Ferrosilicon manganese per pound Mn content	0.65¢ Plus 5%	0.56¢ Plus 4.5%	0.46¢ Plus 3.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1969), TC Publication 272.

Silver

J.G. GEORGE*

Canadian mine production of silver in 1970 was 44,282,680 troy ounces**, 0.75 million ounces greater than in 1969 and about 0.75 million ounces less than the all-time high of 1968. The increase was due mainly to greater output of several base-metal mines which produce silver as a byproduct, particularly that of Anvil Mining Corporation Limited which completed its first full year of operations at its lead-zinc-silver property in the Yukon Territory. Declines in Newfoundland, Nova Scotia, Ontario, and Saskatchewan were more than offset by higher output in the other provinces and the Territories. Ontario was again 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 some one million ounces less than in 1969. The value of Canadian production was $82 million, or about $2 million less than in 1969, because of lower silver prices.

The principal source of silver was again base-metal ores, which accounted for some 92 per cent of total production. More than 7 per cent came from silver-cobalt ores mined in northern Ontario and the remainder was byproduct recovery from lode and placer gold ores.

The principal mine producers of silver in Canada are listed in Table 4 and the accompanying map shows their approximate locations. The four largest producers in declining order of output were Ecstall Mining Limited in Ontario, Cominco Ltd. (Sullivan mine) in southeastern British Columbia, United Keno Hill Mines Limited in the Yukon Territory, and Echo Bay Mines Ltd. in the Northwest Territories. Base-metal ores mined by these four producers accounted for some 46 per cent of total Canadian silver production. Largest producer in the Cobalt-Gowganda area of Ontario was again Silverfields Mining Corporation Limited with output of 1,119,331 ounces.

Canadian Copper Refiners Limited at Montreal East, Quebec, was Canada's largest producer of refined silver. It recovered 12,447,000 ounces from the treatment of anode and blister copper. The silver refinery of Kam-Kotia Mines Limited, Refinery Division, at Cobalt, Ontario, was the second largest producer, recovering 12,187,943 ounces in the processing of silver-cobalt ores and concentrates and in the toll refining of silver bullion and coins imported from the United States. Other producers of refined silver were Cominco Ltd. at Trail, British Columbia (from lead and zinc ores and concentrates); 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, East Coast Smelting and Chemical Company Limited recovered byproduct silver from lead-zinc concentrates treated in an Imperial Smelting Process blast furnace. Late in 1970 it was decided, for economic reasons, to close down the Kam-Kotia refinery at Cobalt, Ontario. The local mines were notified that no shipments would be received after March 31, 1971, as operations were expected to be completely terminated about mid-1971.

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*Mineral Resources Branch.

**Wherever used in this review, the term "ounce" refers to the "troy ounce".

Canada's exports of silver in ores and concentrates and as refined metal totalled 45,227,504 ounces in 1970, or more than 11 million ounces less than the corresponding amount in 1969. The United States continued to be our major market, importing more than 80 per cent of Canada's total exports. Canadian imports of refined silver dropped sharply from 19,168,785 ounces in 1969 to 4,319,357 ounces in 1970. Virtually all of the imports came from the United States with a very minor quantity coming from Britain.

Reported consumption of silver in Canada totalled 6,034,028 ounces in 1970 compared with 5,747,068 ounces in 1969.

TABLE 1

Canada, Silver Production, Trade and Consumption, 1969-70

	1969		1970^p	
	Ounces	$	Ounces	$
Production*				
By province and territories				
Ontario	22,260,439	42,962,647	19,355,700	35,808,050
British Columbia	5,760,534	11,118,024	6,326,100	11,703,290
Quebec	4,334,867	8,366,293	5,259,000	9,729,150
New Brunswick	4,058,976	7,833,824	4,523,840	8,369,100
Yukon Territory	2,685,060	5,182,166	4,265,000	7,890,250
Northwest Territories	2,026,367	3,910,888	2,525,000	4,671,250
Newfoundland	1,024,639	1,977,553	838,560	1,551,340
Manitoba	462,763	893,133	682,300	1,262,260
Saskatchewan	649,699	1,253,919	435,500	805,680
Nova Scotia	267,585	516,439	71,670	132,590
Alberta	12	23	10	20
Total	43,530,941	84,014,909	44,282,680	81,922,980
By sources				
Base-metal ores	38,851,512		40,752,029	
Gold ores	490,172		361,621	
Silver-cobalt ores	4,187,679		3,168,100	
Placer gold ores	1,578		930	
Total	43,530,941	84,014,909	44,282,680	81,922,980
Refined silver	38,204,527		30,391,652	
Exports				
In ores and concentrates				
United States	15,141,088	23,976,000	13,217,030	20,629,000
Japan	1,919,768	2,959,000	2,695,906	4,531,000
Belgium and Luxembourg	2,720,379	4,611,000	2,932,035	4,472,000
West Germany	1,547,458	1,589,000	1,477,693	1,938,000
Sweden	64,365	119,000	248,345	534,000
Britain	333,866	402,000	251,930	300,000
France	12,896	17,000	125,822	117,000
Other countries	143,208	241,000	79,219	59,000
Total	21,883,028	33,914,000	21,027,980	32,580,000
Refined metal				
United States	33,400,033	63,816,000	23,096,055	43,416,000
Belgium and Luxembourg	825,342	1,682,000	985,241	1,717,000
Britain	1,053	7,000	102,393	189,000
Trinidad-Tobago	19,892	40,000	9,070	18,000
Jamaica	6,093	13,000	2,817	6,000
Venezuela	943	2,000	2,572	5,000
Other countries	405,581	855,000	1,376	3,000
Total	34,658,937	66,415,000	24,199,524	45,354,000

TABLE 1 (Cont'd)

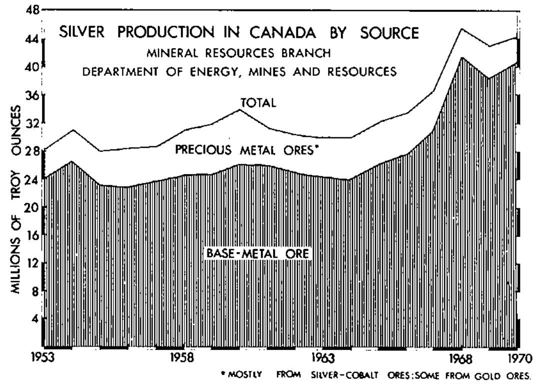
	1969		1970^p	
	Ounces	$	Ounces	$
Imports				
Refined metal				
United States	19,130,769	34,720,000	4,314,913	8,042,000
Britain	25,937	56,000	4,444	10,000
Mexico	11,619	22,000	–	–
Bolivia	460	1,000	–	–
Total	19,168,785	34,799,000	4,319,357	8,052,000
Consumption by use				
Coinage	–		–	
Silver salts	496,506^r		468,095	
Silver alloys	572,954		565,002	
Sterling	889,956		1,167,289	
Wire and rod	22,222		24,366	
Other**	3,765,430^r		3,809,276	
Total	5,747,068		6,034,028	

Source: Dominion Bureau of Statistics.
*Includes: (a) recoverable silver in ores, concentrates and matte shipped for export; (b) silver in crude gold bullion produced; (c) silver in blister and anode copper produced at Canadian smelters; (d) silver in base bullion produced from domestic ores; (e) silver bullion produced from treatment of domestic silver-cobalt ores at Cobalt, Ontario.
**Includes sheet and miscellaneous uses.
^{p}Preliminary; ^{r}Revised; – Nil.

TABLE 2
Canada, Silver Production, Trade and Consumption, 1961-70
(ounces)

	Production		Exports			Imports	Consumption**
	All Forms*	Refined Silver	In Ores and Concentrates	Refined Silver	Total	Refined Silver	Refined Silver
1961	31,381,977	18,239,803	10,352,700	10,783,414	21,136,114	12,278,469	9,614,083
1962	30,422,972	16,749,356	8,861,858	9,445,094	18,306,952	15,182,336	15,419,342
1963	29,932,003	19,772,408	8,286,756	10,834,629	19,121,385	7,950,972	17,574,628
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	30,765,934	21,502,022	28,104,562	49,606,584	14,060,635	13,598,358
1969	43,530,941^r	38,204,527	21,883,028	34,658,937	56,541,965	19,168,785	5,747,068
1970^p	44,282,680	30,391,652	21,027,980	24,199,524	45,227,504	4,319,357	6,034,028

Source: Dominion Bureau of Statistics.
*Includes recoverable silver (a) in ores, concentrates and matte shipped for export; (b) in crude gold bullion produced; (c) in blister and anode copper produced at Canadian smelters; (d) in base bullion produced from domestic ores; (e) in bullion produced from the treatment of silver-cobalt ores.
**Includes consumption for coinage.
^{p}Preliminary; ^{r}Revised.



WORLD PRODUCTION AND CONSUMPTION

Silver production in the non-communist world in 1970, according to an estimate of Handy and Harman,* was 246.6 million ounces, or only 0.2 million ounces more than in 1969. In 1970, non-communist world consumption for both industrial and coinage uses, excluding requirements for United States coinage which are supplied from Treasury stocks, was 397.2 million ounces. The gap between production and consumption, not including United States coinage requirements, was some 151 million ounces or somewhat less than in 1969.

Consumption of silver for coinage in the non-communist world, excluding the United States, was 39.6 million ounces or about 3.3 million ounces more than in 1969. No silver was used in 1970 in the production of Canadian coinage.

Based on preliminary figures, Canada in 1970 was again the world's largest mine producer of silver; other leading producers were the United States, Mexico and Peru.

New production of silver in the United States increased from 41.9 million ounces in 1969 to an estimated 44.1 million ounces in 1970. In the United States, the world's largest silver consumer, consumption for industrial uses and coinage was 135.0 and 0.7 million ounces, respectively, in 1970. The large deficit in requirements was again met by withdrawals from United States Treasury stocks, demonitized coinage, imports, secondary silver and liquidation of speculative holdings. Requirements for United States coinage were again obtained from Treasury stocks which (in bullion form) were reduced during 1970 from 70.2 to 25.1 million ounces, excluding 139.5 million ounces held in the strategic stockpile. The United States Mint used 0.7 million ounces of silver for coinage in 1970 compared with 19.4 million ounces in 1969.

TABLE 3

World Production of Silver 1969-70
(ounces)

	1969	1970^e
Canada	41,929,000*	45,000,000**
United States	41,906,000	44,100,000
Mexico	42,904,000	44,000,000
Peru	34,147,000	35,000,000
Russia^e	37,000,000	..
Australia	24,667,000	..
Japan	10,804,000	..
Bolivia	6,013,000	..
East Germany	4,800,000	..
Honduras	3,905,000	..
Sweden	3,683,000	..
Yugoslavia	3,456,000	..
Republic of South Africa	3,335,000	..
Chile	3,133,000	..
Other countries	26,919,000	131,900,000
Total	288,601,000	300,000,000

Sources: 1969 statistics from U.S. Bureau of Mines Minerals Yearbook, 1969. 1970 statistics from U.S. Bureau of Mines Commodity Data Summaries, January 1971.

*This figure has since been revised to 43,530,941 by the Dominion Bureau of Statistics. **A later preliminary estimate for this figure by the Dominion Bureau of Statistics is 44,282,680.

^{e}Estimated; .. Not available.

On November 10, 1970, the United States government bowed out of the silver market. On that day the Treasury Department made its final 1½-million ounces sale at its last public auction. Since August 4, 1967, when weekly sales began, the General Services Administration (GSA) has disposed of some 305 million ounces of silver. Of this total, 212 million ounces were obtained from the melting of silver dimes and quarters. Until May 27, 1969, these sales were at the rate of 2 million ounces a week; thereafter they amounted to 1½-million ounces weekly. On December 31, 1970, Public Law PL-91-607 was signed by President Nixon. It includes a provision authorizing the minting of 150 million Eisenhower dollar coins containing 40 per cent silver. The use of silver in these commemorative coins was not expected to have any significant effect on the market as the United States Treasury Department 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, also authorized in Public Law PL-91-607. In March 1970, the strategic stockpile objective was reduced from 165,000,000 to 139,500,000 ounces.

The Silver Market 1970, compiled by Handy and Harman.

The New York silver price fluctuated throughout 1970 between a high of $1.930 an ounce on January 29 and a low of $1.572 on December 10. At year-end it was $1.620.

OUTLOOK

Canada's mine production of silver in 1971 is forecast to be some 45 million ounces and, from 1972-76, it could range between 44 and 50 million ounces annually.

Despite the decline in world consumption of silver in recent years, it is expected that consumption will continue to exceed production since mine output of silver is largely geared to the production of the major base-metal ores. More than 70 per cent of silver output is derived as a byproduct or co-product 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. However, it is not thought that there will be any real shortage for industrial requirements since sufficient quantities of speculative holdings and some hoarded silver coins will eventually find their way into the market.

At what price these silver stocks will be attracted to the market is still an unknown factor. However, since the United States Treasury Department ceased to be a seller of silver on November 10, 1970, it is possible that silver prices may tend to rise.

In view of the rising industrial use of silver, the demand for primary silver from mine producing countries such as Canada is expected to remain strong over the next few years.

CANADIAN DEVELOPMENTS

YUKON TERRITORY AND NORTHWEST TERRITORIES

A sharp increase in silver production in 1970 in the Yukon Territory resulted mainly from substantially greater byproduct output by Anvil Mining Corporation Limited which completed its first full year of operations at its lead-zinc-silver property at Faro. Also contributing to the Yukon's increase was some byproduct output by Venus Mines Ltd. which began tune-up operations at the 300-ton*-a-day mill at its gold-silver-lead-zinc property about 18 miles south of Carcross.

Hart River Mines Ltd. was considering bringing into production, early in 1971, its silver-base-metals property in the Yukon Territory some 85 air miles northeast of Dawson City. Hudson Bay Mining and Smelting Co., Limited continued development work at its silver-lead-zinc "Tom" claims on the Canol Road near the Yukon-Northwest Territories border. An adit was advanced 1,700 feet into the mountain as part of a planned program that will include some 5,000-6,000 feet of underground development work and about 20,000 feet of diamond drilling. Matt Berry Mines Limited completed an agreement with Canadian Nickel Company Limited (a subsidiary of The International Nickel Company of Canada, Limited) and Metallgesellschaft Canada Limited for a continuing program of exploration, which will include some drilling, on its silver-base-metals property in the Frances Lake area. Previous diamond drilling indicated a deposit containing 415,000 tons with grade averaging 9.12 per cent lead, 6.25 per cent zinc, and 4.33 ounces silver a ton.

In the Northwest Territories silver production was higher in 1970 mainly because of greater output by Terra Mining and Exploration Limited and Echo Bay Mines Ltd. which operate silver-copper properties near Port Radium on the east shore of Great Bear Lake. Cadillac Explorations Ltd. concluded an agreement with Penarroya Canada Limited whereby the latter agreed to spend up to $3 million for exploration and development work at Cadillac's Prairie Creek silver-lead-zinc property in the Nahanni Mining District some 110 miles due west of Fort Simpson. Diamond drilling and drifting have indicated reserves of approximately 2 million tons grading about 11 per cent lead, 13 per cent zinc and 5 ounces silver a ton. Under an agreement with Bathurst Norsemines Ltd., Cominco Ltd. did development work on the Norsemines silver-base-metals prospect in the Hackett River area of the Northwest Territories.

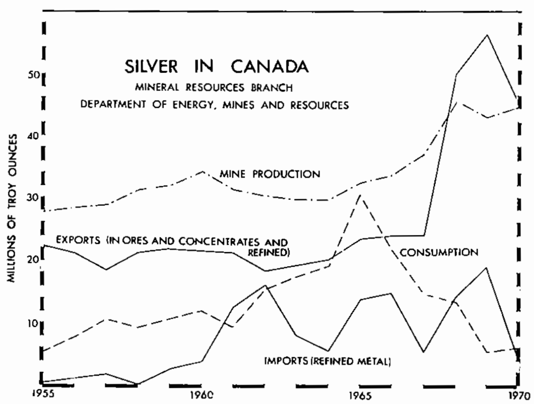
Late in 1970, Federated Mining Corporation Ltd. began mining small quantities of high grade silver ore at its Silver Bay mine in the Camsell River area about 35 miles south of Port Radium. The company planned to treat the ore by the installation of portable milling units. On a nearby property in the same area, Norex Resources Ltd. did further diamond drilling designed to study the continuation of their silver veins at depth.

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 and Bluebell mines in southeastern British Columbia, and from purchased ores and concentrates. On March 31, 1970 milling operations ceased at the silver-lead-zinc property of Utica Mines Ltd. near Keremeos. The plant had been in continous operation since August 1967.

Mill tune-up operations began in October 1970 at the Ruth-Vermont lead-zinc-silver property of Copperline Mines Ltd. in the East Kootenay district near Golden. Mill capacity is 600 tons a day. Copperline holds a 60 per cent interest in the property with the remaining 40 per cent held by Columbia River Mines Ltd. In September 1970, operations began at the silver-lead-zinc property of Silmonac Mines Limited

*Wherever used in this review, the term "ton" refers to the short ton of 2,000 pounds avoirdupois, unless otherwise stated.



near New Denver in the Slocan District of southeastern British Columbia. The ore is custom-milled at a nearby concentrator. The operation is financed and managed by a syndicate headed by Kam-Kotia Mines Limited. Construction work continued on the 125-ton-a-day concentrator at the silver-lead-zinc property of Columbia Metals Corporation Limited near Ferguson in the southeastern part of the province. Mill completion was anticipated early in 1971. Underground exploration and development work continued at the copper-lead-zinc-silver property of Nadina Explorations Limited near Owen Lake, about 30 miles southwest of Housten in central British Columbia.

MANITOBA-SASKATCHEWAN

In Manitoba and Saskatchewan most of the silver continued to come from eight base-metal mines operated by Hudson Bay Mining and Smelting Co., Limited near Flin Flon and Snow Lake, Manitoba. Two of these mines, Anderson Lake and Dickstone, were brought into production by the company in November 1970. Two other new mines were being developed by Hudson Bay in the Flin Flon-Snow Lake area, namely Ghost Lake and White Lake, and were scheduled to begin production during the first half of 1972. Early in 1970, Hudson Bay announced the discovery of a new silver-base-metals mine about 9 miles southeast of Flin Flon. It was named the Centennial mine and diamond drilling to a depth of 1,200 feet up to April 14, 1970 indicated about 1,400,000 tons of copper-zinc ore containing about 0.70 ounce of silver a ton.

ONTARIO

Ontario was again, by far, the leading silver-producing province with its output accounting for almost 44 per cent of Canadian mine production. The largest producer was again Ecstall Mining Limited that recovered over 12 million ounces in copper, lead and zinc concentrates at its Kidd Creek property. This mine was also the largest single mine producer of silver in Canada. In the Cobalt-Gowganda area of northern Ontario, over 3 million ounces were derived from silver-cobalt mines. A large part of the remainder was byproduct production of Noranda Mines Limited (Geco Division) in the Manitouwadge area and The International Nickel Company of Canada, Limited at Sudbury.

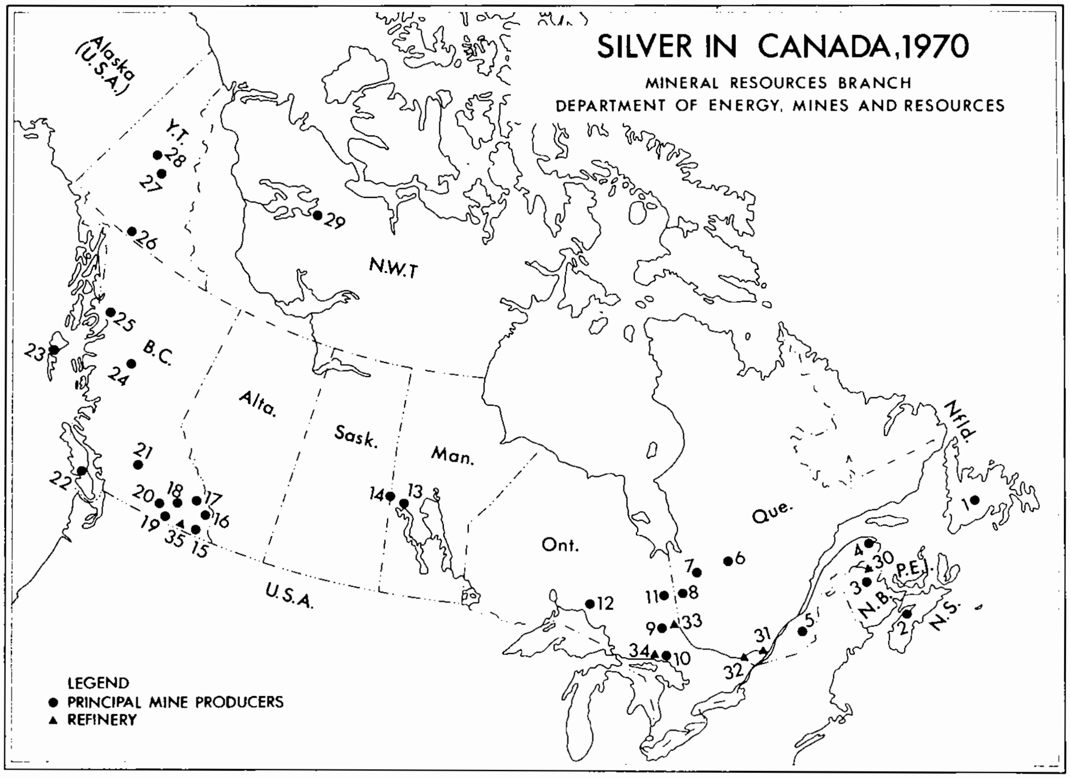
Operations were suspended at the silver property of Manridge Mines Limited about 12 miles from the Siscoe mine in the Gowganda area. The tonnage and grade of ore mined proved to be lower than that indicated by surface diamond drilling. Operations at the property, which began production late in 1969, were managed by Siscoe Metals of Ontario Limited under a leasing agreement with Manridge. The ore was custom-treated at the Siscoe mill.

A new company, Mattabi Mines Limited, owned 60 per cent by Mattagami Lake Mines Limited and 40 per cent by Abitibi Paper Company Ltd., was incorporated late in 1970 to acquire the mineral lands containing the major ore deposit discovered by Mattagami on Abitibi's timber limit Block 7 in the Sturgeon Lake area northwest of Lake Superior. The mine is now being developed for production at an anticipated rate of 3,000 tons a day, with operations expected to begin about mid-1972. Ore reserves have been estimated at some 13 million tons grading 7.6 per cent zinc, 0.91 per cent copper, 0.84 per cent lead, and 3.13 ounces of silver and 0.007 ounce of gold a ton. In October 1970, Falconbridge Nickel Mines Limited made an important discovery when drilling an anomaly on property optioned from New Brunswick Uranium Metals & Mining Limited and which adjoins the Mattagami Lake main orebody on the east, in the Sturgeon Lake area. Falconbridge planned to do considerably more follow-up drilling to further probe the anomaly containing copper-zinc-lead-silver mineralization.

South Bay Mines Limited continued development work at its copper-zinc-silver property in the Uchi Lake area of northwestern Ontario. The shaft was collared and surface plant construction was started. Production at a rate of 500 tons per day was expected to begin about mid-1971. South Bay is associated with Selection Trust Limited of London, England.

QUEBEC

Silver output in the province, derived almost entirely from gold and base-metal ores, was considerably higher in 1970 than in 1969. The increase was mainly attributable to greater byproduct production by Manitou-Barvue Mines Limited and Delbridge Mines Limited which latter completed its first full year of operations. A major development program was continued at the silver-base-metals property of D'Estrie



PRINCIPAL MINE PRODUCERS

(numbers refer to numbers on the map)

1. American Smelting and Refining Company (Buchans Unit)
2. Dresser Minerals, Division of Dresser Industries, Inc.
3. Brunswick Mining and Smelting Corporation Limited (Nos. 12 and 6 mines)
   Heath Steele Mines Limited
   Nigadoo River Mines Limited
4. Gaspé Copper Mines, Limited
5. D'Estrie Mining Company Ltd.
   Sullivan Mining Group Ltd. (Cupra Division)
   Sullivan Mining Group Ltd. (Solbec Division)
6. Campbell Chibougamau Mines Ltd.
   Opemiska Copper Mines (Quebec) Limited
   The Patino Mining Corporation, Copper Rand Mines Division
7. Mattagami Lake Mines Limited
   Orchan Mines Limited
8. Delbridge Mines Limited
   Lake Dufault Mines Limited
   Manitou-Barvue Mines Limited
   Noranda Mines Limited (Horne mine)
   Normetal Mines Limited
   Quemont Mines Limited
9. Agnico Mines Limited
   Glen Lake Silver Mines Limited
   Hiho Silver Mines Limited
   Manridge Mines Limited
   Patricia Silver Mines Limited
   Silverfields Mining Corporation Limited
   Siscoe Metals of Ontario Limited
10. The International Nickel Company of Canada, Limited
    Falconbridge Nickel Mines Limited
11. Ecstall Mining Limited
12. Big Nama Creek Mines Limited
    Noranda Mines Limited (Geco Division)
    Willroy Mines Limited
13. Hudson Bay Mining and Smelting Co., Limited (Anderson Lake, Chisel Lake, Dickstone, Osborne Lake, and Stall Lake mines)
14. Hudson Bay Mining and Smelting Co., Limited (Flexar, Flin Flon, and Schist Lake mines).
15. Reeves MacDonald Mines Limited
16. Cominco Ltd. (Sullivan and Bluebell mines)
17. Copperline Mines Ltd., Ruth-Vermont mine
    Kam-Kotia Mines Limited, Silmonac mine

PRINCIPAL MINE PRODUCERS (Cont'd)

18. Brenda Mines Limited
19. The Granby Mining Company Limited, Phoenix Copper Division
20. Leitch Mines Limited
    Utica Mines Ltd.
21. Bethlehem Copper Corporation Ltd.
22. Western Mines Limited
23. Wesfrob Mines Limited
24. The Granby Mining Company Limited, Granisle mine
25. Granduc Operating Company
26. Venus Mines Ltd.
27. Anvil Mining Corporation Limited
28. United Keno Hill Mines Limited
29. Echo Bay Mines Ltd.
    Terra Mining and Exploration Limited

REFINERIES

30. East Coast Smelting and Chemical Company Limited
31. Canadian Copper Refiners Limited
32. Royal Canadian Mint
33. Kam-Kotia Mines Limited (Refinery Division)
34. The International Nickel Company of Canada, Limited
35. Cominco Ltd.

Mining Company Ltd. adjacent to the Cupra mine of Sullivan Mining Group Ltd. (Cupra Division) at Stratford Centre. The property was brought into production late in 1970; the ore being custom-milled at the Cupra concentrator.

NEW BRUNSWICK

Silver output in New Brunswick was somewhat higher in 1970 than in 1969 mainly as a result of greater production at the copper-lead-zinc-silver property of Heath Steele Mines Limited in the Newcastle area. The company's expanded facilities, involving a doubling of its mill capacity from 1,500 to 3,000 tons daily, came on stream in the first quarter of 1970. The base-metal property of Brunswick Mining and Smelting Corporation Limited near Bathurst, however, continued to be the principal silver producer in the province, accounting for about 56 per cent of provincial output.

The Anaconda Company (Canada) Ltd. continued exploration and development work at its lead-zinc-copper-silver deposit about 30 miles west of Bathurst. A feasibility study is in progress and it was planned to build a 300-ton-a-day pilot mill to start operations in 1971. The property is known as the Caribou deposit. It is owned 75 per cent by Anaconda and 25 per cent by Cominco Ltd., with Anaconda being in charge of operations. Underground development work was done at the lead-zinc-silver deposit held by North American Rare Metals Limited and Mistango River Mines Limited. Further drifting and diamond drilling were planned at the property which is in the Millstream River area about 20 miles west of Bathurst.

USES

Although the number of industrial applications for silver has increased, substantial quantities of the metal are still used in the manufacture of coinage. This is because it strongly resists corrosion, has good alloying properties, and has an attractive appearance and intrinsic value. The quantity of silver required for coinage, however, declined again because of the continuing trend toward using silverless coins or ones of reduced silver content. According to *Handy and Harman*, non-communist world consumption of silver for coinage dropped from a high of 381.1 million troy ounces in 1965 to 40.3 million ounces in 1970. Silver is used extensively in jewelry, sterling and plated silverware, and as a decorative material, for 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. The photographic industry, in which the use of silver is based on the light sensitivity and ease of reduction of certain silver compounds, has now become the metal's greatest single user.

Greater quantities are being used in the electrical and electronics industries because of the increasing 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 space flights. 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. 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 finding increased application 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 voyage of Apollo 11 to the moon. Two such batteries serviced the command module and two were located in the lunar excursion module.

TABLE 4

Principal Silver Producers in Canada, 1970

Company and Location	Mill Capacity (tons of ore/day)	Type of Ore Milled	Silver Grade 1970 (1969) (oz/ton)	Ore Produced 1970 (1969) (tons)	Contained Silver Produced 1970 (1969) (troy ounces)	Remarks
YUKON TERRITORY–NORTHWEST TERRITORIES						
Anvil Mining Corporation, Limited, Faro, Y.T.	6,600	Pb,Zn,Ag	. . (1.2)	1,961,000 (. .)	1,497,901 (273,500)	Mill capacity was increased from 5,500 to 6,600 tons a day.
Echo Bay Mines Ltd. Port Radium, N.W.T.	150	Ag,Cu	70.0 (67.99)	36,924 (34,797)	2,511,267 (2,404,637)	Internal shaft sunk an additional 750 feet to provide five new levels or a total of eight levels.
Terra Mining and Exploration Limited, Camsell River area	300	Ag,Cu	13.7 (. .)	32,867 (. .)	393,054 (. .)	Operations began October 1969, but production suspended February 3 to May 8, 1970 because of a fire which damaged the company's coarse ore bin, crusher and conveyor system.
United Keno Hill Mines Limited, Calumet and Hector, Elsa and Husky mines, Mayo District, Y.T.	500	Ag,Pb,Zn	27.30 (27.98)	93,215 (87,483)	2,663,584 (2,405,615)	Company plans extensive exploration in the Yukon Territory in general, and in Mayo district in particular.
Venus Mines Ltd., Carcross, Y.T.	300	Ag, Pb,Zn	5.30 (–)	23,796 (–)	80,738 (–)	Mill construction completed, and tune-up operations began September 1970.
BRITISH COLUMBIA						
Bethlehem Copper Corporation Ltd., Highland Valley	14,000	Cu,Ag,Au	2.08 (. .)	5,450,746 (5,236,914)	161,542 (. .)	Mill capacity to be increased to 16,000 tons a day by early 1972.
Brenda Mines Ltd., Peachland	24,000	Cu,Mo,Ag	3.34 (–)	7,326,559 (–)	225,411 (–)	Operations began early in 1970.
Cominco Ltd.,						
Sullivan mine, Kimberley	10,000	Pb,Zn,Ag	. . (. .)	2,194,743 (2,157,522)	2,933,096 (3,039,430)	Cominco's total output ot silver in 1970 was 6,044,600 troy ounces.
Bluebell mine, Riondel	700	Pb,Zn,Ag	. . (. .)	245,529 (230,956)	. . (. .)	

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (tons of ore/day)	Type of Ore Milled	Silver Grade 1970 (1969) (oz/ton)	Ore Produced 1970 (1969) (tons)	Contained Silver Produced 1970 (1969) (troy ounces)	Remarks
Copperline Mines Ltd., Ruth-Vermont mine, Golden	600	Pb,Zn,Ag	4.62 (–)	36,228 (–)	139,150 (–)	Mill tune-up operations began October 1970. Mill capacity being increased to 700 tons-a-day.
The Granby Mining Company Limited, Granisle mine, Babine Lake	6,500	Cu,Au,Ag	. . (. .)	2,393,161 (2,329,957)	105,274 (135,792)	Ore reserves increased to 89,600,000 tons grading 0.44 per cent copper as at December 31, 1970.
The Granby Mining Company Limited, Phoenix Copper Division, Greenwood	2,400	Cu,Au,Ag	0.243 (0.26)	862,156 (759,299)	135,863 (94,725)	Ore reserves were 1,865,000 tons grading 0.78 per cent copper as at December 31, 1970.
Granduc Operating Company, Stewart	7,500	Cu,Ag,Au	0.43 (–)	105,230 (–)	32,682 (–)	Operations began September 1, 1970.
Kam-Kotia Mines Limited, Silmonac mine, Slocan District	Ore custom-milled	Ag,Pb,Zn	19.0 (–)	13,232 (–)	245,827 (–)	Mill tune-up operations began September 1970.
Leitch Mines Limited, Beaverdell (mine formerly owned by Mastodon-Highland Bell Mines Limited)	115	Ag,Pb,Zn	13.37 (13.74)	33,225 (37,120)	444,290 (510,149)	Exploration and development work is being concentrated in the upper levels of the mine.
Reeves MacDonald Mines Limited,	1,200 (treated at central mill)					
Reeves mine, Remac		Pb,Zn,Ag	. . (. .)	107,312 (201,215)	7,905 (28,626)	
Annex mine, Remac		Pb,Zn,Ag	3.3 (–)	70,714 (–)	198,283 (–)	New Annex mine started production August 1, 1970.
Utica Mines Ltd., Keremeos	350	Ag,Au,Pb,Zn	. . (. .)	18,603 (74,915)	130,274 (555,943)	Mill ceased operations March 31, 1970, but underground development work continuing.
Wesfrob Mines Limited, Tasu Harbour, Queen Charlotte Island	10,000	Fe,Cu,Ag	. . (0.191)	1,200,000[1] (871,809)[1]	237,000 (147,007)	Began preproduction stripping of No. 2 ore zone.

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (tons of ore/day)	Type of Ore Milled	Silver Grade 1970 (1969) (oz/ton)	Ore Produced 1970 (1969) (tons)	Contained Silver Produced 1970 (1969) (troy ounces)	Remarks
Western Mines Limited, Myra Falls, Vancouver Island	1,000	Zn,Cu,Pb,Ag	1.36 (1.54)	386,976 (373,850)	396,868 (. .)	Installed lead circuit in concentrator.
MANITOBA–SASKATCHEWAN						
Hudson Bay Mining and Smelting Co., Limited	6,000 (treated at central mill at Flin Flon)	Cu,Zn,Pb,Ag	0.61 (0.6)	1,709,130 (1,701,000)	1,034,209 (735,649)	Anderson Lake and Dickstone mines began production in November 1970.
Flexar mine, Flin Flon, Man.		Cu,Zn,Ag	0.2 (0.1)	120,700 (93,400)		
Flin Flon mine, Flin Flon, Man.		Cu,Zn,Ag	0.8 (0.8)	622,300 (622,400)		
Schist Lake mine, Flin Flon, Man.		Cu,Zn,Ag	1.0 (0.9)	100,700 (122,600)		
Anderson Lake mine, Snow Lake, Man.		Cu,Ag,Au	0.3 (–)	59,600 (–)		
Chisel Lake mine, Snow Lake, Man.		Zn,Cu,Pb,Ag	0.9 (0.8)	281,500 (282,400)		
Dickstone mine, Snow Lake, Man.		Cu,Zn,Ag	0.4 (–)	26,100 (–)		
Osborne Lake mine, Snow Lake, Man.		Zn,Cu,Ag	. . (. .)	319,400 (376,100)		
Stall Lake mine, Snow Lake, Man.		Cu,Zn,Ag	0.6 (0.6)	179,200 (204,100)		
ONTARIO						
Big Nama Creek Mines Limited, Manitouwadge	Ore custom-milled	Zn,Cu,Ag	0.99 (1.08)	88,965 (57,472)	29,643 (23,977)	Ore milled at Willroy concentrator. Ore produced in 1969 was from preproduction development work.

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (tons of ore/day)	Type of Ore Milled	Silver Grade 1970 (1969) (oz/ton)	Ore Produced 1970 (1969) (tons)	Contained Silver Produced 1970 (1969) (troy ounces)	Remarks
Ecstall Mining Limited (Texas Gulf Sulphur Company), Kidd Creek mine, Timmins	9,000	Zn,Cu,Ag,Pb	. . (. .)	3,584,124 (3,617,226)	12,233,834 (13,822,000)	Beginning in 1972, open-pit mining will be co-ordinated with production from underground. 3,000-ft shaft from surface to be completed in 1971.
Falconbridge Nickel Mines Limited, (East, Falconbridge, Fecunis Lake, Hardy-Boundary, Longvack South, North, Onaping, and Strathcona mines) Falconbridge	3,000 (Falconbridge) 2,400 (Fecunis Lake) 1,500 (Hardy) 6,000 (Strathcona)	Ni,Cu	. . (. .)	4,631,000 (3,118,000)	. . (. .)	Production in 1969 was curtailed by a three-month labour strike.
Noranda Mines Limited (Geco Division), Manitouwadge	5,000	Cu,Zn,Ag,Pb	1.82 (2.34)	1,366,176 (1,320,000)	1,978,752 (2,351,000)	Mill expanded from 4,000 to 5,000 tons of ore a day.
Willroy Mines Limited, Manitouwadge (includes production from Willecho Mines Limited which was amalgamated with Willroy Mines Limited)	1,700	Zn,Cu,Ag,Pb	1.99 (. .)	388,005 (445,449)	520,973 (494,935)	Routine exploration and development.
The International Nickel Company of Canada, Limited, Sudbury, Ont. and Thompson, Man.	82,500	Ni,Cu	. . (. .)	28,300,000 (18,800,000)	1,051,000[2] (1,111,000)[2]	In 1970, brought into production Copper Cliff North and Kirkwood mines in Sudbury District, Ont., raising to 13 the number of the company's producing mines in Canada.
Agnico Mines Limited, 407 mine, 96 shaft mine and Penn-Canadian mine, Cobalt District	400	Ag,Cu,Co	17.28 (17.14)	64,695 (35,525)[3]	1,070,031 (573,511)	Bringing new Trout Lake No. 2 shaft mine, in South Lorraine Township, Ont., into production in 1971.
Glen Lake Silver Mines Limited, Bailey mine, Cobalt District	250	Ag,Cu,Co	– (. .)	– (72,180)[4]	– (52,344)	Operations suspended in 1969.

Company and Location	Mill Capacity (tons of ore/day)	Type of Ore Milled	Silver Grade 1970 (1969) (oz/ton)	Ore Produced 1970 (1969) (tons)	Contained Silver Produced 1970 (1969) (troy ounces)	Remarks
Hiho Silver Mines Limited, Cleopatra and Giroux Lake properties in Cobalt District	150	Ag,Cu,Co	7.11 (17.57)	46,801 (47,015)	332,847 (826,062)	Operations suspended late in 1970.
Manridge Mines Limited, Gowganda District	Ore custom-milled	Ag,Cu,Co	21.54 (. .)	8,096 (. .)	130,067	Production began late in 1969 and operations were suspended at the end of 1970.
Patricia Silver Mines Limited, Nipissing-North property, Cobalt District	Ore custom-milled	Ag,Cu,Co	. . (. .)	. . (. .)	187,947 (. .)	Continuing operations with diamond drill exploration for new ore.
Silverfields Mining Corporation Limited, Cobalt District	250	Ag,Cu,Co	14.5 (14.4)	78,583 (79,556)	1,119,331 (1,143,018)	Continuing routine underground exploration and development work
Siscoe Metals of Ontario Limited, Gowganda District	275	Ag,Cu,Co	13.0 (19.78)	38,614 (41,808)	407,785 (799,798)	Continuing routine underground exploration and development work at main mine and Castle property.
QUEBEC						
Campbell Chibougamau Mines Ltd., Chibougamau District	3,500	Cu,Au,Ag	0.2842 (0.2557)	1,309,718 (1,196,849)	243,054 (204,895)	Development continued on major new zones at Henderson and Cedar Bay mines which are expected to add materially to ore reserves.
Delbridge Mines Limited, Noranda	Ore custom-milled	Zn,Cu,Ag	3.48 (3.25)	196,844 (57,494)	421,563 (103,380)	Production began September 1969.
D'Estrie Mining Company Ltd., Stratford Centre	Ore custom-milled	Cu,Zn,Pb,Ag	. . (–)	. . (–)	. . (–)	Mine began production late in 1970. Ore milled at Cupra concentrator.
Gaspé Copper Mines, Limited, Gaspe mine, Murdochville	11,250	Cu,Mo,Ag	. . (. .)	4,070,853 (2,997,800)	612,418 (345,066)	Company considering tripling mill capacity to 34,000 tons per day to permit mining large tonnage of lower grade open-pit ore at Copper Mountain mine.

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (tons of ore/day)	Type of Ore Milled	Silver Grade 1970 (1969) (oz/ton)	Ore Produced 1970 (1969) (tons)	Contained Silver Produced 1970 (1969) (troy ounces)	Remarks
Lake Dufault Mines Limited, Noranda	1,300	Cu,Zn,Ag	0.53 (0.77)	419,171 (405,790)	169,743 (236,600)	Shaft at Millenbach mine completed to its final depth of 3,984 feet, and production planned for latter part of 1971.
Manitou-Barvue Mines Limited, Golden Manitou mine, Val d'Or	1,600	Zn,Cu,Pb,Ag	4.66 (2.27)	273,200[5] (198,605)[5]	1,014,660 (380,538)	Mill capacity was increased from 1,300 to 1,600 tons a day.
Mattagami Lake Mines Limited, Matagami	3,850	Zn,Cu,Ag,Au	0.86 (1.02)	1,430,864 (1,413,651)	496,211 (664,795)	Underground crusher and conveyor system is being installed.
Noranda Mines Limited, Horne mine, Noranda	3,200	Cu,Au	0.408 (. .)	654,262 (754,365)	151,247 (. .)	Ore production expected to decline progressively until 1973 when ore reserves will be exhausted.
Normetal Mines Limited, Normetal	1,000	Zn,Cu,Ag	1.474 (1.48)	348,100 (355,495)	321,583 (348,380)	Routine development of remaining ore reserves.
Opemiska Copper Mines (Quebec) Limited, Chapais	3,000	Cu,Ag,Au	0.33 (0.37)	835,942 (792,549)	231,173 (243,583)	Gradual expansion of mill capacity from 2,000 to 3,000 tons daily expected to be completed by mid-1971.
Orchan Mines Limited, Matagami	1,900	Zn,Cu,Ag	1.36 (1.09)	414,521 (308,732)	225,877 (133,185)	Removal of overburden from No. 1 orebody was completed and open cast mining started.
Quemont Mines Limited, Noranda	2,300	Cu,Zn,Au	0.91 (0.74)	299,636 (334,432)	127,850 (148,771)	Mine is expected to cease operations in 1971 because of exhaustion of ore reserves.
The Patino Mining Corporation, Copper Rand Mines Division (Machin Point, Portage, Jaculet and Copper Cliff mines), Chibougamau	3,000	Cu,Au,Ag	0.205 (0.20)	837,187 (731,953)	135,765 (112,143)	Copper Cliff mine placed in production in July 1970.
Sullivan Mining Group Ltd., (Cupra Division)[6], Stratford Centre	1,500	Cu,Zn,Pb,Ag	0.990 (1.177)	193,450 (232,760)	. . (. .)	Ore reserves increased by some 100,000 tons to 636,000 tons as at September 1, 1970.

Company and Location	Mill Capacity (tons of ore/day)	Type of Ore Milled	Silver Grade 1970 (1969) (oz/ton)	Ore Produced 1970 (1969) (tons)	Contained Silver Produced 1970 (1969) (troy ounces)	Remarks
Sullivan Mining Group Ltd., (Solbec Division)[6], Stratford Centre	Ore custom-milled	Cu,Zn,Pb,Ag	2.041 (2.069)	132,060 (196,961)	. . (. .)	Mine closed in December 1970 because of exhaustion of ore reserves.
NEW BRUNSWICK						
Brunswick Mining and Smelting Corporation Limited, No. 12 mine, Bathurst	6,500	Zn,Pb,Cu,Ag	2.19 (2.13)	1,519,981 (1,696,408)	1,695,000 (1,706,447)	Both mines and mills closed by a labour strike from March 3 to April 10, 1970.
No. 6 mine, Bathurst	3,500	Zn,Pb,Cu,Ag	1.84 (1.87)	1,100,703 (1,134,224)	827,500 (961,370)	
Heath Steele Mines Limited, Newcastle	3,000	Zn,Cu,Pb,Ag	2.20 (1.71)	1,030,899 (321,403)	1,254,659 (224,477)	Mill capacity increased from 1,500 to 3,000 tons a day.
Nigadoo River Mines Limited[6], Bathurst	1,000	Pb,Zn,Cu,Ag	3.59 (3.71)	319,689 (321,397)	903,897 (891,037)	Ore reserves at August 31, 1970 were 2,200,000 tons averaging 2.88 per cent lead, 2.84 per cent zinc, 0.23 per cent copper and 3.67 oz silver a ton.
NOVA SCOTIA						
Dresser Minerals, Division of Dresser Industries, Inc., Walton	125	Pb,Cu,Zn,Ag	3.58 (5.5)	27,263 (49,870)	84,508 (227,822)	Developing lower levels.
NEWFOUNDLAND						
American Smelting and Refining Company (Buchans Unit), Buchans	1,250	Zn,Pb,Cu,Ag	3.73 (4.01)	359,000 (371,000)	1,146,489 (1,300,784)	Proven and probable ore reserves are sufficient to support mine production for another 8 to 10 years.

Source: Company reports.

[1]Ore produced in No. 3 zone only. [2]Silver delivered to markets. [3]Production does not include old mill tailings treated in separate 1,000-ton-a-day reclamation plant. In 1969, 151,323 tons of tailings grading 2.70 ounces silver a ton were treated. This reclamation plant was not operated in 1970. [4]Production does not include old mill tailings from Peterson Lake that were treated in separate reclamation plant. In 1969, 160,382 ounces of silver were recovered from processing such mill tailings. [5]Production does not include copper ore milled in separate circuit. [6]Production for fiscal years ending August 31.

– Nil; . . Not available.

TABLE 5

Prospective* Silver Producing Mines in Canada

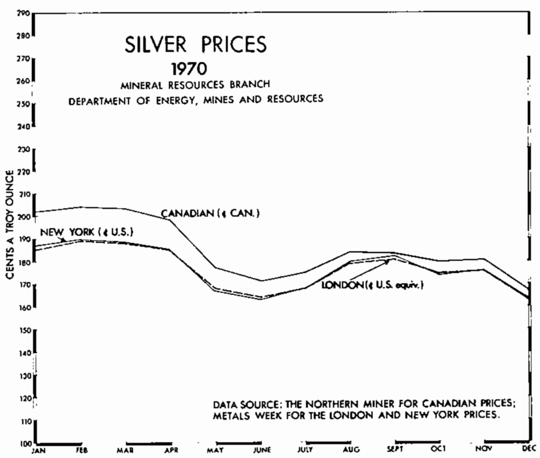
Company and Location	Year Production Expected	Mill or Mine Capacity (tons ore/day)	Indicated Ore Reserves (tons)	Average Grade of Ore: Lead (%)	Zinc (%)	Copper (%)	Silver (oz/ton)	Remarks
BRITISH COLUMBIA								
Columbia Metals Corporation Limited, Ferguson	1971	125	100,000	6.0	6.7	..	6.9	Initial production will come from the True Fissure portion of the property.
MANITOBA								
Hudson Bay Mining and Smelting Co., Limited								
Ghost Lake Mine, Snow Lake	1972	..	261,000	0.91	11.6	1.42	1.14	Mine is being developed by trackless methods.
White Lake Mine, Flin Flon	1972	..	352,000	0.5	6.2	2.22	1.12	Shaft-sinking started in September 1970.
ONTARIO								
Mattabi Mines Limited, Sturgeon Lake area	1972	3,000	13,000,000	0.84	7.6	0.91	3.13	Initial open-pit production expected to begin about mid-1972.
South Bay Mines Limited, Uchi Lake area	1971	500	..	–	14.11	2.24	3.64	Mine developed by vertical shaft from surface to 300-ft level and which will later be deepened to the 680-ft level. A 9-ft by 15-ft decline also spirals down from surface to the 50- and 100-ft sub-levels and the 150-ft level.

*Those mines which have announced production plans.

.. Not available.

PRICES

In 1970, the New York silver price again followed an erratic pattern but the range of price fluctuations was narrower than in 1969. The year opened with the price at $1.840 an ounce and on January 29 it reached a high of $1.930. A low of $1.572 occurred on December 10 and at year-end the price was $1.620. The London price ranged between a high of 197.0 pence an ounce, equivalent to $1.971 (U.S.), on January 29 and a low of 156.8 pence, equivalent to $1.568 (U.S.), on May 26. At year-end it was 164.0 pence, equivalent to $1.635 (U.S.).



In 1970, the Canadian silver price closely followed its United States counterpart with the essential difference being the exchange rate; it fluctuated between a high of $2.075 an ounce on January 29 and a low of $1.609 on December 10. Average for the year was $1.853.

TARIFFS

CANADA

Item No.		Most Favoured Nation
32900-1	Ores of metals, n.o.p.	free
35800-1	Anodes of silver	free
35900-1	Silver in ingots, blocks, bars, drops, sheets or plates, unmanufactured; silver sweepings	free
35905-1	Scrap silver and metal alloy scrap containing silver	free*
36100-1	Silver leaf	20%
36200-1	Articles consisting wholly or in part of sterling or other silverware, n.o.p.; manufactures of silver, n.o.p.	22½%

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

*Expires October 31, 1972.

n.o.p. Not otherwise provided for.

UNITED STATES

601.39	Precious metal ores, silver content	free
605.20	Gold or silver bullion, dore, and gold or silver precipitates	free
605.46	Silver, unwrought, platinum-plated	19%*
605.47	Silver, unwrought, gold-plated	30%*
605.65	Rolled silver	12.5%*
605.70	Precious metal sweepings and other precious metal waste and scrap, silver content	free

Source: Tariff Schedules of the United States, Annotated (1970) TC Publication 304.

*Effective January 1, 1971.

Sodium Sulphate

W.E. KOEPKE*

Sodium sulphate (Na_2SO_4), commonly known as 'salt cake', is one of the key raw materials used in the manufacture of pulp and paper by the 'kraft' process. It can be produced: from natural deposits and brines in alkaline lakes that occur in areas of little or no drainage and dry climates; from subsurface deposits and brines; or as a byproduct from a number of chemical processes such as the reaction of sodium chloride with sulphuric acid to make hydrochloric acid. Canada's sodium sulphate industry is based on natural brines and deposits in many alkaline lakes in the southern prairies of Saskatchewan and Alberta. Small quantities of byproduct salt cake are also recovered at a viscose-rayon plant in eastern Canada. Also, beginning in 1971, some byproduct sodium sulphate is to be produced from a strontium sulphate-carbonate operation in Nova Scotia.

Elsewhere in North America, naturally occurring sodium sulphate is produced in California, Texas and Wyoming and the byproduct type is produced in the eastern States.

PRODUCTION AND DEVELOPMENT IN CANADA

Production (shipments) of sodium sulphate in Canada amounted to 478,000 tons valued at $7.6 million in 1970, down somewhat from the alltime high of 518,000 tons valued at $8.1 million in 1969. The figures for 1970 are preliminary and both years exclude about 15,000 tons of byproduct salt cake recovered at a viscose-rayon plant in Ontario. The lower level of output for 1970 is attributed to conditions in the pulp and paper industry; a number of new pulp mills had not yet reached full operating capacity and improved technology has tended to lower the quantity of make-up sodium sulphate in the pulp manufacturing process. The sluggishness in demand has led to some oversupply of sodium sulphate and an accompanying weakness in prices.

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 months are

* Mineral Resources Branch.

TABLE 1

Canada, Sodium Sulphate Production and Trade, 1969-70

	1969		1970p	
	Short Tons	$	Short Tons	$
Production				
Shipments	518,299	8,051,627	478,000	7,611,000
Imports				
Total crude salt cake and Glauber's salt				
United States	20,016	490,000	16,916	347,000
Belgium and Luxembourg	5,604	102,000	8,879	169,000
Britain	3,967	76,000	3,360	73,000
Other countries	33	1,000	–	–
Total	29,620	669,000	29,155	589,000
Exports				
Crude sodium sulphate				
United States	107,233	2,556,000	105,108	2,146,000
South Africa	4,034	67,000	9,059	128,000
Mozambique	2,499	51,000	5,719	57,000
Trinidad Tobago	1	...	2	...
Other countries	6,647	133,000	–	–
Total	120,414	2,807,000	119,888	2,331,000

Source: Dominion Bureau of Statistics.
pPreliminary; – Nil; ... Less than one thousand dollars.

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 the Saskatchewan producers, weather conditions are equally as important for the recovery of sodium sulphate as for its deposition. A supply of fresh water is also an essential part of recovery.

Sodium sulphate recovery generally begins by pumping concentrated lake brines into reservoirs during the summer months. Pumping takes place when the brine is at the highest degree of 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 in depth, is then excavated using scrapers, shovels or draglines and moved to a stockpile. Stockpiling is done in the winter months 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-flowing characteristics are important in material handling and use.

The Alberta-based producer uses a solution recovery system rather than the seasonal harvesting method. The raw Glauber's salt is recovered from the

TABLE 2

Canada, Sodium Sulphate Production, Trade and Consumption, 1961-70

	Production*	Imports**	Exports	Consumption
1961	250,996	33,209	87,048	200,096
1962	246,672	31,773	74,049	210,691
1963	256,914	14,497	65,348	238,321
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	397,167
1970^{p}	478,000	29,155	119,888	423,000^{e}

Source: Dominion Bureau of Statistics.
*Producers' shipments of crude sodium sulphate. ** Includes Glauber's salt and crude salt cake.
^{p}Preliminary; ^{e} Estimated.

lake bed by solution methods, a system which apparently has proven very successful during both the summer and winter months. The brine is then subjected to an evaporation and crystallization process to recover the sodium sulphate.

Courtaulds (Canada) Limited produced about 15,000 tons of byproduct salt cake in 1970 from the operation of a viscose-rayon plant at Cornwall, Ontario.

Beginning in 1971, Kaiser Celestite Mining Limited, a subsidiary of Kaiser Aluminum & Chemical Canada Limited, plans to recover byproduct salt cake at the rate of 100 tons daily from the production of strontium sulphate and strontium carbonate at Point Edward, Nova Scotia.

CANADIAN CONSUMPTION AND TRADE

About 95 per cent of the sodium sulphate consumed in Canada is used as a raw material in the production of pulp and paper by the 'kraft' process. The kraft process yields a pulp with a very long fibre that allows manufacture of stronger paper than with other pulps

TABLE 3

Canada, Sodium Sulphate Plants, 1970

Company	Plant Location	Source Lake	Annual Capacity in Short Tons
Alberta Sulphate Limited	Metiskow, Alta.	Horseshoe, Alta.	100,000
Francana Minerals Ltd.	Cabri, Sask.	Snakehole, Sask.	100,000
	Alsask, Sask.*	Alsask, Sask.	50,000
Midwest Chemicals Limited	Palo, Sask.	Whiteshore, Sask.	120,000
Ormiston Mining and Smelting Co. Ltd.	Ormiston, Sask.	Horseshoe, Sask.	100,000
Saskatchewan Minerals	Chaplin, Sask.	Chaplin, Sask.	150,000
Saskatchewan Minerals	Bishopric, Sask.	Frederick, Sask.	70,000
Saskatchewan Minerals	Fox Valley, Sask.	Ingebrigt, Sask.	150,000
Sybouts Sodium Sulphate Co., Ltd.	Gladmar, Sask.	East Coteau, Sask.	50,000
Total			890,000

*Inactive.

and the process also makes it easier to control pollution at pulp mills. There were 38 kraft pulp mills operating in Canada at the end of 1970 – fifteen in British Columbia, nine in Quebec, eight in Ontario, three in New Brunswick and one each in Nova Scotia, Saskatchewan and Alberta. Consumption of sodium sulphate in the pulp and paper industry has increased from 154,000 tons in 1960 to an estimated 400,000 tons in 1970.

Sodium sulphate is also consumed in the manufacture of glass, detergents, mineral-feed supplements, medicinals and a number of other chemical products, and in base-metal smelting.

Exports of sodium sulphate, the bulk of which went to the United States, amounted to 119,888 tons valued at $2,331,000 in 1970. The level of exports was about the same as the past six years.

Imports of sodium sulphate, mainly from the United States, have remained fairly steady around 30,000 tons annually during the past 15 years. In 1970, imports totalled 29,155 tons valued at $589,000. Most of the imports are of the byproduct type and serve markets in eastern Canada that are not as readily accessible by shipments from western Canada. Freight charges can represent more than one half the cost of sodium sulphate to the eastern Canadian consumer for shipments from Saskatchewan and Alberta.

TABLE 4

Canada, Available Data on Sodium Sulphate Consumption, 1968-70
(short tons)

	1968	1969	1970e
Pulp and paper	370,430	375,000e	400,000
Glass and glasswool	6,173	7,177	7,000
Soaps	8,655	8,072	9,000
Other products*	6,695	6,918	7,000
Total	391,953	397,167e	423,000

Source: Dominion Bureau of Statistics, breakdown by Mineral Resources Branch.

*Colours, pigments, foundries, feed supplements and other minor uses.

eEstimated.

PRICES

Canadian prices for sodium sulphate, as quoted by *Canadian Chemical Processing, Buyers Guide*, December, 1970 were:

	(Can. $ per short ton)
Sodium sulphate (salt cake)	
Bulk, carlots, f.o.b. works	18.00 - 20.00
Detergent and grade, bulk, f.o.b. works	23.50

According to *Oil, Paint and Drug Reporter*, December 28, 1970, the United States prices were:

	(US $ per short ton)
Salt cake, 100%Na_2SO_4 basis f.o.b. works	28.00
Salt cake, domestic, West, bulk, carlots, f.o.b. producing point	18.50
Sodium sulphate, detergent, rayon-grade, carlots, f.o.b. works, bulk	
East	34.00
West	24.50

Quoted prices remained unchanged from 1969, but indications are that most sales of Canadian produced bulk grade were made at $16.50 a ton, the price that existed prior to 1968.

TARIFFS

CANADA

Natural sodium sulphate	
British Preferential	10%
Most Favoured Nation	12½%
General	25%

UNITED STATES

Crude (salt cake)	free
Anhydrous, per long ton	
Jan. 1, 1970 to Dec. 31, 1970	35¢
Jan. 1, 1971 to Dec. 31, 1971	30¢
Crystallized (Glauber's salt), per long ton	
Jan. 1, 1970 to Dec. 31, 1970	70¢
Jan. 1, 1971 to Dec. 31, 1971	60¢

Reductions under the Kennedy Round of the General Agreement on Tariffs and Trade (GATT), that was convened in 1964 and concluded in 1967, will lower United States tariffs to 25¢ and 50¢, respectively, on and after Jan. 1, 1972.

Source: Tariff Schedules of United States, Annotated (1970) T.C. Publication 304.

Stone

D. H. STONEHOUSE*

Stone production in Canada, either as dimension stone or as crushed stone, is used either directly or indirectly by the construction industry. 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.

Total value of construction in Canada for 1971 is estimated to approach $15.2 billion compared with a preliminary estimate of $13.6 billion for 1970. Engineering construction is expected to increase to a value of $6.4 billion from $5.6 billion in 1970. Although these estimates indicate that greater amounts of construction materials, including stone, will be used, it is unlikely that increases will be in direct proportion by volume.

CRUSHED STONE

Crushed stone accounts for over 80 per cent of stone production. 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 rip-rap 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.

Rehabilitation of a stone quarry to permit subsequent land-use is generally more difficult and costly than for gravel pits. They do provide the same disruptions to the natural environment and to urban development and are therefore included in continuing studies to plan efficient land-use. Justifiable concern has been shown relative to the future development, operation and rehabilitation of pits and quarries in all locations and specifically in and near districts where urban development is surrounding quarry sites and over-running potential sources of raw mineral materials used by the construction industry. Master plans are required to co-ordinate all phases of development and to provide for optimum utilization of these non-renewable resources. In Ontario, the Niagara Escarpment Protection Act, June 26, 1970, prohibits future mining on the escarpment face and for 300 feet back from the face. This is indicative of the firm action necessary today to control environmental problems. A Pit and Quarry Control Act is currently being studied for Ontario.

Crushed stone uses 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.

*Mineral Resources Branch.

TABLE 1

Canada – Production (Shipments) Total Stone, 1968, 1969 and 1970

	1968		1969		1970p	
	Short Tons	$	Short Tons	$	Short Tons	$
By Provinces						
Newfoundland	876,768	1,097,848	189,929	338,703	200,000	350,000
Prince Edward Island	439,775	413,600	–	–	–	–
Nova Scotia	819,788	2,340,640	1,015,901	2,406,638	1,250,000	2,500,000
New Brunswick	2,137,748	2,934,769	1,208,512	2,153,359	1,200,000	2,200,000
Quebec	34,952,128	39,422,561	32,008,732	39,312,048	31,500,000	40,000,000
Ontario	28,636,257	37,733,856	27,034,506	32,293,526	30,000,000	39,000,000
Manitoba	2,305,900	3,021,925	699,123	2,010,398	1,900,000	3,200,000
Alberta	220,523	695,872	314,701	1,097,982	400,000	1,200,000
British Columbia	5,550,880	7,997,004	5,005,608	8,573,608	4,250,000	7,400,000
Canada	75,939,767	95,658,075	67,477,012	88,186,262	70,700,000	95,850,000
By Use						
Building stone						
Rough	66,244	800,295	55,356	1,330,667		
Dressed	51,294	3,214,734	51,159	4,700,671		
Monumental and ornamental stone						
Rough	21,883	707,098	23,454	860,502		
Dressed	9,509	794,392	8,082	1,292,089		
Flagstone	20,400	219,174	8,316	53,458		
Curbstone	6,050	161,030	8,487	211,717		
Paving blocks	3,220	13,987	416	4,995		
Chemical and metallurgical						
Cement plants, foreign	1,309,620	1,340,542	1,151,792	1,220,420		
Lining open-hearth furnaces	299,922	319,516	271,728	178,873		
Flux in iron and steel furnaces	1,641,164	2,532,438	1,533,782	1,874,574		
Flux in non-ferrous smelters	155,994	178,643	119,482	133,010		
Glass factories	154,800	558,408	158,880	472,401		
Lime kilns, foreign	258,468	558,289	261,725	469,467		
Pulp and paper mills	360,296	1,071,583	372,609	1,102,549		
Sugar refineries	77,807	180,296	100,478	222,223		
Other chemical uses	240,376	268,134	677,965	822,344		
Pulverized stone						
Whiting (substitute)	159,142	191,132	199,438	393,080		
Asphalt filler	484,066	877,225	467,595	779,570		
Dusting coal mines	8,062	47,521	6,062	32,755		
Agricultural purposes and fertilizer plants	1,038,960	2,745,983	840,664	2,335,449		
Other uses	769,954	1,313,169	336,219	589,975		

TABLE 1 (Cont'd)

	1968		1969		1970P	
	Short Tons	$	Short Tons	$	Short Tons	$
Crushed stone						
For manufacture of artificial stone	101,355	302,297	85,348	279,536		
Roofing granules	175,933	1,981,740	93,185	1,764,717		
Poultry grit	25,942	244,230	19,273	139,382		
Stucco dash	7,158	178,872	13,165	370,276		
Terrazzo chips	10,490	163,708	12,743	230,954		
Rock wool	7,438	57,306	7,741	33,629		
Rubble and rip-rap	11,024,886	10,974,375	3,538,547	3,348,993		
Concrete aggregate	10,956,477	12,577,576	12,230,784	14,822,419		
Road metal	33,758,308	37,936,311	30,068,306	31,702,630		
Railroad ballast	3,725,067	4,029,472	2,449,038	3,581,999		
Other uses	9,009,482	9,118,599	12,305,193	12,830,938		
Total	75,939,767	95,658,075	67,477,012	88,186,262		

Source: Dominion Bureau of Statistics.
PPreliminary; – Nil.

TABLE 2

Canada – Production (Shipments) Limestone, 1968 and 1969

	1968		1969	
	Short Tons	$	Short Tons	$
By Provinces				
Newfoundland	439,144	543,225	83,929	124,308
Nova Scotia	369,025	1,237,629	383,784	975,326
New Brunswick	492,613	1,040,303	300,877	749,774
Quebec	21,102,888	22,129,938	28,052,715	28,071,916
Ontario	26,538,776	32,508,180	26,202,850	28,638,664
Manitoba	2,293,930	2,890,850	698,683	1,690,448
Alberta	217,172	641,202	313,751	1,063,284
British Columbia	3,085,248	4,628,626	3,573,767	5,905,283
Canada	54,538,796	65,619,953	59,610,356	67,219,003
By Use				
Building stone				
Rough	36,923	286,385	13,577	165,122
Dressed	25,242	1,014,892	29,301	1,060,228
Monumental and ornamental				
Rough	2,741	75,740	1,105	25,259
Dressed	–	–	739	5,912
Flagstone	12,836	59,941	6,850	16,351
Curbstone	50	1,000	12	36
Paving blocks	2,950	13,200	–	–
Chemical and metallurgical				
Cement plants, foreign	1,309,620	1,340,542	1,151,792	1,220,420
Lining open-hearth furnaces	299,922	319,516	271,728	178,873
Flux, iron and steel furnaces	1,641,164	2,532,438	1,533,782	1,874,574
Flux, non-ferrous smelters	155,994	178,643	119,482	133,010
Glass factories	154,800	558,408	158,880	472,401
Lime kilns, foreign	258,468	558,289	261,725	469,467
Pulp and paper mills	360,296	1,071,583	372,609	1,102,549
Sugar refineries	77,807	180,296	100,478	222,223
Other chemical uses	240,376	268,134	677,965	822,344
Pulverized stone				
Whiting substitute	159,142	191,132	199,438	393,080
Asphalt filler	351,256	523,079	343,108	532,037
Dusting coal mines	8,062	47,521	6,062	32,755
Agricultural purposes and fertilizer plants	1,027,120	2,719,645	825,329	2,303,319
Other uses	769,954	1,313,169	336,219	589,975
Crushed stone				
For artificial stone	86,582	196,839	55,091	208,767
Roofing granules	31,120	116,642	5,655	25,464
Poultry grit	16,496	125,422	15,480	112,023
Stucco dash	5,918	165,383	13,165	370,276
Terrazzo chips	110	655	200	1,200
Rock wool	531	1,059	1,242	1,134
Rubble and rip-rap	1,330,189	1,387,773	3,104,627	2,845,528
Concrete aggregate	9,818,994	10,404,188	10,286,625	11,094,338
Road metal	28,582,594	31,915,208	26,208,450	26,721,742
Railroad ballast	1,477,041	1,569,404	2,036,953	2,477,974
Other uses	6,294,498	6,483,827	11,472,687	11,740,622
Total	54,538,796	65,619,953	59,610,356	67,219,003

Source: Dominion Bureau of Statistics.
– Nil.

TABLE 3

Canada – Production (Shipments) Marble, 1968 and 1969

	1968		1969	
	Short Tons	$	Short Tons	$
By Provinces				
Nova Scotia	7,000	23,500	–	–
Quebec	128,100	223,735	76,363	175,124
Ontario	29,207	367,503	9,485	215,475
British Columbia	700	23,107	–	–
Total, Canada	165,007	637,845	85,848	390,599
By Use				
Building stone				
Rough	1,554	60,346	420	15,500
Dressed	249	13,376	140	9,600
Pulverized stone				
Whiting substitute	–	–	–	–
Agricultural purposes and fertilizer plants	11,840	26,338	15,335	32,130
Other uses	–	–	–	–
Crushed stone				
For manufacture of artificial stone	14,773	105,458	5,257	20,769
Roofing granules	5,005	37,879	5,383	26,346
Poultry grit	3,626	38,260	–	–
Stucco dash	1,240	13,489	–	–
Terrazzo chips	10,159	162,257	12,082	228,094
Rock wool	6,907	56,247	–	–
Concrete aggregate	34,960	42,072	15,687	19,320
Road metal	74,000	79,000	31,544	38,840
Other uses	694	3,123	–	–
Total	165,007	637,845	85,848	390,599

Source: Dominion Bureau of Statistics.
– Nil.

TABLE 4

Canada – Production (Shipments) Granite, 1968 and 1969

	1968		1969	
	Short Tons	$	Short Tons	$
By Provinces				
Newfoundland	–	–	–	–
Nova Scotia	14,563	172,523	11,092	139,194
New Brunswick	987,919	1,288,690	905,320	1,298,568
Quebec	12,098,739	15,300,764	2,386,712	8,984,478
Ontario	2,048,327	4,554,570	769,407	2,962,757
Manitoba	11,970	131,075	440	319,950
Alberta	1,290	2,064	–	–
British Columbia	1,491,927	1,860,845	1,326,841	2,127,213
Total, Canada	16,654,735	23,310,531	5,399,812	15,832,160

TABLE 4 (Cont'd)

	1968		1969	
	Short Tons	$	Short Tons	$
By Use				
Building stone				
Rough	6,486	126,596	17,600	633,539
Dressed	25,569	2,176,097	21,368	3,603,727
Monumental and ornamental				
Rough	19,142	631,358	21,399	800,545
Dressed	9,509	794,392	7,343	1,286,177
Flagstone	1,143	66,325	10	190
Curbstone	6,000	160,030	8,125	199,181
Paving blocks	–	–	–	–
Chemical uses	–	–	–	–
Pulverized				
Asphalt filler	36,201	112,896	8,487	15,533
Other pulverized uses	–	–	–	–
Crushed stone				
For artificial stone	–	–	–	–
Roofing granules	137,346	1,820,276	78,642	1,703,726
Poultry grit	3,823	69,465	978	11,736
Stucco dash	–	–	–	–
Rubble and rip-rap	9,527,980	9,357,002	431,253	493,976
Concrete aggregate	711,063	1,014,083	1,120,291	1,998,904
Road metal	2,583,923	3,279,340	2,690,005	3,379,653
Railroad ballast	1,141,492	1,205,522	208,796	700,488
Other uses	2,445,058	2,497,149	785,515	1,004,785
Total	16,654,735	23,310,531	5,399,812	15,832,160

Source: Dominion Bureau of Statistics.
– Nil.

TABLE 5

Canada – Production (Shipments) Sandstone, 1968 and 1969

	1968		1969	
	Short Tons	$	Short Tons	$
By Provinces				
Newfoundland	317,770	434,769	106,000	214,395
Prince Edward Island	439,775	413,600	–	–
Nova Scotia	429,200	906,988	621,025	1,292,118
New Brunswick	657,216	605,776	2,315	105,017
Quebec	1,578,061	1,741,153	1,492,942	2,080,530
Ontario	19,947	303,603	52,764	476,630
Manitoba	–	–	–	–
Alberta	2,061	52,606	950	34,698
British Columbia	823,361	678,163	–	–
Total, Canada	4,267,391	5,136,658	2,275,996	4,203,388
By Use				
Building stone				
Rough	21,281	326,968	23,759	516,506
Dressed	234	10,369	350	27,116

TABLE 5 (Cont'd)

	1968		1969	
	Short Tons	$	Short Tons	$
By Use (Cont'd)				
Monumental and ornamental				
Rough	–	–	950	34,698
Flagstone	6,421	92,908	1,456	36,917
Curbstone	–	–	350	12,500
Paving blocks	270	787	416	4,995
Pulverized stone				
Asphalt filler	95,000	204,250	116,000	232,000
Crushed stone				
For artificial stone	–	–	25,000	50,000
Roofing granules	2,462	6,943	3,505	9,181
Poultry grit	1,997	11,083	2,815	15,623
Stucco dash	–	–	–	–
Terrazzo chips	221	796	461	1,660
Rock wool	–	–	6,499	32,495
Rubble and rip-rap	166,717	229,600	2,667	9,489
Concrete aggregate	281,676	426,722	703,181	1,168,745
Road metal	2,315,346	2,437,186	1,138,307	1,562,395
Railroad ballast	1,106,534	1,254,546	203,289	403,537
Other uses	269,232	134,500	46,991	85,531
Total	4,267,391	5,136,658	2,275,996	4,203,388

Source: Dominion Bureau of Statistics.
– Nil.

TABLE 6

Canada – Production (Shipments) Shale, 1968 and 1969

	1968		1969	
	Short Tons	$	Short Tons	$
By Province				
Newfoundland	119,854	119,854	–	–
Quebec	44,340	26,971	–	–
British Columbia	149,644	806,263	105,000	541,112
Total, Canada	313,838	953,088	105,000	541,112
By Use				
Chemical and metallurgical				
Cement plants in Canada	–	–	–	–
Other chemical uses	–	–	–	–
Pulverized				
Asphalt filler	1,609	37,000	–	–
Crushed stone				
Concrete aggregate	109,784	690,511	105,000	541,112
Road metal	202,445	225,577	–	–
Rails and ballast	–	–	–	–
Other uses	–	–	–	–
Total	313,838	953,088	105,000	541,112

Source: Dominion Bureau of Statistics.
– Nil.

TABLE 7

Canada – Production (Shipments) Stone by Types, 1960-70

	Granite		Limestone		Marble		Sandstone	
	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$
1960	5,237,243	11,885,953	36,405,875	44,763,355	69,496	650,468	3,420,667	3,079,253
1961	6,355,734	14,162,206	38,152,775	47,183,610	67,643	775,949	4,226,299	4,078,777
1962	5,386,880	13,942,156	41,551,585	50,315,116	71,888	707,724	3,492,071	3,735,957
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
1970p	..	..	..	..	..	..	..	..

	Shale		Slate		Total	
	Short Tons	$	Short Tons	$	Short Tons	$
1960	179,642	233,546	46,526	28,046	45,359,449	60,640,621
1961	135,103	365,376	1,250	1,750	48,938,804	66,567,668
1962	45,686	149,684	5,375	15,721	50,553,485	68,866,358
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	2,338,492	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
1970p	..	..	..	..	70,700,000	95,850,000

Source: Dominion Bureau of Statistics.
p Preliminary; .. Not available; – Nil.

Pulverized stone is used as follows: granite, limestone and sandstone as asphalt filler; limestone for dusting coal-mines; limestone and marble for agricultural application. Also, in excess of 3.5 million tons of limestone is produced for chemical and metallurgical uses in the iron and steel industry, the glass industry, the pulp and paper industry and in sugar manufacture.

BUILDING AND ORNAMENTAL STONE

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. Until recently, granite, limestone and sandstone were quarried as the principal building materials for the construction of office buildings, houses, walls, dams, etc., but competitive materials such as concrete and steel have replaced stone as a major construction material in many applications. 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.

CANADIAN INDUSTRY

ATLANTIC PROVINCES

Limestone

At Corner Brook, Newfoundland, Westland Equipment quarried a high-calcium limestone for use by

Bowaters Newfoundland Limited in the calcium-acid sulphite process of pulp preparation. About 20,000 tons a year is used.

Mosher Limestone Company Limited quarried a dolomitic limestone at Upper Musquodoboit, Nova Scotia. Some crushed material was shipped by rail to the steel works at Sydney, Nova Scotia, and pulverized material was sold for agricultural use throughout the Atlantic Provinces. Sydney Steel Corporation produced 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.

In New Brunswick, limestone was quarried at three locations – Brookville, Elm Tree and Havelock – for use as a crushed stone, as an aggregate, or for agricultural application.

There are three cement producers and two lime manufacturing plants in the Atlantic Provinces, each operating its own limestone quarry. Reference should be made to the Cement and Lime sections of the Canadian Minerals Yearbook, 1970.

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. In 1970 there was no production from old granite quarries in the Halifax, New Germany or Queensport areas. Quartzitic rock referred to as "blue stone" was quarried at Lake Echo, north of Dartmouth, for use as facing stone.

In New Brunswick, a coarse-grained, grey-brown granite was quarried near St. Stephen, and fine-grained, pink, grey and blue-grey granites were available in the Hampstead (Spoon Island) district. In the Bathurst area, a brown to grey, coarse-grained granite was quarried upon demand, as was a salmon-coloured, medium-grained granite near Antinouri Lake, and a black, ferromagnesian rock in the Bocabec River area. Red granite was available in the St. George district.

Sandstone

A medium-grained, buff-coloured, sandstone was quarried at Wallace, Nova Scotia, in 1970, for use as heavy rip-rap 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 of the Mount Allison University campus. A number of 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 in geological age from Precambrian to Carboniferous, and vary widely in purity, colour, texture and chemical composition.

Of over 90 limestone producers in Quebec, about 50 were classed to stone quarries with non-cement, non-lime associations. These were located near major market areas such as Montreal, Quebec, Sherbrooke, Ottawa-Hull and Trois-Rivières and supplied crushed stone to the construction industry mainly for use in concrete and asphalt and as highway subgrade. Between 70 and 80 per cent of all stone quarried in Quebec was limestone, of which about 85 per cent was used as a crushed stone.

The pulp and paper industry, the metallurgical industry and the agricultural industry each used substantial quantities of limestone. At Kilmar, in western Quebec, Canadian Refractories Limited mined a magnesite-dolomite ore from which it produced refractory grade magnesia and magnesia products.

Six companies operated a total of seven cement manufacturing plants in Quebec while lime was produced by four companies at four locations. (See Cement and Lime sections of the Canadian Minerals Yearbook 1970.)

A fine-grained, brownish-grey, fossiliferous limestone is available in the St.-Marc-des-Carrières region of Quebec.

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, in the Eastern Townships. North 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-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 of much younger geological age and are essentially greyish in colour.

Sandstone

There were 14 mining operations in Quebec in which sandstone was being quarried for construction uses. The material was used as a facing stone and as an 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 in age, 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 amounted to over 90 per cent of total stone production in Ontario during 1970.

Marble, ranging in colour from blue to pink, has been quarried for construction purposes from deposits near Perth. Marble is widely distributed over southeastern Ontario and according to Ontario Department of Mines Reports underlays as much as 100 square miles.

The limestone industries of Ontario are described in detail in publications of the Ontario Department of Mines.

Nine companies operated a total of eleven lime producing facilities in Ontario in 1970 and five companies produced portland cement at a total of seven locations. (See Cement and Lime sections of the Canadian Minerals Yearbook, 1970.) Crushed stone was shipped from the most of these plants.

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 south and southwestern Ontario, where ample, good-quality limestones and sandstones are readily available for building purposes. The areas most active in granite building stone production have been the Vermillion 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 in colour 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.

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 limestones 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 has found wide acceptance 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. 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.

The eastern ranges of the Rocky Mountains contain limestones spanning the geological ages from Cambrian to Triassic with major deposits in the Devonian and Carboniferous systems in which a wide variety of types occurs. 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 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. Other operations at Terrace, Clinton, Westwold, Popkum, Dahl Lake, Koeye River and Cobble Hill produced stone for construction use, for filler use, and cement manufacture. Beginning in 1969, shipments of limestone from a new quarry on Aristazabal Island, 350 miles north of Vancouver, were made to the Portland, Oregon area by Laredo Limestone Ltd.

Eight cement plants and seven lime plants were operated in western Canada in 1970. (See Cement and Lime sections of the Canadian Minerals Yearbook, 1970.)

Granite

In Manitoba, at Lac du Bonnet northeast of Winnipeg, a durable, red granite was 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".

MARKETS, OUTLOOK AND TRADE

Limestones are widely distributed in Canada and generally are available in sufficient quantity and with the chemical or physical specifications such 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.

TABLE 8

Canada, Stone Imports and Exports, 1968-70

	1968		1969		1970p	
	Short Tons	$	Short Tons	$	Short Tons	$
IMPORTS						
Building stone, rough	18,522	777,000	21,308	901,000	1,062	889,000
Natural stone basic products	..	1,628,000	..	2,175,000	..	3,215,000
Total		2,405,000		3,076,000		4,104,000
EXPORTS						
Stone crude n.e.s.	19,276	92,000	1,121	53,000	2,377	49,000
Building stone rough n.e.s.	12,919	442,000	15,307	571,000	14,697	528,000
Granite, rough	13,166	582,000	14,271	665,000	13,048	567,000
Marble, rough	5,745	495,000	6,445	569,000	4,676	378,000
Shaped or dressed granite	..	227,000	..	548,000	..	408,000
Shaped or dressed marble	..	483,000	..	542,000	..	666,000
Natural stone basic products	..	247,000	..	281,000	..	195,000
Total		2,568,000		3,229,000		2,791,000

Source: Dominion Bureau of Statistics.
pPreliminary; .. Not available; n.e.s. Not elsewhere specified.

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.

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 a 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 to 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 construction-materials based operations can, through mergers and acquisitions, obtain captive markets for their products in operating construction firms. Construction firms can also integrate backwards into the resource field.

TABLE 9

Value of Construction in Canada, 1969-71
(millions)

	1969	1970	1971*	% change 1970-1971
TOTAL CONSTRUCTION	**13,207.4**	**13,622.9**	**15,215.2**	**+11.7**
Total building construction	**8,055.5**	**8,038.1**	**8,827.2**	+ 9.8
Residential	4,227.9	3,935.4	4,690.0	+19.2
Industrial	869.1	995.9	1,007.1	+ 1.1
Commercial	1,151.8	1,262.4	1,268.7	+ 0.5
Institutional	1,334.5	1,345.9	1,327.0	− 1.4
Other building	472.1	498.5	534.4	+ 7.2
Total engineering construction	**5,151.9**	**5,584.8**	**6,387.9**	**+14.4**
Marine	165.4	144.7	171.4	+18.7
Highways, aerodromes	1,255.3	1,348.3	1,438.9	+ 6.8
Waterworks, sewage systems	397.8	469.9	556.1	+18.1
Dams, irrigation	68.7	63.8	78.2	+22.6
Electric power	1,005.1	1,099.1	1,212.5	+10.3
Railways, telephones	525.3	562.0	594.9	+ 5.9
Gas, oil facilities	966.0	1,098.6	1,341.6	+22.1
Other engineering	768.4	798.4	994.3	+24.6

Source: Dominion Bureau of Statistics.
*Intentions.

TABLE 10

Canada – Value of Construction Work Performed by Principal Type of Construction by Industry, 1968-71
($ million)

Industry	1968 Building	1968 Engineering	1968 Total	1969 Building	1969 Engineering	1969 Total	1970 Building	1970 Engineering	1970 Total	1971* Building	1971* Engineering	1971* Total
Agriculture and fishing	228	123	351	225	121	346	206	111	317	209	113	322
Forestry	7	45	52	10	58	68	7	57	64	7	61	68
Mining, quarrying, oil wells	158	733	891	201	807	1,008	149	874	1,023	265	1,013	1,278
Construction	20	–	20	20	–	20	21	–	21	21	–	21
Manufacturing	563	287	850	682	295	977	831	361	1,192	733	366	1,099
Utilities	193	1,941	2,134	214	1,858	2,072	261	2,056	2,317	246	2,489	2,735
Trade	250	15	265	251	13	264	258	11	269	238	11	249
Finance, insurance, real estate	424	8	432	433	8	441	459	7	466	457	10	467
Commercial services	132	7	139	130	1	131	149	2	151	158	1	159
Housing	3,587	–	3,587	4,228	–	4,228	3,935	–	3,935	4,690	–	4,690
Institutional services	1,274	13	1,287	1,228	10	1,238	1,242	15	1,257	1,227	13	1,240
Government departments	422	1,784	2,206	434	1,980	2,414	520	2,091	2,611	576	2,311	2,887
Total	7,258	4,956	12,214	8,055	5,151	13,207	8,038	5,585	13,623	8,827	6,388	15,215

Source: Dominion Bureau of Statistics.
*Intentions; –Nil.

The possibility of substitutes for aggregates is not likely to occur in Canada in the near future 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, is minimal and probably takes place in immediate border regions where transportation costs rather than quality of material are the main reason for use of 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 pre-cast or cast-in-place concrete. For aesthetic qualities not available elsewhere, rough and/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 in the near future. 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	free	free	20%
30510-1	Granite, rough, not hammered or chiselled	free	free	20%
30515-1	Marble, sawn or sand rubbed, not polished	free	5%	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	free	7½%	10%
30610-1	Building stone, other than marble or granite, planed, turned, cut or further manufactured than sawn on four sides	free	12½%	15%
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	free	20%
30700-1	Marble, n.o.p.	17½%	17½%	40%
30705-1	Manufactures of marble, n.o.p.	17½%	17½%	40%
30710-1	Granite, n.o.p.	17½%	17½%	40%
30715-1	Manufactures of granite, n.o.p.	17½%	17½%	40%
30800-1	Manufactures of stone, n.o.p.	17½%	17½%	35%
30900-1	Roofing slate, per square of 100 square feet	free	free	75¢
30905-1	Granules, whether or not coloured or coated, for use in manufacture of roofing, including shingles and siding	free	free	25%

TARIFFS (Cont'd)

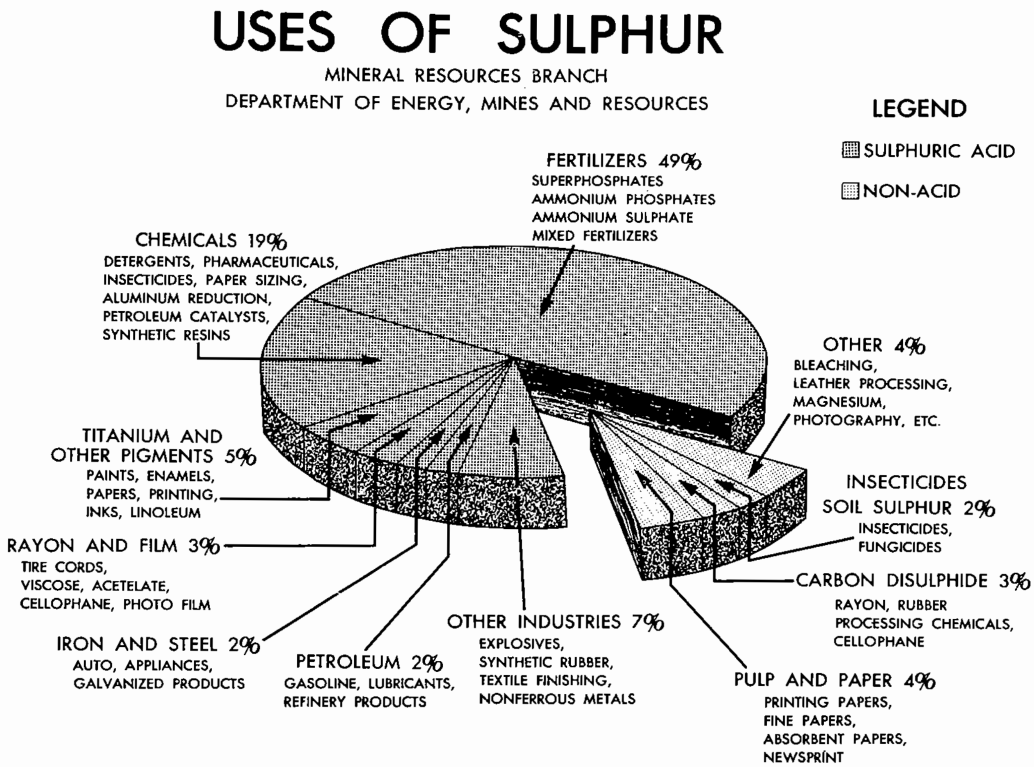
UNITED STATES		British Preferential	Most Favoured Nation	General
Item No.				
513.61	Granite, not manufactured, and not suitable for use as monumental, paving, or building stone		free	
514.11	Limestone, crude, not suitable for use as monumental, paving, or building stone			
	On and after Jan. 1, 1970		14¢ per short ton	
	On and after Jan. 1, 1971		12¢ per short ton	
	On and after Jan. 1, 1972		10¢ per short ton	
513.21	Marble chips and crushed			
	On and after Jan. 1, 1970		7%	
	On and after Jan. 1, 1971		6%	
	On and after Jan. 1, 1972		5%	
514.91	Quartzite whether or not manufactured		free	
515.11	Roofing slate			
	On and after Jan. 1, 1970		17%	
	On and after Jan. 1, 1971		15%	
	On and after Jan. 1, 1972		12.5%	
515.14	Other slate			
	On and after Jan. 1, 1970		7%	
	On and after Jan. 1, 1971		6%	
	On and after Jan. 1, 1972		5%	
515.41	Stone, other, not manufactured, and not suitable for use as monumental, paving, or building stone		free	

Note: Varying tariffs are in effect on the more fabricated stone categories.
Source: Tariff Schedules of the United States Annotated (1971) T.C. Publication 344.

Sulphur

P. R. COTE*

Sulphur is one of mankind's most important industrial chemicals and has an almost endless variety of uses. It is produced from various sources in one form or another in some 60 countries. Almost half of the world's sulphur output is produced in the form of elemental sulphur from native sulphur deposits and from sour natural gas. The remainder is recovered from metallic sulphides. Nearly all sulphur produced is consumed in the form of sulphuric acid approximately one half of which is used in the manufacture of fertilizers. The chemicals, and pulp and paper industries are the next largest consuming sectors.



*Mineral Resources Branch.

TABLE 1

Canada, Sulphur Production and Trade, 1969-70

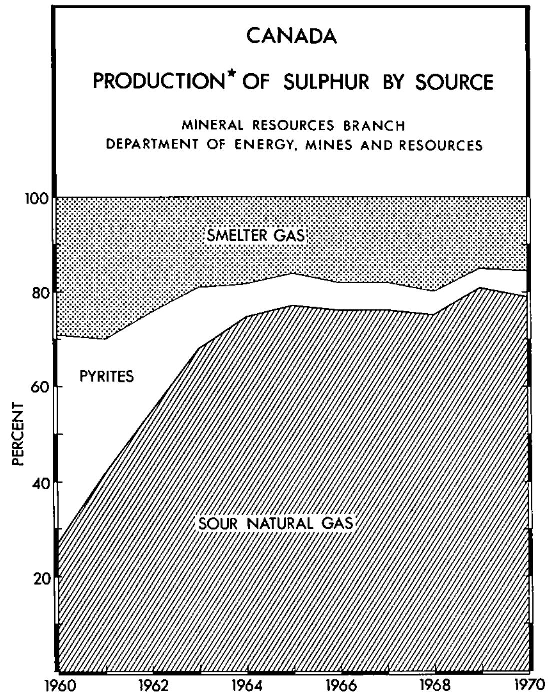
	1969		1970[p]	
	Short Tons	$	Short Tons	$
Production (shipments)				
Pyrite and pyrrhotite[1]				
Gross weight	(376,159)		(325,700)	
Sulphur content	171,212	2,219,362	182,882	1,849,000
Sulphur in smelter gases[2]	676,189	7,953,011	708,800	7,282,000
Elemental sulphur[3]	2,973,506	60,725,726	3,779,850	30,710,800
Total sulphur content	3,820,907	70,898,099	4,671,532	39,841,800
Imports				
Sulphur, crude or refined				
United States	45,483	1,694,000	53,455	1,468,000
France	25	3,000	–	–
Total	45,508	1,697,000	53,455	1,468,000
Exports				
Sulphur in ores (pyrite)				
United States	..	1,018,000	..	1,118,000
Japan	..	87,000	..	108,000
Total	..	1,105,000	..	1,226,000
Sulphur, crude or refined n.e.s.				
United States	1,033,855	26,266,000	1,180,301	16,773,000
India	241,703	6,514,000	383,017	6,285,000
Australia	256,974	7,396,000	220,246	3,447,000
Taiwan	119,931	3,904,000	234,323	3,312,000
New Zealand	155,601	5,347,000	180,187	3,250,000
Britain	22,000	714,000	195,683	2,785,000
Korea, South	147,950	4,623,000	158,381	1,744,000
South Africa	89,217	2,757,000	72,315	1,525,000
Italy	–	–	90,408	1,420,000
Netherlands	107,238	2,670,000	56,330	890,000
Chile	16,035	320,000	62,899	378,000
Pakistan	1,789	51,000	12,304	244,000
Other countries	71,988	2,180,000	142,038	808,000
Total	2,264,281	62,742,000	2,988,432	42,861,000

Source: Dominion Bureau of Statistics.
[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; n.e.s. Not elsewhere specified.

In 1970, western world sulphur production in all forms reached an estimated 29.7 million metric tons while consumption increased some 4 per cent over 1969 to reach 29.4 million metric tons. However, increased sales of sulphur into the western world market by Poland (estimated at 1.1 million metric tons in 1970) resulted in a surplus supply situation for the third consecutive year and as a result, producers' stockpiles continued to mount, particularly in Canada and the United States. The rate of increase in consumption recorded in 1970 was in keeping with the long term historical growth rate of between 4-5 per cent but was considerably less than the average annual growth rate of some 8 per cent recorded from 1963-1967.

The abnormal growth rate in consumption in this period resulted in the last world sulphur shortage situation which terminated abruptly in 1968 due to slackening demands in the major sulphur consuming industries–notably the fertilizer industry which consumes some 50 per cent of sulphur marketed. Coupled with this decrease in demand has been a rapid increase in output particularly in Canada and Poland. The oversupply situation is exerting severe downward pressure on prices which began to drop in the latter part of 1968 and continued throughout 1970. Competition on export markets remained keen.

In the past, the world sulphur market has exhibited cyclical imbalances between supply and demand. However, the oversupply situation which began in 1968 contains major new factors, which will adversely affect the establishment of an equilibrium within the foreseeable future, namely the presence of large additional sulphur supplies produced involuntarily from such sources as natural gas processing and as a result of pollution abatement measures throughout the world as well as large and continually growing producer inventories. North American producer inventories at the close of 1970 stood at 7.5 million long tons, roughly equivalent to 30 per cent of current total western world yearly demand.



*PRODUCER SHIPMENTS

PRODUCTION AND DEVELOPMENTS IN CANADA

In Canada, sulphur is recovered from two sources: hydrocarbons and metallic sulphides. Production falls into three statistical classes: elemental sulphur, sulphur recovered from smelter gases, and sulphur contained in pyrite concentrates. In 1970, 79 per cent of Canada's sulphur shipments were in the elemental form, almost totally recovered from sour natural gas plants in western Canada. Minor tonnages of elemental sulphur were recovered from the refining of crude oils and from the electrolytic refining of nickel sulphide matte. As indicated in Table 1, the remainder of Canada's sulphur output originated from metallic sulphides, either in the form of sulphuric acid and to a lesser extent liquid SO_2, at various metallurgical plants or in byproduct pyrites shipped for subsequent conversion to sulphur dioxide or sulphuric acid. As indicated in Figure 2, sources of sulphur in Canada have changed markedly in the past decade due primarily to the rapid expansion of output associated with the processing of sour natural gas.

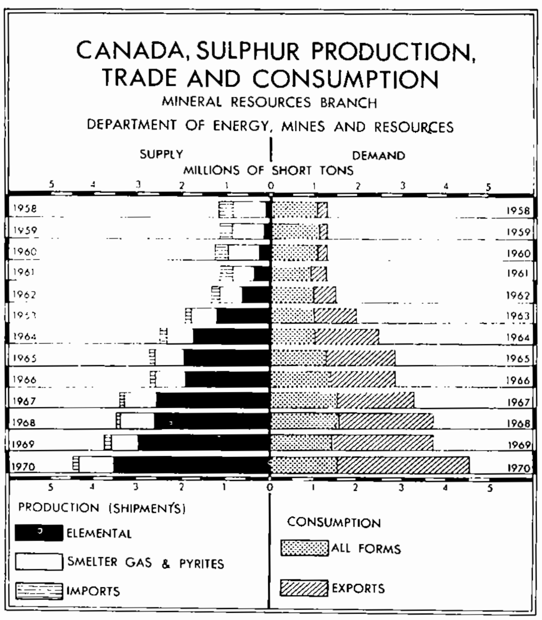
Since 1960, Canada has changed from a net importer of sulphur to become, since 1968, the world's largest exporter of elemental sulphur and the western world's second largest producer, surpassed only by the United States. Canada, now firmly established as a major supplier of sulphur to world markets, has supplied about one third of the world's increased output since the early 1960's. This production has originated as recovered sulphur from sour natural gas plants in western Canada. At the end of 1970, the productive capacity of sulphur from sour natural gas stood at 16,282 long tons daily, a 28 per cent increase over 1969.

Canadian sulphur shipments in all forms in 1970 amounted to 4,671,532 tons valued at $39,841,800. This represents a tonnage increase of 22 per cent and a value decrease of 78 per cent compared to 1969. The decrease in value clearly reflects the downward pressure on sulphur prices due to world oversupply. The unit value of marketed sulphur f.o.b. Alberta processing plant stood at $12.15 a long ton in January 1970 and declined steadily throughout the year to $7.43 a long ton by December 1970.

HYDROCARBON SOURCES

Most hydrocarbons contain sulphur. Minute sulphur contamination seldom presents a serious problem in marketing and utilization of hydrocarbons but when the sulphur content is unacceptably high it must be lowered. Sulphur present in natural gases is normally in the form of hydrogen sulphide (H_2S), a highly corrosive and toxic gas. Hydrogen sulphide is also a common constituent of sulphurous crude oils and coal. Sulphur recovered from hydrocarbons constitutes about one fifth of total world production.

Canada is the world's largest producer of sulphur from hydrocarbon sources, a remarkable achievement considering that prior to 1951, there was little or no production of sour natural gas and no elemental sulphur from this source. Since 1960, elemental sulphur production in Canada has increased from 275,000 tons to 4.7 million tons in 1969.



SOUR NATURAL GAS

Many of the natural gas fields in western Canada contain hydrogen sulphide. Although the H_2S content of these '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.

Briefly, H_2S contained in sour natural gas is absorbed chemically at sulphur recovery plants located at or near the gas producing fields. The acid gas fraction containing H_2S is burned under controlled conditions in a combustion chamber and elemental sulphur droplets are released in a vapour of steam. The vapour is passed over a sequence of condensers and converters where liquid elemental sulphur is recovered and pumped to storage vats. The elemental sulphur so produced is an involuntary byproduct of natural gas production.

Canada's first sour gas sulphur plant came on stream in Alberta in 1951. By the end of 1970, 35 recovery plants were operating in Alberta with one each in British Columbia and Saskatchewan. According to the Alberta Oil and Gas Conservation Board, Alberta's recoverable reserves of sulphur from sour gas fields amounted to an estimated 159.1 million long tons, in 1970. Combined daily capacity of the sour gas plants in the three provinces was 16,282 long tons at the end of 1970. This daily capacity, which is based upon the designed maximum raw gas throughput, is never sustained throughout the year as gas sales are subject to seasonal fluctuations.

Production of gas-associated elemental sulphur in Alberta as reported by the Alberta Oil and Gas Conservation Board was 4,181,636 long tons, an increase of 14 per cent over 1969. Sales did not keep pace with this growth in production and, in 1970, 3,071,544 long tons were marketed, up 20 per cent from the previous year. The value of sales, reflecting the rapid deterioration in world sulphur prices, declined from $58,925,957 in 1969 to $27,434,650 in 1970. The gap between production and sales continued to widen and inventories at year's end stood at 3.4 million long tons.

Production of gas-associated elemental sulphur in British Columbia was 57,888 long tons and in Saskatchewan 2,392 long tons resulting in a total production of sour gas sulphur in western Canada of 4,241,616 long tons in 1970.

In 1970, five gas plants with a combined daily rated capacity of 2,349 long tons came on stream. These were: Atlantic Richfield, Canada Ltd.; Gold Creek (100); Gulf Oil Canada Limited, Strachan (830); Hudson's Bay Oil and Gas Company Limited, Kaybob South (1004); Imperial Oil Limited, Quirk Creek (225) and Shell Canada Limited, Burnt Timber (190). In addition to these new plants, all located in the province of Alberta, two existing gas processing plants increased capacity: Imperial Oil, Redwater and Amerada Hess Corporation, Olds. Expansions and new facilities increased daily rated capacity 2,349 long tons over 1969.

In order to meet ever-growing demands for Canadian natural gas, particularly in the United States, new plants and expansions scheduled for completion during 1971 will result in a further increase in daily rated sulphur capacity of 6,123 long tons by year-end. This additional capacity will boost elemental sulphur production considerably in 1971 depending upon when in the year various plants become fully operational. In any event, by the close of 1971 the potential for producing some 6.4 million long tons a year should exist in Alberta. No expansions or new plant construction have been indicated outside of Alberta for 1971. Recent drilling in the Strachan and Ricinus gas fields in the foothills area northwest of Calgary has disclosed substantial reserves of sour natural gas. Aquitaine Company of Canada Ltd. has announced that the first

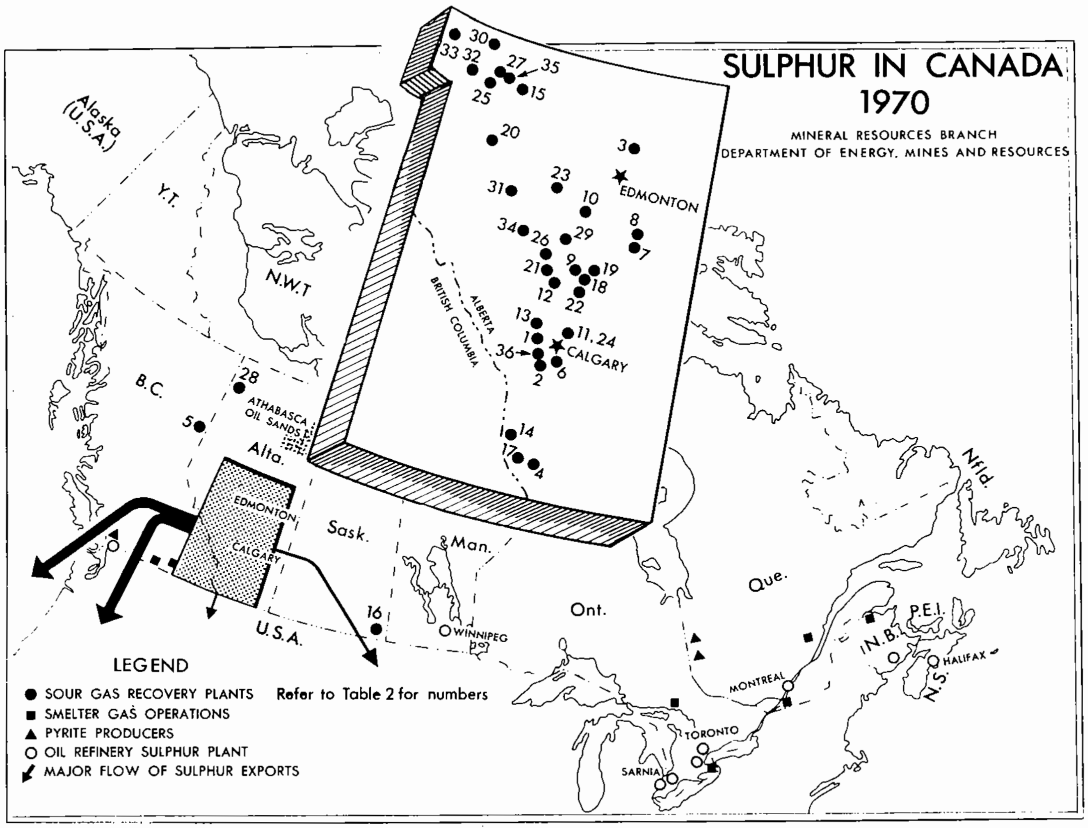


TABLE 2

Canada, Sour Gas Sulphur Extraction Plants, 1970

Operating Company	Source Field or Plant Location	% H_2S in Raw Gas	Daily Capacity (long tons)
1. Shell Canada	Jumping Pound, Alta.	3-5	240
2. Gulf Oil Canada	Turner Valley, Alta.	4	35
3. Imperial Oil*	Redwater, Alta.*	3	21
4. Gulf Oil Canada	Pincher Creek, Alta.	10	675
5. Jefferson Lake Petro.	Taylor Flats, B.C.	3	325
6. Texas Gulf Sulphur	Okotoks, Alta.	33	430
7. Gulf Oil Canada	Nevis, Alta.	3-7	198
8. Chevron Standard	Nevis, Alta.	7	204
9. Shell Canada	Innisfail, Alta.	14	115
10. Gulf Oil Canada	Rimbey, Alta.	1-3	328
11. Petrogas Processing	Crossfield, Alta.	31	1,970
12. Home Oil	Carstairs, Alta.	1	42
13. Canadian Fina Oil	Wildcat Hills, Alta.	4	137
14. Jefferson Lake Petro.	Savannah Creek, Alta.	13	375
15. Texas Gulf Sulphur	Windfall, Alta.	16	1,875
16. Steelman Gas	Steelman, Sask.	1	12
17. Shell Canada	Waterton, Alta.	18-25	1,650

TABLE 2 (Cont'd)

Operating Company	Source Field or Plant Location	% H_2S in Raw Gas	Daily Capacity (long tons)
18. Amerada Hess Corp.*	Olds, Alta.*	11	600
19. Mobil Oil Canada	Wimborne, Alta.	14	244
20. Hudson's Bay Oil and Gas	Edson, Alta.	3	304
21. Canadian Superior Oil	Harmattan-Elkton, (Alta.)	53	805
22. Hudson's Bay Oil and Gas	Lone Pine Creek, Alta.	8-17	176
23. Canadian Delhi Oil	Minnehik-Buck Lake, Alta.		18
24. Amoco Canada Petroleum	East Crossfield, Alta.	34	1,480
25. Amoco Canada Petroleum	Bigstone, Alta.	19	320
26. Hudson's Bay Oil and Gas	Caroline, Alta.		26
27. Hudson's Bay Oil and Gas	Kaybob South, Alta.	2-17	1,044
28. Banff Oil Ltd.	Rainbow Lake, Alta.		70
29. Hudson's Bay Oil and Gas	Hespero, Alta.		11
30. Hudson's Bay Oil and Gas	Sturgeon Lake South, Alta.		50
31. Hudson's Bay Oil and Gas	Brazeau River, Alta.		50
32. Shell Canada	Simonette, Alta.		90
33. Atlantic Richfield**	Gold Creek, Alta.		100
34. Gulf Oil Canada**	Strachan, Alta.		830
35. Hudson's Bay Oil and Gas**	Kaybob South, Alta.		1,004
36. Imperial Oil**	Quirk Creek, Alta.		225
37. Shell Canada**	Burnt Timber, Alta.		190
Total daily rated capacity December 31, 1970			16,282

* Plants increased capacity in 1970.

**New Plants 1970 (Gulf Oil's Strachan and Imperial Oil's Quirk Creek were scheduled for completion in December 1970 and may or may not have actually come on stream in 1970).

phase of a new gas plant located at Ram River, Alberta to service this area is expected to be completed late in 1971. This plant will have a daily rated capacity of 1,900 long tons of elemental sulphur. In addition, the company intends to proceed with a second stage scheduled for completion late in 1972. The combined daily rated capacity could be in the order of 3,500 long tons rendering this complex the largest single sour gas sulphur recovery plant in the world with a potential annual output by late 1972 of 1 million long tons of sulphur. Of the 39 gas plants expected to be operational in Alberta by the end of 1971, three plants, the Aquitaine plant referred to above together with the expanded Waterton plant of Shell Oil and the new Kaybob South plant of Chevron Standard will have, by the end of 1971, a combined daily rated capacity of 7,541 long tons. This is equivalent to a production potential of 2.2 million long tons a year – slightly over 50 per cent of total production recorded in 1970.

The offshore export market, excluding the United States, (Canada's largest export market) remains extremely important. Sulphur destined for these offshore markets is currently railed in bulk from Alberta to loading terminals at Vancouver some 650 miles from Alberta processing plants. Thus, transportation from Alberta to Vancouver constitutes a major economic factor in the competitive marketing of Canadian elemental sulphur. In mid 1970, unit-train movement of sulphur was inaugurated and resulted in substantial savings in transportation costs. However, even with these savings, loading, transportation and terminal handling costs still exceed the average net back to the Alberta plant per ton of sulphur marketed offshore. For example, the average value of marketed sulphur in Alberta for the year 1970 was $8.98 a long ton. With 1970 unit-train rates ($5.12 a ton Alberta staging plant to Vancouver) transportation, loading and terminal handling costs approached $10 a ton.

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 Alberta Oil and Gas Conservation Board estimated that oil reserves in place exceed 600 billion barrels. The bitumen averages 4.5 per cent by weight sulphur, thereby constituting an extremely large reserve of sulphur. The Canadian Petroleum Association estimates reserves that could be recovered by the existing oil sand extraction plant at 40.8 million long tons of sulphur.

TABLE 3

Proposed New Plants and Expansion for 1971

Operating Company	Location	Proposed Daily Rated Capacity (long tons)
Banff Oil	Ram River, Alta.	1,900
Canadian Delhi*	Minnehik-Buck Lake*, Alta.	32
Chevron Standard	Kaybob South, Alta.	2,666
Gulf Oil	Berland River, Alta.	125
Hudson's Bay Oil and Gas	Brazeau River,* Alta.	59
Shell Canada	Waterton,* Alta.	2,975
Tenneco	Brazeau River, Alta.	26
Westcoast Transmission	Fort Nelson, B.C.	250
Anticipated daily rated capacity end of 1971		22,405

*Expansions to existing plants.

In late 1967, Great Canadian Oil Sands Limited (GCOS) completed the first commercial oil-sand oil extraction plant at a cost of $240 million. The ancillary sulphur recovery plant is designed to produce 300 long tons of sulphur daily. Many of the difficulties experienced in start-up operations have now been overcome and in 1970 some 47,000 long tons of sulphur were recovered.

OIL REFINERIES

Some crude oils contain as much as 5 per cent sulphur either as hydrogen sulphide or in some other compound. 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 and New Brunswick. Output from these refineries (estimated at 25,000 tons in 1969) is not included in Canadian sulphur production statistics. Sulphur, recovered from domestic crudes at oil refineries near Toronto, Sarnia, Winnipeg and Vancouver, amounted to an estimated 60,000 tons in 1969. More rigid regulations designed to combat air pollution will undoubtedly result in increased sulphur recovery from this source in the years ahead.

COKING OPERATIONS

Coke oven gases generally contain some hydrogen sulphide, the quantity being 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.

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 came from metallic sulphides prior to 1951 at which time the first sour gas sulphur recovery plant was built. In 1968, metallic sulphides provided almost 829,000 tons of contained sulphur and accounted for 22 per cent of Canada's total sulphur production.

SMELTER GASES

The recovery of sulphur from smelter gases is accomplished in the following manner. Effluent gas, normally containing from 1 to 12 per cent sulphur dioxide, is cleaned and the SO_2 is purified and cooled.

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, $H_2S_2O_7$).

For this review, sulphur in smelter gases includes sulphur values recovered from metallurgical SO_2 gases and converted directly to H_2SO_4, liquid SO_2 and oleum. These metallurgical works include base-metal and iron ore recovery plants located in New Brunswick, Quebec, Ontario and British Columbia. Production in 1970 was 708,800 tons of contained sulphur representing 15 per cent of Canada's total sulphur output.

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 2,255 tons of H_2SO_4 based on SO_2 gas from The International Nickel Company of Canada, Limited's iron ore recovery plant. 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.

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 of Belledune Fertilizer Limited, which is also a subsidiary of Brunswick.

Cominco Ltd. operates sulphuric acid plants at Kimberley and Trail, British Columbia, based on its pyrrhotite roaster and lead-zinc smelter, respectively. Combined capacity of these acid plants is in the order of 850,000 tons of H_2SO_4 a year. Much of the acid produced is utilized by Cominco in the manufacture of fertilizers.

Alcan Aluminum Limited, Allied Chemical Canada, Ltd., Canadian Electrolytic Zinc Limited and Sherbrooke Metallurgical Company Limited produce sulphuric acid from the roasting of zinc concentrates at Arvida and Valleyfield, Quebec, and Port Maitland, Ontario.

In 1970, Allied Chemical completed construction of a sulphur recovery unit associated with the pyrrhotite roasting facility of Falconbridge Nickel Mines Limited at Falconbridge, Ontario. This sulphur recovery unit is unique in Canada, for, rather than recovery from SO_2 metallurgical gas in the form of sulphuric acid, the plant is designed to recover some 135,000 tons a year of sulphur in the elemental form. Production began in early 1972.

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, and Kimberley, British Columbia, 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, so this production is reported as pyrite and pyrrhotite.

Four companies – Noranda Mines Limited, Normetal Mines Limited, Quemont Mines Limited and The Anaconda Company (Canada) Ltd. – are engaged

TABLE 4

Canada, Principal Sulphur Operations Based on Metallic Sulphides, 1970

Operating Company	Plant Location	Raw Material	Annual Capacity in Short Tons	
			100% H_2SO_4	Approx. S equiv.
Smelter Gases				
Belledune Acid	Belledune, N.B.	SO_2 lead-zinc	250,000	80,000
Alcan	Arvida, Que.	SO_2 zinc conc.	50,000	17,000
Allied Chemical	Valleyfield, Que.	SO_2 zinc conc.	160,000	53,000
Allied Chemical	Falconbridge, Ont.	SO_2 pyrrhotite	–	135,000*
Can. Electrolytic Zinc	Valleyfield, Que.	SO_2 zinc conc.	135,000	45,000
Sherbrooke Metallurgical	Port Maitland, Ont.	SO_2 zinc conc.	90,000	30,000
Canadian Industries	Copper Cliff, Ont.	SO_2 pyrrhotite	750,000	250,000**
Cominco	Kimberley, B.C.	SO_2 pyrrhotite	360,000	120,000
Cominco	Trail, B.C.	SO_2 lead-zinc	490,000	160,000**
Pyrite and Pyrrhotite			Product	
Noranda Mines	Noranda, Que.	Sulphide ore	Pyrite concentrate	
Normetal Mines	Normetal, Que.	Sulphide ore	Pyrite concentrate	
Quemont Mines	Noranda, Que.	Sulphide ore	Pyrite concentrate	
Anaconda	Britannia, B.C.	Sulphide ore	Pyrite concentrate	

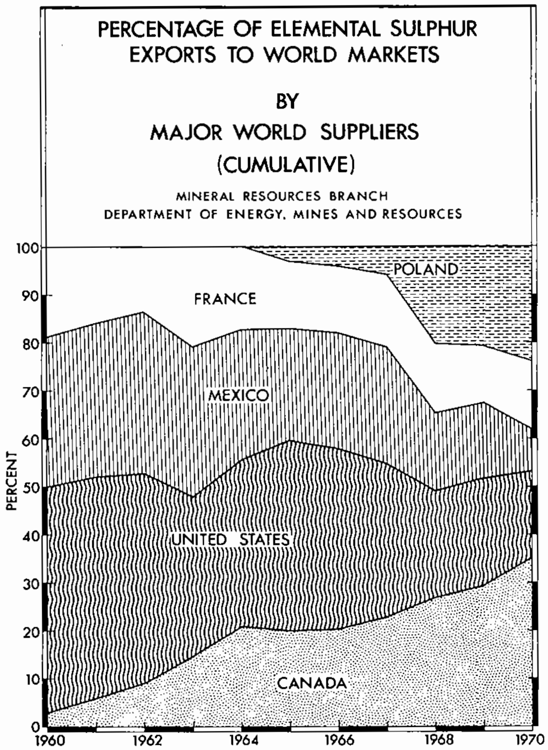
*Sulphur in elemental form. **Includes sulphur content in liquid SO_2 production.

from time to time in shipping pyrite and pyrrhotite concentrates to pyrite roasters, principally in northeastern United States. Other companies are stockpiling pyrite concentrates pending development of future markets for this material. In 1969, Canada's pyrite and pyrrhotite shipments amounted to 325,700 tons of concentrates (182,882 tons contained sulphur) valued at $1,849,000.

CANADIAN CONSUMPTION AND TRADE

Canadian consumption of sulphur as reported by consumers in all forms in 1970 amounted to an estimated 1.6 million tons of which elemental sulphur accounted for approximately 50 per cent with the remainder being supplied for metallic sulphides. Domestic consumption accounted for 34 per cent of producers shipments, clearly demonstrating that Canada is highly dependent upon export markets for sulphur sales. Except for minor tonnages of pyrite concentrates, all exports are in the elemental form from western Canada. Of a total of 3.8 million tons of elemental sulphur marketed, only .8 million or 21 per cent was consumed domestically.

Canada is now the largest supplier of sulphur to world markets – a position attained in 1968. Currently Canada accounts for some 34.5 per cent of total world trade in this commodity.



SOURCE: BRITISH SULPHUR CORPORATION

TABLE 5

Canada, Sulphur Production and Trade, 1961-70
(short tons)

	Production[1]				Imports	Exports	
	In Pyrites[3]	In Smelter Gases	Elemental Sulphur	Total	Elemental Sulphur	Pyrite[2] $	Elemental Sulphur
1961	255,376	277,056	394,762	927,194	329,556	889,755	217,866
1962	257,084	292,728	695,098	1,244,910	195,089	890,055	400,026
1963	235,410	353,243	1,249,887	1,838,540	150,637	937,883	820,929
1964	173,182	443,448	1,788,165	2,404,795	149,567	878,545	1,294,587
1965	186,960	444,758	2,068,394	2,700,112	162,201	978,828	1,497,947
1966	162,300	500,338	2,041,528	2,704,166	145,465	981,000	1,399,096
1967	182,377	592,035	2,499,205	3,273,617	124,781	1,067,000	1,773,671
1968	155,842	666,370	2,580,746	3,402,958	75,815	1,056,000	2,111,135
1969	171,212	676,189	2,973,506	3,820,907	45,508	1,105,000	2,246,281
1970[p]	182,882	708,800	3,779,850	4,671,532	53,455	1,136,000	2,988,432

Source: Dominion Bureau of Statistics.
[1]See footnotes for Table 1. [2]Dollar value of pyrite exports, quantities not available. [3]Excludes pyrite used to make byproduct iron sinter beginning in 1961.
[p]Preliminary.

In 1970, Canada's exports of elemental sulphur reached a record 2,988,432 tons – a 30 per cent increase over 1969. However, reflecting lower prices on international markets, due to oversupply, the value of exports declined from $63 million in 1969 to $43 million in 1970. The following table shows major Canadian export markets.

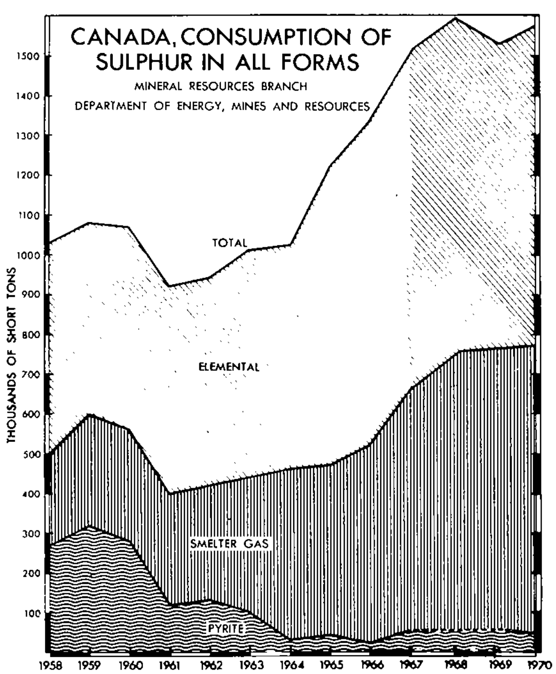


TABLE 6

Canadian Export Markets 1970

Country or Area	Exports (millions of tons)	Percent of Total
U.S.A.	1.18	39.4
Europe	.44	14.7
India	.38	12.7
Taiwan	.23	7.7
Australia	.22	7.5
New Zealand	.18	6.0
Korea	.16	5.4
Africa	.07	2.3
South America	.07	2.3
Others	.06	2.0
	2.99	100.0

TABLE 7

Canada, Sulphur Consumption, 1961-70
(short tons)

	From Pyrites and Smelter Gases[e]	Elemental Sulphur*	Total[e]
1961	406,952	513,048	920,000
1962	427,097	522,903	950,000
1963	451,550	558,450	1,010,000
1964	485,608	544,392	1,030,000
1965	490,777	739,223	1,230,000
1966	516,889	812,111	1,330,000
1967	661,050[r]	843,373	1,504,000
1968	750,183	830,147	1,580,000
1969	762,139	770,846	1,532,985
1970[p]	770,416	800,000[e]	1,570,416

Source: Dominion Bureau of Statistics.
*As reported by consumers.
[e]Estimated by Mineral Resources Branch; [r]Revised; [p]Preliminary.

TABLE 8

Canada, Consumption of Elemental Sulphur by Industry, 1968-69
(short tons)

	1968	1969
Chemicals	190,385	177,224
Pulp and paper	419,559	417,107
Rubber products	3,203	3,902
Fertilizers	206,082[r]	146,716
Foundry	14,198	3,657
Other industries*	23,536	22,240
Total	856,963	770,846

Source: Dominion Bureau of Statistics. Breakdown by Mineral Resources Branch.
* Includes production of titanium pigments, pharmaceuticals and medicinals, starch, soaps and detergents, explosives, food processing, sugar refining and other minor uses.
[r]Revised.

As shown in Table 6 almost 40 per cent of elemental sulphur exports are to the United States – by far Canada's most important sulphur export market. Involuntary byproduct sulphur from western Canada, because of its highly competitive nature, has penetrated a large portion of the United States domestic market. Some high-production-cost Frasch sulphur mines in the United States have been forced to close down because of the rapid deterioration in sulphur prices.

Recognizing the impact of Canadian imports on the domestic market, Senator Russell Long (Louisiana), in July 1970, introduced Bill S.4075 into the United States Congress. This Bill, which to date has made little progress through the Congress, seeks to restrict sulphur imports into the United States, to the average quantity imported, on a country-by-country basis, during the calendar years 1965-1967. The terms of the Bill would require a decrease of some 30 per cent in the current level of Canadian sulphur imports.

Freeport Sulphur Company and Duval Corporation, both major United States Frasch sulphur producing companies presented statements during the latter part of 1970 to the U.S. Tariff Commission claiming that Canadian sulphur was entering the United States at prices below actual production costs and thereby, indicating that Canadian producers were guilty of unfair competitive business practices. Both companies supported Senator Long's Bill. Clearly, the free entry of Canadian sulphur into the United States, at current price levels, is now under considerable pressure.

Toward the end of the year, representatives of the Province of Alberta met in Mexico City with other major world sulphur producers including: Mexico, France and Poland to review the long-term world sulphur supply-demand situation and to explore methods of regulating world sulphur markets in the face of rapidly deteriorating prices and mounting global oversupply.

TABLE 9

Canada, Sulphuric Acid Production, Trade and Apparent Consumption, 1961-70
(short tons – 100% acid)

	Production	Imports	Exports	Apparent Consumption
1961	1,614,000	7,275	38,914	1,582,361
1962	1,696,000	7,162	34,960	1,668,202
1963	1,790,000	5,634	37,316	1,758,318
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[r]	3,626	84,280	2,668,625[r]
1968	2,852,027	2,606	125,971	2,728,662
1969	2,396,535	60,746	103,386	2,353,895
1970[p]	2,728,298	10,966	142,559	2,596,705

Source: Dominion Bureau of Statistics.
[p]Preliminary; [r]Revised.

WORLD REVIEW

The major factor in the 1970 world sulphur industry, as in the previous year, was the large gap between demand and supply resulting in rapidly mounting producer inventories and falling prices. This was due to a combination of increased production in Canada and Poland and slow growth in the major sulphur consuming industries – in particular the fertilizer industry. Export markets remained extremely competitive throughout the year.

Consumption of sulphur in the western world amounted to some 29.4 million long tons, an increase of 4 per cent over 1969. Western world sulphur production, in all forms, was 29.7 million long tons. Production exceeded consumption for the third consecutive year.

The major increase in world sulphur production in 1970 was from sour natural gas plants in western Canada. Poland gained greater importance as a sulphur supplier to world markets and production in 1969 reached an estimated 3 million metric tons – approximately double that country's output in 1968. Of this, nearly 1.1 million metric tons were delivered to western world markets. In late 1969 the Machow mine, which will eventually become the world's largest open-pit sulphur operation, came on stream. At the present time however virtually all Polish production is by the Frasch method. In addition, Poland is providing

TABLE 10

Canada, Available Data on Consumption of Sulphuric Acid by Industry, 1968
(short tons – 100% acid)

Iron and steel mills	68,664
Other iron and steel	13,038
Electrical products	6,680
Leather tanneries	3,190
Pulp and paper mills	96,935
Processing of uranium ore	98,229
Manufacture of mixed fertilizers[1]	96,809
Manufacture of plastics and synthetic resins	24,461
Manufacture of soaps and cleaning compounds	19,022
Other chemical industries	12,972
Manufacture of industrial chemicals[2]	1,757,764
Petroleum refining	33,966
Mining[3]	47,549
Miscellaneous[4]	68,631
Total accounted for	2,347,910

Source: Dominion Bureau of Statistics.
[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, non-metal 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.

technical assistance and is financially involved in the development of large sulphur deposits in Iraq. Two mines in Iraq, with a combined annual output of 1.3 million tons, could be operational, depending upon the future trend of world sulphur prices, within three years. Polish investment in these projects is thought to be in the order of $34 million.

The world's largest producer of sulphur in all forms is the United States, with the majority of production being 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 1969, for the first time in many years, Frasch sulphur production declined, dropping from 7.5 million tons in 1968 to 7.1 million tons. The decline in output continued in 1970 to an estimated 7.08 million long tons. In mid-1969 Freeport Sulphur Company suspended operations at the company's newly-opened Caminada mine, offshore Louisiana, and later in the year, Phelan Sulphur Company terminated sulphur operations at Nash Dome, in Texas. Both operations are reported to be on a standby basis and could be brought back into production should sulphur demand and prices improve. In contrast to these closures, Duval Corporation brought a new sulphur mine into production in Culberson County, Texas. Capacity of this operation is in the order of 1.5 million tons a year. Elcor Corporation discontinued work on the company's Rock House facility in Texas originally designed to recover 1,000 long tons of sulphur a day from extensive gypsum deposits. A combination of technical problems and falling sulphur prices was the reason.

In Mexico production of elemental sulphur dropped from 1.72 million long tons in 1969 to 1.4 million long tons in 1970. In August 1969, Gulf Resources and Chemical Corporation negotiated an agreement with Inversiones Azufreras S.A. for the sale of Gulf's Frasch facilities in Mexico. The sale did not materialize and the company ceased production in Mexico on December 31st.

Production of elemental sulphur from sour natural gas from the Lacq field in France reached 1.7 million long tons, approximately equal to production in 1969.

OUTLOOK

Involuntary Canadian elemental sulphur, recovered from sour natural gas in western Canada, is one of the world's largest sources of abundant low-cost material and 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.

TABLE 11
World Production of Sulphur in All Forms 1969-1970
('000 metric tons)

	1969			1970		
	Elemental	Other*	Total	Elemental	Other	Total
U. S. A.	8,687	1,638	10,325	8,630	1,650	10,280
USSR	1,650	3,975	5,625	2,025	4,839	6,864
Canada	3,855	728	4,853	4,397	800	5,197
Japan	347	2,411	2,758	320	2,480	2,800
France	1,698	214	1,912	1,740	222	1,962
Mexico	1,719	32	1,751	1,378	32	1,410
Poland	1,942	240	2,182	2,730	220	2,950
Spain	5	1,330	1,335	5	1,476	1,481
China	200	837	1,085	230	916	1,146
Italy	64	840	904	61	855	916
West Germany	129	623	752	176	573	749
Britain	40	470	510	50	390	440
East Germany	110	272	382	115	275	390
Finland	112	333	445	115	390	505
Norway	2	381	383	2	430	432
Others	607	3,449	4,056	928	3,682	4,610
Total	21,079	17,773	38,852	22,902	19,230	42,132

Source: British Sulphur Corporation.
*Sulphur in other forms includes sulphur contained in pyrites and contained sulphur recovered from metallurgical waste gases mostly in the form of sulphuric acid.

In 1970 Canada secured some 35 per cent of the world export market. In the near term, Canada will continue to be the world's largest exporter, but other sources—many related to pollution abatement and not yet on stream—will exert considerable influence on world markets and the maintenance of Canadian exports at current levels will prove difficult.

In 1970, production of gas-associated sulphur in Canada was 4.7 million long tons and by 1971 output could increase to 6.3 million long tons. Spurred on by ever increasing demands for Canadian natural gas, largely in the export market of the United States, involuntary sulphur output by 1975 is forecast to increase to 9.7 million long tons yearly and by 1980 to some 12.5 million tons.

Sales will not keep pace with this rapid growth in output and stockpiles will continue to mount. In the face of large inventories overhanging world markets and the forecast diversity of supply both by type and by country, it is difficult to envisage a significant improvement in prices in world markets.

The world oversupply problem will likely continue throughout the decade as output from a multitude of sources will continue to increase far beyond market demand. Sulphur recovered from pollution abatement sources is likely to make serious inroads into markets now served by existing sources. Barring significant new uses for sulphur, world consumption is forecast to increase at about 4 per cent a year resulting in a western world demand of some 36 million long tons in 1975 and 46 million long tons by 1980.

A new era in sulphur supply has begun. The effect of changes upon what we now consider "traditional" sources will be as profound on the global sulphur industry as was the advent of the Frasch process some eighty years ago. International trade patterns will continue to change as many nations, now net importers of sulphur, will become net exporters.

PRICES

Reflecting the world oversupply situation and the extremely competitive nature of export markets, prices declined sharply throughout 1970.

In January 1970, the unit value of elemental sulphur at sour gas plants in Alberta averaged Can. $12.15 a long ton. By the end of December this had decreased to Can. $7.43 a long ton.

Canadian sulphur prices in 1970, as quoted in *Canadian Chemical Processing,* were as follows:

Sulphur, elemental, f.o.b. works, contract, car load, per long ton
January 1970 – $15 – $18
November 1970 – $11 – $12
December 1970 – $11

Sulphuric acid, f.o.b. plants, East, 66° Be, tanks, per short tons
December 1970 – $31

United States prices, quoted in *Engineering and Mining Journal,* December 1970, were as follows:

Sulphur, elemental	
U.S. producers, term contracts, f.o.b. vessel at Gulf ports, L.A. and Tex., per long ton	
bright	$40
dark	$39
Export prices, f.o.b. Gulf ports	
bright	$26
dark	$25
Mexican export, f.o.b. 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

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

TARIFFS (cont'd)

UNITED STATES		British Preferential	Most Favoured Nation	General
418.90	Pyrites		free	
415.45	Sulphur, elemental		free	
416.35	Sulphuric acid		free	
422.94	Sulphur dioxide			
	On and after Jan. 1, 1970		8.5%	
	On and after Jan. 1, 1971		7%	
	On and after Jan. 1, 1972		6%	

Source: Tariff Schedules of the United States, Annotated, (1970) TC Publication 344.

Talc, Soapstone and Pyrophyllite

P.R. COTE*

In Canada talc is produced in two provinces, Quebec and Ontario, while pyrophyllite is produced only in the Province of Newfoundland. In 1970, the value of talc and soapstone shipments increased to \$628,000 from \$543,633 in 1969. The value of pyrophyllite production increased marginally in 1970 to reach \$555,000.

Talc, $H_2Mg_3(SiO_3)_4$, is a hydrated magnesium silicate which occurs as a secondary mineral formed by the alteration of other magnesium silicates - most commonly serpentine and pyroxene - or by the alteration of carbonate rocks. It is a soft flaky mineral with a greasy feel or 'slip', is readily ground to a near white powder, has a high fusion point, low thermal and electrical conductivity and is relatively chemically inert. Talc grades are most commonly specified by end uses, e.g., cosmetic grade, ceramic grade, pharmaceutical grade, paint grade, etc.

Soapstone is an impure talcose rock, generally occurring in massive deposits, from which blocks can be sawn.

Pyrophyllite, $H_2Al_2(SiO_3)_4$, a hydrous aluminum silicate, is physically similar to talc. Most commonly it occurs as a massive replacement of siliceous rocks. The colour is generally white to yellowish-white and the ground product is utilized in the manufacture of ceramic tile.

PRODUCTION AND DEVELOPMENTS IN CANADA

TALC, SOAPSTONE

Baker Talc Limited produces talc and soapstone from an underground mine at 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 the past, Baker Talc has produced a relatively low-grade, low-cost product suitable for use primarlily as a dry-wall joint filler and as a dusting compound for asphalt roofing. In 1967-68, tests were conducted, with the support of the federal Department of Industry, Trade and Commerce, to upgrade talc products by using micromagnetic separation techniques as applied through a Jones High Intensity Wet Magnetic Separator. Baker Talc has been closely associated with development of this beneficiation technique. Testing indicated that the talc could be upgraded to the point where it would be acceptable for use in the paint, cosmetic, and paper industries. In 1969 a Jones Separator was added to the beneficiation circuit. Throughout 1970 the new mill circuit was tested and a number of modifications were made including the addition of more flotation capacity and a thickener. Achievement of a saleable high quality product had been delayed by contamination from fuel oil used to heat the dryer. This problem has apparently been solved by using propane as a fuel. Shaft sinking and the development of a second level at the Van Reet mine were completed during the year. The company estimates ore reserves to be adequate for 15 to 20 years of operation. Along with talc output the company, from time to time 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 metal-worker'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

*Mineral Resources Branch.

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.

Talc and soapstone occurrences are known elsewhere in Canada, particularly in Ontario and British Columbia. However, to date none of these have proven to be commercially viable.

TABLE 1

Talc and Soapstone, Pyrophyllite Production
Trade and Consumption

	1969		1970p	
	Short Tons	$	Short Tons	$
Production (shipments)				
Talc and soapstone				
Quebec[1]	..	228,286	..	250,000
Ontario[2]	..	315,347	..	378,000
Total	..	543,633	..	628,000
Pyrophyllite				
Newfoundland	..	553,935	..	555,000
Total production value	75,850	1,097,568	75,000	1,183,000
Imports (talc)				
United States	34,453	1,662,000	32,427	1,782,000
Italy	400	28,000	558	44,000
France	57	7,000	60	4,000
China, Peoples Republic	–	–	23	1,000
Total	34,910	1,697,000	33,068	1,831,000

	1968	1969
	Short Tons	
Consumption[3] (ground talc, available data)		
Ceramic products	4,748	9,870
Paints and wall-joint sealers	6,920r	6,965
Roofing	6,823	7,462
Paper and paper products	3,833	4,166
Rubber	1,954	1,705
Insecticides	636	718
Toilet preparations	709	923
Cleaning compounds	680	653
Pharmaceutical preparations	365	300
Linoleum and tile	129	115
Other products[4]	6,134	4,897
Total	32,931	37,774

Source: Dominion Bureau of Statistics.
[1] Ground Talc, soapstone blocks and crayons. [2] Ground talc. [3] Breakdown by Mineral Resources Branch.
[4] Chemicals, foundries, gypsum products and other miscellaneous uses.
p Preliminary; r Revised; - Nil; .. Not available.

PYROPHYLLITE

Newfoundland Minerals Limited, a subsidiary of American Olean Tile Company, Inc. produces pyrophyllite from an open-pit mine near Manuels, Newfoundland. Ore is crushed, sized and hand-cobbed at the minesite prior to trucking a short distance to tidewater. Rigid quality control is a major aspect of the operation and careful blending of ore takes place at the dock prior to shipment, in bulk, to the parent company's operations at Lansdale, Pennsylvania, where it is used in the manufacture of ceramic tile. Continuous chemical analyses and physical tests are run on all material delivered from the mine to the loading dock. 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.

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. To date, these superior-grade talcs have not been produced in Canada but beneficiation techniques at Baker Talc's operations should result in domestic production of higher quality material in the near future. Imports in 1970 amounted to 33,068 tons valued at $1,831,000. Of this 32,427 tons were imported from the United States with minor quantities received from France, Italy and China. Average value of imports in 1970 was $55 a ton while domestic production sells in the range $10-$25 a ton depending upon quality.

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, 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 free of 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

TABLE 2
Production and Trade 1960-69
(short tons)

	Production[1]			Imports	Exports[e]
	Talc and Soapstone	Pyrophillite[2]	Total[3]	Talc	Talc
1961	23,691	24,425	48,116	20,205	2,000
1962	23,367	22,794	46,161	24,148	2,200
1963	22,467	31,783	54,250	27,539	2,300
1964	25,316	32,816	58,132	31,598	2,700
1965	22,703	30,134	52,837	27,858	3,500
1966	29,596	40,548	70,144	24,918	6,000
1967	..	..	60,665	26,482	9,000
1968	..	..	80,589	28,244	10,000
1969	..	..	75,850	34,910	10,000
1970p	..	..	75,000	33,068	8,000

Source: Dominion Bureau of Statistics.
[1] Producers' shipments. [2] Producers' shipments of pyrophyllite, all exported. [3] From 1967 break down of Producers' shipments not available for publication.
[p] Preliminary:
[e] Estimated by Mineral Resources Branch. .. Not available.

composition, colour, particle size, oil absorption and consistency of, and dispersion in, a talc-vehicle system. A low content of carbonates, a near-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 and abrasive impurities.

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 metal-workers 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.

Chemical analyses of some of the most noteworthy talc and pyrophyllite resources in the world are given below.*

TALC	Luzenoc France	Norway	Mautern Austria	Italy	Johnson Vt. U.S.A.
SiO_2	61.00	38.40	61.54	60.34	42.73
FeO	0.03	5.21	-	0.85	4.93
Fe_2O_3	0.84	0.91	0.76	0.23	
Al_2O_3	2.36	1.74	1.74	1.77	1.17
CaO	0.56	1.22	1.81	0.64	0.10
MgO	33.75	31.98	30.09	31.14	33.16
Na_2O	-	-	-	-	-
K_2O	-	-	-	-	-
CO_2	-	16.26	3.65	0.78	4.74
H_2O (above 150° C)	1.03	3.58		5.20	12.95

PYROPHYLLITE

	Carolina U.S.A.	Japan	Newfoundland Canada	India	S. Korea
SiO_2	76.40	54.09	63.36	64.50	66.07
Fe_2O_3	-	0.20	0.64	0.23	0.53
Al_2O_3	20.05	36.09	30.16	28.30	27.09
CaO	trace	-	-	0.43	0.36
MgO	trace	-	trace	trace	0.07
Na_2O	0.21	-	-	-	0.60
K_2O	0.05	-	-	trace	0.10
Loss on ignition	3.33	8.70	5.07	6.67	5.43

*Source: Industrial Minerals, January 1971.

TABLE 3
World Production of Talc, Soapstone and Pyrophyllite, 1968-1970
(short tons)

	1968	1969p	1970e
Japan	1,865,815	1,876,593	1,900,000
United States	958,262	1,029,238	935,000
USSRe	407,000	418,000	..
France	232,576	240,419	235,000
India	193,577	205,292	..
South Korea	164,692	204,067	..
China (Mainland)e	165,000	165,000	..
Italy	127,445	150,151	130,000
Rumania	143,300	143,300	..
Austria	93,009	88,000	90,000
Norway	84,346	85,000	90,000
Canada	80,589	75,850	75,000
Other countries	352,564	328,283	1,465,000
Total	4,868,175	5,009,193	4,920,000

Source: U.S. Bureau of Mines, Minerals Yearbook. Preprint 1969, U.S. Bureau of Mines Commodity Data. Summaries, January 1971; Dominion Bureau of Statistics.

p Preliminary; e Estimated; .. Not available.

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, mainland 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 and Chinese talcs are shipped throughout the world.

PRICES

United States talc prices according to *Oil, Paint and Drug Reporter,* December 28, 1970, were as follows:

Canadian - ground, bags, carlot, f.o.b. mines,
- per ton - $20.00 - $35.00
bags, less than carlots.
- per ton - $26.60

Vermont - domestic, ordinary, off-colour, ground, bags, carlot, f.o.b. works
- per ton - $22.25

California - domestic, ordinary, off-colour. bags, carlot, f.o.b. works
- per ton - $34.00 - $39.50

New York - domestic, fibrous, ground, bags,
- per ton - $33.00
- bags, less than carlots, f.o.b. works
- per ton - $36.00 - $37.00

TARIFFS

CANADA		British Preferential	Most Favoured Nation	General
Item No.				
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 manufacture of ceramic tile (expires 31 Jan. 1972)	free	free	25%

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

TARIFFS (Cont'd.)

UNITED STATES

Talc, steatite and soapstone

523.31	Crude and not ground	0.02¢ per lb
523.33	Ground, washed, powdered or pulverized	
	On and after Jan. 1, 1970	8%
	" " " Jan. 1, 1971	7%
	" " " Jan. 1, 1972	6%

Source: Tariff Schedules of the United States, Annotated (1970) TC Publication 304.

Tin

D.B. FRASER*

Tin is not smelted in Canada and there is no large production of tin concentrate. The only producer is Cominco Ltd., which recovers cassiterite (SnO_2) as a byproduct from milling lead-zinc ores at Kimberley, British Columbia. The concentrate is exported, mainly to Mexico. In addition, a lead-tin alloy is obtained from the treatment of lead bullion dross in the indium circuit of the Trail, British Columbia, smelter of Cominco Ltd. The company also produces, from purchased commercial-grade metal, small quantities of Tadanac Brand high purity tin (99.999 per cent) and special research-grade (99.9999 per cent).

Canadian output in 1970 of tin in tin concentrate and in lead-tin alloy was 125 tons** valued at $531,000.

Industrial requirements of tin in Canada are purchased abroad. Imports in 1970 were 5,030 tons valued at $20,148,000. The main consumers use high quality tin and Straits brand from Malaysia continues to be the main source.

Brunswick Tin Mines Limited, a subsidiary of Sullivan Mining Group Ltd., continued exploration of the Mount Pleasant prospect, near St. Stephen, New Brunswick. The predominant minerals in this deposit are molybdenum, tungsten and bismuth, with variable amounts of tin, and with disseminated sulphides of copper, lead, zinc and arsenic. Work on extractive metallurgy was continued.

Ecstall Mining Limited, a subsidiary of Texas Gulf Sulphur Company, has conducted extensive research in a pilot plant at its Kidd Creek mine near Timmins, Ontario on recovery of byproduct tin and other metals from mill tailings from zinc-copper-lead-silver ores. It is planned to recover tin concentrate from these tailings in the future.

The principal use of tin in Canada, accounting for about 50 per cent of total consumption, is in the manufacture of tinplate. There are two producers: Dominion Foundries and Steel, Limited, and The Steel Company of Canada, Limited, both at Hamilton, Ontario. Improvements in the quality of steel used in tinplate manufacture and control of the electroplating process resulted in a better product requiring less tin which led to the cessation of hot-dip tinplate production at the end of 1966. All Canadian output of tinplate, estimated at 470,000 tons in 1970, is now electrolytic. Estimated consumption of tin in the manufacture of tinplate is 2,500 tons. The steel companies at Hamilton each have two electrolytic tinplate lines, and each has a third line under construction.

The second largest use of tin, accounting for 30 per cent of consumption, is in the manufacture of solder, the two main producers being The Canada Metal Company, Limited and Federated Metals Canada Limited.

*Mineral Resources Branch.
**Long tons of 2,240 pounds are used throughout this review except where specified.

TABLE 1

Canada, Tin Production, Imports and Consumption, 1969-70

	1969		1970^p	
	Long Tons	$	Long Tons	$
Production				
Tin content of tin concentrates and lead-tin alloy.	129	470,136	125	531,000
Imports				
Blocks, pigs, bars				
Malaysia	3,640	13,194,000	3,742	14,785,000
United States	573	2,223,000	913	3,817,000
Nigeria	597	2,018,000	235	956,000
Netherlands	75	284,000	75	324,000
Britain	60	226,000	65	266,000
Total	4,945	17,945,000	5,030	20,148,000
Tinplate				
United States	6,027	1,219,000	3,303	780,000
Britain	465	114,000	286	110,000
Total	6,492	1,333,000	3,589	890,000
Tin, fabricated materials, n.e.s.				
United States	63	171,000	36	143,000
Exports				
Tin in ores and concentrates and scrap				
Mexico	188	502,000	181	409,000
United States	86	35,000	77	29,000
Britain	29	5,000	–	–
Belgium	–	–	5	11,000
Total	303	542,000	263	449,000
Tinplate scrap				
United States	18,763	567,000	21,609	666,000
Republic of South Africa	19	...	–	–
Total	18,782	567,000	21,609	666,000
Consumption				
Tinplate and tinning	2,241		..	
Solder	1,445		..	
Babbitt	172		..	
Bronze	249		..	
Galvanizing	12		..	
Other uses (including collapsible containers, foil, etc.)	161		..	
Total	4,280		..	

Source: Dominion Bureau of Statistics.
^{p}Preliminary; ... Less than one thousand dollars; n.e.s. Not elsewhere specified; – Nil; .. Not available.

WORLD DEVELOPMENTS

Tin is the only metal for which there is formal co-operation between producer and consumer interests and among governments to modify problems of price and demand. 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 postwar 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 tin industry is characterized by a low consumption growth rate and a widely fluctuating price for the metal.

The Third International Tin Agreement is operative for a five-year period beginning July 1, 1966. The main object is the consideration of short-term problems of price and supply. Decisions that affect price and supply are made with regard to long-term trends. Consumer and producer members have an equal number of votes in a governing body, the International Tin Council. Canada is a signatory to the Agreement and, in proportion to its consumption, has 49 out of the total of 1,000 votes allocated to consumer members. The 19 consumer members in 1970 accounted for 55 per cent of total consumption. The total does not include most communist countries' consumption as the data is not available. The United States (53,000 tons) and West Germany (13,800 tons) are the main non-member countries among western consuming nations. Producer members are Bolivia, Congo (Dem. Rep.), Indonesia, Malaysia, Nigeria, and Thailand. Counted together, producer and consumer members of the Council account for 94 per cent of the non-communist production of tin-in-concentrate.

For the Third Agreement producer members contributed cash to establish a buffer stock. The operation of the stock is vested in a manager appointed by Tin 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. Council may impose export controls to curtail metal supply if tin in the buffer stock and other conditions appear to warrant such action.

The accompanying graph shows tin price fluctuations from 1951 to 1970 in relation to price ranges considered desirable by Council at various periods. Prices from 1951 to 1969 are shown in pounds sterling per long ton as quoted on the London Metal Exchange. Beginning on January 2, 1970 prices were quoted on the London Metal Exchange in pounds sterling per metric* ton. The equivalent ranges at that date were:

	£s per long ton	£s per metric ton
Floor price	1,280	1,260
Lower sector	1,280–1,400	1,260–1,380
Middle sector	1,400–1,515	1,380–1,490
Upper sector	1,515–1,630	1,490–1,605
Ceiling price	1,630	1,605

Throughout 1964 and 1965 prices exceeded the established ranges and problems were mainly those of increasing the supply. The shortfall between production and demand was met in various ways, including decreases in consumer stocks, sales from governmental stockpiles and improved utilization of tin by consumers. The prolonged stimulus of price gradually had the desired effect of increasing mine production.

*1 metric ton = 2,205 pounds.

TABLE 2
Canada, Tin Production, Exports, Imports and Consumption, 1960-69
(long tons)

Year	Production[1]	Exports[2]	Imports[3]	Consumption[3]
1960	278	. .	3,768	3,880
1961	500	479	3,525	3,953
1962	291	287	2,274	4,507
1963	414	800	4,193	4,942
1964	157	329	4,849	4,822
1965	168	216	4,993	4,892
1966	317	337	4,254	4,972
1967	195	326	4,548	4,812
1968	160	117	4,300	4,251
1969	129	303	4,945	4,280
1970[p]	125	263	5,030	. .

Source: Dominion Bureau of Statistics.
[1]Tin content of tin concentrates shipped, plus tin content of lead-tin alloys produced. [2]Tin in ores, concentrates and scrap. [3]Tin metal.
[p]Preliminary; . . Not available.

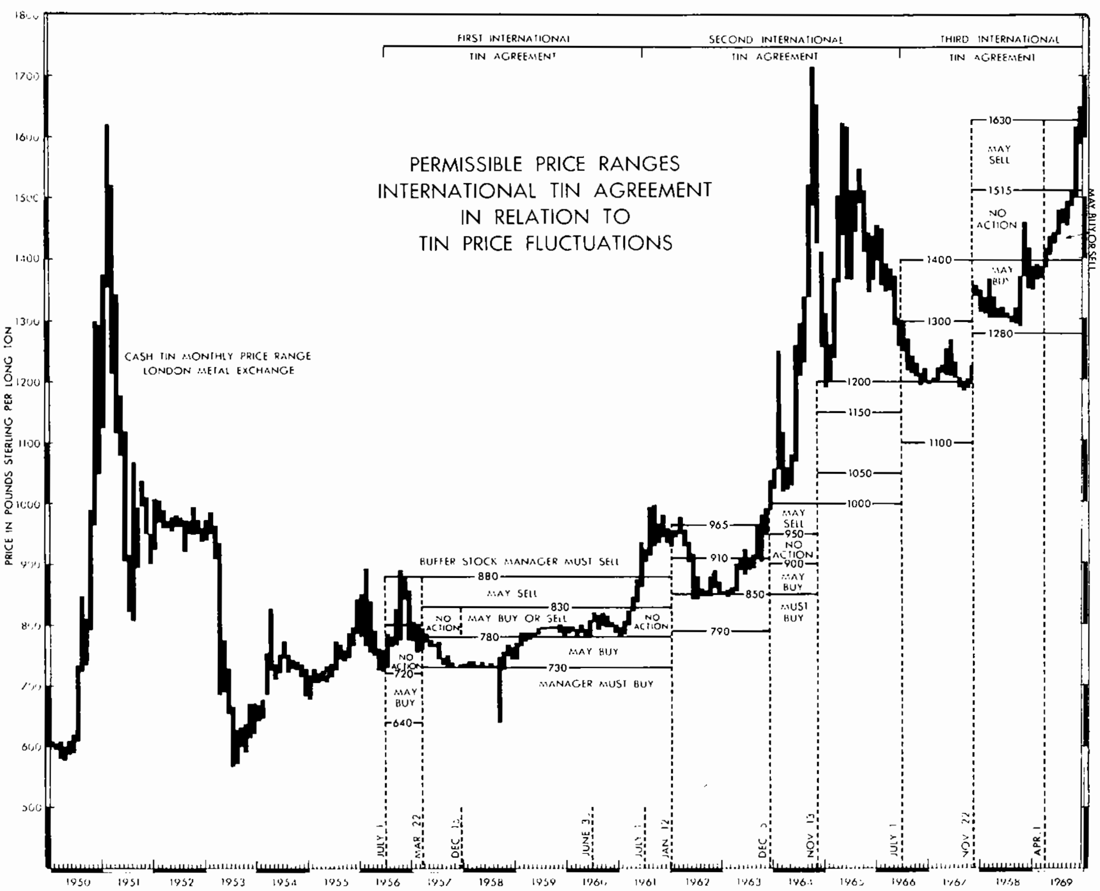
Production of tin in concentrates from 1960 to 1968 rose significantly and during 1968 exceeded consumption. To correct the imbalance, the Tin Council from September 1968 to the end of 1969 maintained an export control program. Tin prices rose from a level of £1,370 per ton at the beginning of 1969 to £1,620 per ton at the end of that year.

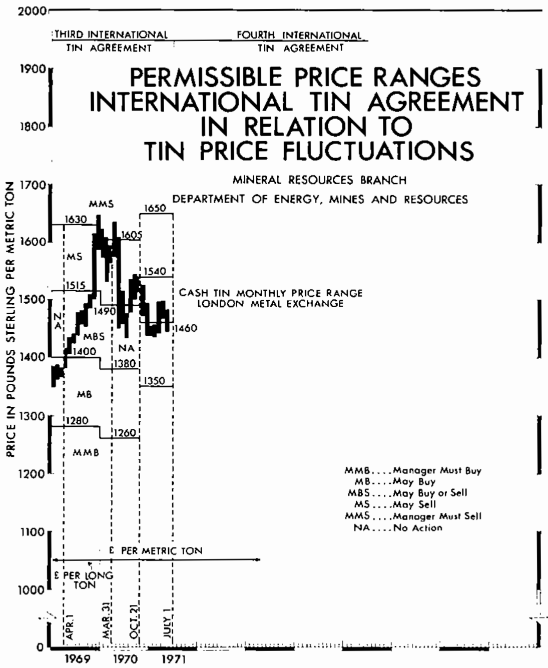
During 1970, consumption of tin declined in the major consuming countries while production was rising. The Tin Council's buffer stock, and private and United States government stocks, were all reduced during the year. Tin prices declined as increased supplies became available, and at December 31 were £1,438 per metric ton, compared with £1,620 at the start of 1970. Though price movement was relatively large, prices were in the neutral "no action" and upper "may sell" zones for most of the year. Production and consumption of tin were in near-balance.

The Tin Council decided not to extend the authority of the Buffer Stock Manager to operate within the "no action" middle sector after March 31, 1970; that is, the market mechanism after that date was allowed to operate freely in that sector. On October 21, the Council agreed to raise the floor price per metric ton in the Tin Agreement from £1,260 to £1,350 and the ceiling price from £1,605 to £1,650. The last previous adjustment, except for that made in November 1967 for the devaluation of the pound sterling and in January 1970 for the conversion from long to metric tons, had been made on July 1, 1966.

Price maintenance by buffer stock action resulted in the accumulation of 35 tons in 1966, rising to 4,755 tons by the end of 1967 and 11,290 tons at the end of 1968. The Council reduced its stocks during the period of export controls in 1969 and made further reductions through the first half of 1970; at June 30, the Buffer Stock had 955 tons. In the fourth quarter these stocks were increased to 1,213 tons, the year-end figure. The United States stockpile originally held 348,310 tons in 1962, before disposals began. The stockpile objective was raised on March 27, 1969 from 200,000 to 232,000 tons, leaving 25,524 tons authorized and available for disposal. Releases totalled 2,048 tons in 1969 and 3,069 tons in 1970, all under the program of the United States Agency of International Development (AID). Releases from 1962 to the end of 1970 totalled 95,909 tons, 80,000 of which were sold to commercial users and the remainder disposed of through AID and similar programs.

The United Nations convened a conference in Geneva from April 13 to May 15, 1970 to draft the Fourth International Tin Agreement. The Third Agreement, established on July 1, 1966, was scheduled to expire on June 30, 1971. The conference was attended by the members of the Third Agreement, plus some important non-members, including West Germany, United States, and USSR. An agreement was drawn up embodying the objectives and control mechanisms of the Third Agreement. The principal change is that the Buffer Stock Manager under the new agreement has the authority to both buy and sell in the upper and lower price sectors, which it is expected will make buffer stock operations more flexible. The Fourth Agreement came into force on July 1, 1971 with the following changes in membership: Australia became a producer member, having been a consumer member; West Germany and the USSR joined as new consumer members. Another change, not part of the terms of the Agreement, is that the International Monetary Fund will permit countries to finance their buffer





Bolivia started production in the late fall of 1970 at a new tin smelter at Oruro, operated by the state-owned National Foundry Company. The planned operating rate of 7,500 metric tons annually was reached in the spring of 1971. Bolivia's mine production in 1970 was 30,100 metric tons; its surplus of tin in concentrates is exported mainly to Britain (21,195 metric tons in 1970) and United States (3,561 metric tons).

China (People's Republic) is a major producer of tin with an output in the order 22,000 metric tons annually. In 1970, China shipped 4,000 metric tons to non-Communist countries. The USSR is also a major producer with an annual output of about 25,000 metric tons, but is an importer too, taking 5,000 metric tons in 1970 from Britain and Malaysia. Bulgaria and Romania took 1,500 metric tons in total from Britain and Malaysia. The communist bloc is thus a net importer of tin.

USES

Tin metal is unequalled as a protective hygienic coating on steel, and the manufacture of tinplate represents the largest market for tin. Available world data indicates that 76,400 metric tons were used in 1970 in the production of 12.5 million tons of tinplate. The tin coating on the steel varies with the product mix of tinplate plants from 0.25 pound per

TABLE 3

Estimated World* Production of Tin-in-Concentrates, 1960, 1969-70
(long tons)

	1960	1969	1970
Malaysia	51,979	72,167	72,643
Bolivia	20,219	29,572	29,630
Thailand	12,081	20,759	21,440
Indonesia	22,596	16,281	18,794
Federation of Nigeria	7,675	8,603	7,835
Australia	2,176	8,000	8,840
Congo (Dem. Rep.)	9,202	6,534	6,346
Total, including countries not listed	136,500	177,000	181,700

Source: International Tin Council, Statistical Bulletin.
*Excludes communist countries, except Czechoslovakia, Poland and Hungary; it should be noted that China (People's Republic) and USSR are large tin producers.

TABLE 4

Estimated World* Production of Primary Tin Metal, 1960, 1969-70
(long tons)

	1960	1969	1970
Malaysia	76,366	87,089	90,670
Britain	26,374	25,982	21,691
Thailand	218	22,048	21,730
Netherlands	6,393	5,298	5,844
Federation of Nigeria	–	8,839	7,943
Belgium	8,255	4,444	4,191
Indonesia	1,977	4,560	5,109
United States	13,500	345	2,993
Australia	2,255	4,160	5,122
Spain	464	2,068	2,470
Brazil	1,312	2,245	3,018
Japan	1,189	1,378	1,354
Congo (Dem. Rep.)	2,507	1,800	1,374
Total, including countries not listed	145,900	174,700	177,700

Source: International Tin Council, Statistical Bulletin.
*Excludes Communist countries, except Czechoslovakia, Poland and Hungary.
– Nil.

stock contributions by the use of International Monetary Fund drawing rights. This permission was granted in recognition of the Agreement's importance as an intergovernmental stabilizing force in the tin commodity market.

TABLE 5

Estimated World* Tin Position, 1968-70
(long tons)

	1968	1969	1970
Ore Supply			
Production of tin-in-concentrates	181,800	176,800	181,700
Stocks at year's end	24,700	23,600	19,000
Primary Metal Supply			
Smelter production of tin metal	184,000	174,800	177,700
Net sales to centrally-planned countries	4,600	6,100	4,500
Government stockpile sales	3,495	2,048	3,069
Buffer stock, sales+, purchases−	6,535−	6,700+	3,377+
Commercial stocks at year's end	62,300	49,000	42,200
Primary metal consumption	173,300	181,500	175,500

Source: International Tin Council, Statistical Bulletin.
*Excludes Communist countries, except Czechoslovakia, Poland and Hungary.

base box for electrolytic tinplate up to 1.25 pounds for the hot-dip process. Tinplate is sold by the base box (31,360 square inches). There is currently no substitute for tinplate in most container applications involving food processing but for beverages chrome-plated steel or aluminum are increasingly competitive.

The chemicals, stannous chloride and stannous sulphate as well as sodium stannate and potassium stannate, are used as an electrolyte in the tin-plate process. The chloride stabilizes the colour and perfume in soap. Stannic oxide is an opacifier in enamels. Stannic chloride is the basic chemical in the manufacture of organotin compounds. Such compounds are used as fungicides and to stabilize chlorinated transformer oils and rubber-base paints. The di-octyl and di-butyl compounds are stabilizers in the polyvinyl chloride plastics, which have growing importance in container applications.

In recent years, a change in glass technology resulted from the development of a method of making plate glass by floating molten glass on molten tin.

The alloy applications of tin have a long tradition. A relatively new application is the use of tin in cast irons for automobile engine blocks. The solders are indispensable for joining the side-seam on cans, for motor-car radiator cores, and for ensuring continuity in electrical contacts. Babbitt and white metal alloy are used for bearings and so are aluminum-tin alloys, which have a higher fatigue strength. The tin bronzes containing over 12 per cent tin are mainly used for castings; wrought alloys contain less tin. The gun-metals contain copper, tin, zinc, and sometimes lead to improved machinability. Continuous casting of standard shapes has reduced fabrication costs and caused renewed interest in bronze as an engineering material. Fusible alloys of tin, bismuth, lead, and cadmium are used in safety devices. Diecasting alloys of tin, antimony and copper have applications in jewellery. Modern pewter is pure tin hardened by the addition of copper and antimony; a representative composition is 91 per cent tin, 2 per cent copper, and 7 per cent antimony. As a minor alloying agent in other metals tin has a wide use. Though aluminum has replaced tin in most foil and tube applications it is still used in some condensers and also in containers for pharmaceutical products.

PRICES

The average price in cents (US) for a pound of tin in 1970 on major markets was as follows: 1) Straits brand, delivered ex-works, Penang, Malaysia, 162.80 equivalent to £1495.5 per metric ton; 2) Prompt tin, New York, 174.14 (£1599.64); and 3) Cash tin, 166.51 (£1529.5) and Forward tin, 166.28 (£1527.4), London, England. The difference in these market prices is nominally transportation and insurance costs plus the cost of financing. Straits ex-works is deliverable in 60 days and London Forward in three months. The other prices are for immediate delivery.

In Canada, larger consumers put their requirements to tender, or negotiate a supply contract, and over a period the price paid is the equivalent of the New York price.

Tin concentrate prices are negotiated between the mine producer and the smelter operator. Smelting charges increase rapidly as the concentrate grade declines and are affected also by such impurities as Fe, WO_3,S, As and others. The *Metal Bulletin* quotes nominal values for concentrate delivered to smelters in Britain, specifying that for concentrate assaying 70 to 75 per cent tin, payment is made for the metal content less 1 unit (22 lb tin), less a smelting charge of £15 to £12 a metric ton of concentrate treated. For concentrate assaying 40 to 65 per cent tin the unit deduction varies from 1.6 to 1.0 units and the smelting charge from £29 to £23. For concentrate assaying 20 to 30 per cent tin the smelter charge is £70 to £65, which includes the unitage deduction.

TARIFFS

CANADA Item no.		Most Favoured Nation Tariff
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	15½%

Source: The Customs Tariff and Ammendments, Department of National Revenue, Customs and Excise Division, Ottawa.

UNITED STATES		
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
608.91	Tinplate and tin coated sheets:	
	Valued at not over 9.4¢ per lb – after Jan. 1, 1970	8.5%
	Valued at not over 10¢ per lb – after Jan. 1, 1971	8.0%
	Valued at not over 10¢ per lb – after Jan. 1, 1972	8.0%
608.92	Tinplate and tin coasted sheets:	
	Valued over 9.4¢ per lb – after Jan. 1, 1970	0.8¢ per lb
	Valued over 10¢ per lb – after Jan. 1, 1971	0.8¢ per lb
	Valued over 10¢ per lb – after Jan. 1, 1972	0.8¢ per lb
644.15	Tin foil:	
	After Jan. 1, 1970	24%
	After Jan. 1, 1971	21%
	After Jan. 1, 1972	17.5%

Source: Tariff Schedules of the United States Annotated (1971) TC Publication 304.

Titanium and Titanium Dioxide

G.P. WIGLE*

Quebec Iron and Titanium Corporation (QIT) produced at a rate about 13 per cent higher than in 1969 when output was also increased by more than 10 per cent following similar increases in the prior two years. In 1970, the company mined 2.22 million long tons of ilmenite to produce 754,200 long tons of titania slag containing 70 to 72 per cent titanium dioxide, and 531,000 long tons of co-product iron. QIT is the only company in Canada mining and processing ilmenite ($FeOTiO_2$) for the production of titania slag used by manufacturers of sulphate-process titanium-dioxide pigment for the paint, paper, and plastics industries.

Manufacturers of titanium dioxide pigments are the major consumers of the growing output of the titanium minerals industry but production of titanium metal and alloys is expanding with the requirements of industrial process applications and for components of the aircraft industry.

World production of concentrates of the two titanium minerals, ilmenite ($FeOTiO_2$) and rutile (TiO_2), has increased steadily during the past decade. While the annual production of ilmenite increased from 2.2 million tons in 1960 to 3.4 million tons in 1969, an annual growth of about 5 per cent, the production of rutile, preferred by the makers of chloride-process titanium pigment, welding rod, and titanium metal, has increased at an annual rate of nearly 15 per cent from 114,200 tons in 1960 to over 400,000 tons in 1969.

Efforts are being made to supplement the titanium supply through the development of processes to produce synthetic rutile from cheaper and more abundant ilmenite or titania slag. The importance of these programs is emphasized by the fact that presently planned chloride-process titania pigment manufacturing capacity alone would consume some 450,000 tons of rutile annually by 1972. This demand will further aggravate increasingly severe rutile supply problems and attendant higher prices.

Published prices for rutile, 96 per cent TiO_2, f.o.b. United States Atlantic and Great Lakes ports, increased in 1970 from U.S. $160 to U.S. $185 a short ton. The published price of imported ilmenite, 54 per cent TiO_2, f.o.b. Atlantic ports was unchanged at U.S. $20-21 a long ton. Titania slag, 70 per cent TiO_2, f.o.b. producer's plant, was also unchanged at the year-end at U.S. $45 a long ton.

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*Mineral Resources Branch.

TABLE 1

Canada–Titanium Production and Trade, 1969-70

	1969		1970p	
	Short Tons	$	Short Tons	$
Production[1]				
Titanium dioxide	..	30,363,558	..	34,470,000
Imports				
Titanium dioxide pure				
United States	1,025	552,000	1,175	626,000
West Germany	808	327,000	1,026	467,000
Belgium and Luxembourg	–	–	288	104,000
Britain	664	257,000	243	98,000
Other countries	7	3,000	49	17,000
Total	2,504	1,139,000	2,781	1,312,000
Titanium dioxide, extended				
United States	8,651	1,628,000	8,174	1,484,000
Titanium metal				
United States	305	1,788,000	275	2,326,000
Britain	1	8,000	4	69,000
Japan	73	205,000	9	26,000
Netherlands	–	–	1	2,000
Sweden	1	6,000	*	1,000
Total	380	2,007,000	289	2,424,000
Export[2] to the United States				
Titanium metal, unwrought, incl. waste and scrap	214	138,421	107**	95,597**
Titanium metal, wrought	66	447,439	420**	2,318,731**
Titanium dioxide	3,993	1,674,566	7,514**	3,282,851**

Source: Dominion Bureau of Statistics.
[1]Producers' shipment of slag. [2]U. S. Department of Commerce, Imports for Consumption, Report FT 135; no identifiable classes are available from Canadian export statistics.
*Less than one ton. **11 months 1970.
pPreliminary; – Nil; . . Not available.

OUTLOOK

Growth of the titanium minerals industry is assured by the increasing requirements for titanium dioxide in the pigments industry and the use of titanium metal products in the aircraft industry and in industrial process applications.

The development of processes for the production of high-grade titanium dioxide (synthetic rutile) from ilmenite, if economically successful, would have a regulatory influence on the price of natural rutile concentrates, a restraint on the depletion of existing rutile reserves, and expand the utilization of ilmenite.

Rutile will remain in short supply; growth of ilmenite production will continue at about 5 per cent annually over the next several years due to the time required to bring new up grading process facilities into production.

PRODUCTION

CANADA

Ilmenite is mined by open-pit methods in the Lac Tio-Allard Lake area of Quebec by Quebec Iron and Titanium Corporation. The ilmenite, crushed to minus 3 inches, is transported 27 miles by rail to Havre St. Pierre and shipped up the St. Lawrence River to the company's beneficiation plant and smelter at Sorel near Montreal. The company owns one of the world's largest deposits of ilmenite, with reserves averaging 35 per cent TiO_2 and 40 per cent iron. The ilmenite occurs, with finely disseminated hematite (Fe_2O_3), in dykes, irregular lenses, and sill-like bodies within a large mass of anorthosite; it averages 86 per cent total oxides of titanium and iron and is upgraded, using heavy media, spirals and cyclones, to 93 per cent combined oxides in the beneficiation plant. 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. The slag is tapped into slag-lined cars, cooled, solidified and then crushed to minus ½ inch. The iron, after tapping from the smelting unit, is superheated in an induction furnace, and desulphurized and carburized by a special ladle technique. Manganese and silicon may be added to make various grades of foundry pig iron. The iron is cast into forty-pound pigs.

Canadian Titanium Pigments Limited, a wholly-owned subsidiary of National Lead Company, New York, produced titanium dioxide pigment at its Varennes, Quebec, location through 1970. The company operated its 30,000 ton-a-year sulphate-process unit at or above rated capacity in 1970 and a chloride-process unit rated at 10,000 tons per year capacity. For the sulphate-process unit, the main raw material, titanium dioxide slag, was obtained from Quebec Iron and Titanium Corporation. Sulphur for the manufacture of sulphuric acid is the other principal raw material. For the chloride-process unit the starting material is rutile sand from Australia. Chlorine and oxygen, which are also required as raw materials, are purchased from Canadian sources. While the bulk of the pigment produced was sold in the domestic market, a substantial part of the output was exported, particularly to Britain.

Tioxide of Canada Limited, Sorel, Quebec, a subsidiary of British Titan Products Limited, operated its 27,000 ton-a-year sulphate-process pigment plant at capacity during 1970. A small increase in production

TABLE 2

Titania Slag and Iron Production,
Quebec Iron and Titanium Corporation, 1968-70
(long tons)

	1968	1969	1970
Ore mined	1,501,634	1,754,747	2,222,000
Ore beneficiated	1,424,552	1,646,656	1,862,400
Ore smelted	1,232,354	1,381,342	1,571,245
Titania slag produced	600,773	668,959	754,200
Iron produced	410,085	469,109	531,200

Source: QIT.

TABLE 3

Canadian Titanium Production Trade and Consumption, 1961-70
(short tons)

	Production		Imports			Consumption	
	Ilmenite[1]	Titanium Dioxide Slag[2]	Titanium Dioxide Pure	Titanium Dioxide Extended[3]	Total Titanium Dioxide Pigments[4]	Titanium Dioxide Pigments[5]	Ferro-titanium[6]
1961	1,155,977	463,316	..	..	26,621	37,098	198
1962	745,753	301,448	12,620	12,323	24,943	37,213	94
1963	915,360	379,320	3,367	9,319	12,686	37,480	78
1964	1,388,262	544,721	1,839	10,443	12,282	41,539	42
1965	1,318,402	545,916	1,565	9,534	11,099	39,682	65
1966	1,264,683	524,773	1,627	9,774	11,401	43,579r	49
1967	1,442,238	602,455	1,616	9,763	11,379	43,447	54
1968	1,595,498	672,866	2,387	9,697	12,084	45,472	22
1969	1,844,255	749,234	2,504	8,651	11,155	..	34
1970p	2,488,640	844,704	2,781	8,174	10,955	..	..

Sources: Dominion Bureau of Statistics, and company reports.

[1]Producers' shipments of ilmenite from Allard Lake and St. Urbain areas, 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]In 1961 titanium and oxide pigments containing not less than 14 per cent by weight of TiO_2; from 1962 on, includes pure and extended TiO_2. [5]Includes pure and extended TiO_2 pigments. [6]Ti content.

pPreliminary; .. Not available; rRevised.

was foreseen in 1970 and late in the year plant modifications were being made to bring capacity to 33,000 tons a year by mid-1971. A large part of the output was sold in Canada but significant quantities were exported to Britain, Europe and the United States.

Titanium-dioxide pigment prices in Canada were raised in December 1969 by 1¢ a pound bringing refined anatase and rutile pigment prices to $26 and $28 a hundred pounds respectively. Both anatase and rutile grades are nearly pure TiO_2 but differ in opacity because of different crystal structure and index of refraction.

Atlas Titanium Limited, Welland, Ontario, a subsidiary of Rio Algom Mines Limited, melts imported titanium ingot in a consumable electrode vacuum arc furnace and processes the metal into various mill products for sale in domestic and foreign markets. The company's titanium baskets are widely used in the nickel plating industry and its mill products are directed to both military and industrial uses.

Macro Division of Kennametal Inc., Port Coquitlam, British Columbia, manufactures titanium-carbide and tungsten-titanium-carbide powders and granules that are extensively used in cutting, grinding and drilling equipment and processes. The company

TABLE 4

Salient Titanium Statistics, United States, 1969-70
(short tons)

	Ilmenite		Rutile		Titanium[1]	
	1969	1970[e]	1969	1970[e]	1969	1970[e]
Production	931,000	870,000	–	–	. .	. .
Imports	317,000[2]	226,000[2]	204,907	200,000	6,332	7,000
Consumption	1,142,000[2]	1,200,000[2]	185,702	180,000	20,124	17,000
Price/pound	n.a.	n.a.	8.0c[4]	9.3c[4]	$1.32	$1.32
Price/long ton	$20-21[3]	$20-21[3]	n.a.	n.a.	n.a.	n.a.

Source: U.S. Bureau of Mines, Commodity Data Summaries, January 1970.

[1]Short tons sponge metal. [2]Includes titania slag from Canada. [3]54 per cent TiO_2, f.o.b. Atlantic seaboard. [4]f.o.b. Atlantic and Great Lakes ports.

[e]Estimated; . . Not available; n.a. Not applicable; – Nil.

TABLE 5

Consumption of Titanium Concentrates in United States
by Products, 1969
(short tons)

	Ilmenite[1]		Titania Slag		Rutile	
Product	Gross Weight	Estimated TiO_2 Content	Gross Weight	Estimated TiO_2 Content	Gross Weight	Estimated TiO_2 Content
Pigments	1,000,874	540,403	138,553	98,075	129,668	124,811
Titanium metal	–	–	–	–	(2)	(2)
Welding-rod coatings	343	208	(3)	(3)	22,001	20,987
Alloys and carbide	1,963	1,106	(3)	(3)	(3)	(3)
Ceramics	(2)	(2)	–	–	472	451
Glass fibres	–	–	–	–	(2)	(2)
Miscellaneous	50	30	–	–	33,561	31,934
Total	1,003,230	541,747	138,553	98,075	185,702	178,183

Source: U.S. Bureau of Mines, Minerals Yearbook 1969.

[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]Included with carbides to avoid disclosure.

– Nil.

specializes in a refining process in which hard metal carbides are precipitated from a metal melt and, recovered by leaching the acid soluble matrix.

UNITED STATES

The United States is the largest producer and consumer of ilmenite; it is also the largest consumer of rutile with 98 per cent of its supply coming from Australia, the principal of the few producers of rutile. Ilmenite was produced in the United States at seven mining operations in New York, Florida, Georgia, Virginia and New Jersey. Over half is produced in New York State and about one quarter in Florida. Domestic and imported ilmenite is consumed by some 18 firms of which five titanium pigment producers in the eastern United States use 99 per cent of the total. Rutile was not produced in 1970. About 90 per cent of titanium metal used went into products for aircraft, missiles, and space applications; the remainder was used in the chemical industry, and in marine and other applications.

TABLE 6

Australian Production and Exports of Ilmenite and Rutile, 1968-69
(long tons)

	1968		1969	
	Concentrate	TiO_2 Content	Concentrate	TiO_2 Content
Ilmenite				
Production	551,501	301,069	693,815	377,963
Exports*	395,911	..	566,520	..
Leucoxene				
Production	1,607	1,444	8,032	7,051
Rutile				
Production	287,617	276,207	353,642	339,640
Exports	284,995	..	299,113	..

Source: Australian Mineral Industry, Quarterly Review.
*Includes leucoxene.
.. Not available.

TABLE 7

Production of Ilmenite Concentrates
by Countries, 1968-70
(thousand short tons)

	1968	1969	1970[e]
United States	978.5	931	870
Canada*	673	749	844.7[r]
Australia	623	785	800
Norway	471	540	600
Finland	154	152	
Malaysia	139	143	
Ceylon	82	91	
India	65	57	(630)
Spain	44	44	
Brazil	20	20	
Japan	5	6	
Portugal	0.6	0.2	
Sierra Leone	8	11	
Total	3,263.1	3,529.2	3,744.7

Sources: U.S. Bureau of Mines, Minerals Yearbook, Commodity Data Summaries; and company reports.
*Titania slag containing 72% TiO_2.
[e]Estimated; [r]Author's revision.

AUSTRALIA

During the past ten years Australia has supplied some 90 per cent of the non-communist world's rutile, about 11 per cent of the ilmenite concentrates, and attained a growth rate of over 15 per cent a year, for that period, in the aggregate value of its exports of the two minerals.

Development of processes for upgrading ilmenite continued and Western Titanium N.L., a large producer of mineral sands, operated a semi-commercial 10,000-ton-a-year beneficiation plant at Capel, western Australia. Shipments were made of test lots of upgraded ilmenite (synthetic rutile) suitable for use in the chloride-process production of pigment. The product was reported to contain over 90 per cent titanium dioxide.

NORWAY

The National Lead Company, New York, announced that its Norwegian affiliate, Titania A.S., will increase the output of its ilmenite mining operations at Tellnes to 1 million tons of concentrates a year during the next two years. The production rate at

TABLE 8

Production of Rutile Concentrates
by Countries, 1968-70
(short tons)

	1968	1969	1970[e]
Australia	322,131	396,080	400,000
Sierra Leone	10,582	14,275	45,000
India	2,961	2,751	
Ceylon	1,270	1,213	(5,000)
Brazil	126	110	
Total	337,070	414,429	450,000

Sources: U. S. Bureau of Mines, Minerals Yearbook, Commodity Data Summaries.
[e]Estimated.

Tellnes was increased to 650,000 tons of ilmenite concentrates a year in the latter part of 1970.

TITANIUM DIOXIDE PROCESSES, CONSUMPTION, USES

The sulphate process is the process most commonly used in producing titanium-dioxide pigment but the chloride process is gaining importance in recent new production installations. The accompanying Table 9 outlines the approximate capacity of the two processes in non-communist countries.

Pigment-grade TiO_2 is manufactured principally by the sulphate process in which finely ground ilmenite or titania slag (70 per cent TiO_2) is treated in sulphuric acid in large lead-lined concrete "digesters". The product is dissolved in water to give a solution of titanyl sulphate that contains iron sulphate and other soluble impurities, and unreacted solids in suspension. Following clarification and filtration, the titanyl sulphate solution is boiled in tanks to precipitate hydrated titanium oxide in a very fine crystalline state. The precipitated titanium oxide pulp is calcined in oil-fired rotary kilns reaching a final closely controlled temperature approaching 1,000°C. The calcined oxide is ground and classified to ensure fine particle size then dried and packaged.

Ilmenite mined by Quebec Iron and Titanium Corporation does not lend itself directly to the sulphate process because of the fine hematite in the ilmenite that would consume an excessive amount of acid. The pyrometallurgical process carried out by QIT at Sorel removes iron and produces the high-titania slag that can be processed with low acid consumption.

The newer chloride process for producing titanium dioxide pigments uses titanium-bearing raw material, preferably rutile, mixed with carbon. The mixture is chlorinated at high temperature to produce titanium tetrachloride, a volatile colourless liquid, which is oxidized with air or oxygen to form titanium dioxide. The chlorine is recovered and recycled. Pigment production capacity using the chloride process has increased considerably since 1959.

Rutile (TiO_2) is favoured as the raw material in the production of titanium tetrachloride, which is the intermediate compound in the production of titanium metal and of TiO_2 pigment made by the chloride process. United States, in 1968, imported 174,366 tons of rutile concentrates, 99 per cent of it from Australia.

Consumption of ilmenite is almost wholly confined to the sulphate process manufacture of TiO_2 pigment,

TABLE 9

Estimated Annual TiO_2 Pigment Production
Capacity by 1973
(short tons)

	Sulphate Process	Chloride Process
Argentina	4,400	
Australia	41,400	
Brazil	32,000	
Britain	165,000	72,000
Belgium	38,000	
Canada	57,000	10,000
Finland	17,600	
France	114,000	20,000
West Germany	215,000	38,000
India	16,500	
Italy	135,000	30,000
Japan	150,000	36,000
Mexico	7,700	
Netherlands	12,000	
Norway	16,500	
Portugal	6,600	
South Africa	21,000	
Spain	10,500	
United States	501,000	289,000
Yugoslavia	20,000	
Total	1,581,200	495,000

Sources: Industrial Minerals, published by Metal Bulletin Ltd., London; Australian Mineral Industry, Quarterly Review, Canberra, Australia.

which has largely replaced materials formerly used as white pigments. Minor amounts of ilmenite are used in the production of ferrotitanium, titanium carbide, and as a coating for welding rods.

TABLE 10

Canada, Consumption of Titanium Dioxide and Titanium Dioxide Pigments
(short tons)

	1966	1967	1968
Refined Titanium Dioxide			
Paint and varnish	24,235	25,629	27,413
Paper	4,073	4,206	4,776
Linoleum	2,104	1,174	843
Rubber	2,078	2,090	2,124
Miscellaneous non-metallic products	835	741	811
Plastic and synthetic resins	148	138	120
Toilet preparations	33	32	35
Industrial chemicals	121	105	57
Other chemicals	821	673	818
Extended Titanium Dioxide Pigments			
Paint and varnish	9,131	8,658	8,473

Source: Dominion Bureau of Statistics, Ottawa.

TITANIUM METAL

Titanium metal is a low-density, silver-grey metal and is important for its combination of lightness, strength, and resistance to corrosion. The density of titanium is 0.164 pound per cubic inch compared with 0.28 for stainless steel. It is 60 per cent heavier than aluminum (0.10 lb/in^3) but only 55 per cent as heavy as alloy steel. Titanium alloys have strength and hardness approaching that of many alloy steels and the strength-to-weight ratio exceeds that of aluminum or stainless steel. The principal disadvantages in making use of this light metal are cost, fabrication difficulties, and reactivity at high temperature.

Titanium ingot production in the United States was 28,490 tons in 1969 compared with 19,234 tons in 1968. Titanium sponge, an intermediate product in titanium metal ingot production, is also produced for domestic and export markets by Japan, Britain, and the USSR.

TITANIUM MINERALS

Ilmenite ($FeOTiO_2$) and rutile (TiO_2) are the only commercially important minerals of titanium. The titanium dioxide content of pure ilmenite is 53 per cent and that of pure rutile is 100 per cent. Titanium-bearing minerals such as anatase, leucoxene and brookite are associated with ilmenite and rutile and often comprise part of the marketed mineral concentrates. Ilmenite is recovered from alluvial and beach sands and from massive mineral deposits. The most important occurrences of rutile are in beach and alluvial sands but it is also found as a minor accessory mineral in rocks.

PRICES

Prices in the United States published in *Metals Week* of December 28, 1970 were:

(1969 year-end prices are shown in brackets underneath, where differing)

	US Currency
Titanium ore	
f.o.b. cars Atlantic ports, Great Lake ports:	$185
Rutile, 96%, per short ton, delivered within 12 months	($160)
Ilmenite, 54%, per long ton, shiploads	20-21
Slag, 70%, per long ton, f.o.b. shipping point	45
Titanium metal	
Sponge, per lb f.o.b. mine or mill	
max. 115 Brinell, 99.3%, 500 lb	1.32
Japanese, British, 99.3%	1.20–1.25
max. 90 Brinell, 99.9%, 25 lb	1.90
max. 75 Brinell, 99.9%, 10 lb	4.00
max. 60 Brinell, 99.9%, 2 lb	25.00
Mill products	
per lb, delivered, 4,000 lb lots	2.76
Billet, Ti–6AL-4V (8" diameter, random lengths)	(2.63)
Bar, Ti–6AL-4V (2" diameter)	3.80
	(3.74)
Ferrotitanium	
Delivered,	
Low carbon, per lb, Ti, 25-40% Ti	1.35
Medium carbon, net ton, 17-21% Ti	375.00
High carbon, net ton, 15-19%	310.00
Titanium dioxide	
Canadian prices of titanium dioxide pigment, effective December 1969, were:	
Anatase, dry milled, bags, car lots, delivered, East, per 100 pounds	$23.50
Anatase, regular, bags, car lots, delivered, East, per 100 pounds	26.00
Rutile pigment, bags, car lots, delivered, East, per 100 pounds	28.00

TARIFFS

CANADA Item No.		British Preferential	Most Favoured Nation	General
32900–1	Titanium ore	free	free	free
92825–1	Titanium oxides	free	12½%	25%
34715–1	Sponge and sponge briquettes, ingots, blooms, slabs, billets and castings in the rough, of titanium or titanium alloys for use in Canadian manufactures (expires 30 June, 1971)	free	free	25%
37506–1	Ferrotitanium	free	5%	5%
34735–1	Tubing of titanium or titanium alloys for use in Canadian manufactures (expires 31 Jan. 1972.)	free	free	25%

UNITED STATES		
601.51	Titanium ore, including ilmenite, ilmenite sand, rutile and rutile sand	free
629.15	Titanium metal, unwrought, waste and scrap (duty on waste and scrap temporarily suspended on or before June 30, 1971)	
	On and after Jan. 1, 1970	18.5%
	On and after Jan. 1, 1971	18%
	On and after Jan. 1, 1972	18%
629.20	Titanium metal wrought	18%
607.60	Ferrotitanium and ferrosilicon titanium	
	On and after Jan. 1, 1970	7%
	On and after Jan. 1, 1971	6%
	On and after Jan. 1, 1972	5%
473.70	Titanium dioxide	
	On and after Jan. 1, 1970	10%
	On and after Jan. 1, 1971	9%
	On and after Jan. 1, 1972	7.5%
422.30	Titanium compounds	
	On and after Jan. 1, 1970	10%
	On and after Jan. 1, 1971	9%
	On and after Jan. 1, 1972	7.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
Tariff Schedules of the United States annotated (1970) TC Publication 304.

Tungsten

G.P. WIGLE*

Canada's only tungsten mine until the latter part of 1970, Canada Tungsten Mining Corporation Limited, produced 2,955,725 pounds of contained tungsten (W) or 186,340 short-ton-units** of WO_3 in scheelite (Ca WO_4) concentrates in 1970 compared with 3,222,746 pounds of contained tungsten or 203,174 short-ton-units of WO_3 in 1969. There were 176,813 tons of ore milled averaging 1.39 per cent WO_3 (tungstic oxide) compared with 167,389 tons averaging 1.54 per cent WO_3 in 1969. Recovery of scheelite was 78.63 per cent and 78.81 per cent in the respective years. Canada Tungsten estimated its ore reserves at the end of 1970 at 558,000 tons averaging 1.56 per cent WO_3 and 89,000 tons averaging 1.43 per cent WO_3 in a stockpile of crushed ore provided during the period of about three and a half months of open-pit mining conducted in the summer. The mine, mill and concentrator, employing a total of some 70 persons, is at Tungsten in the Northwest Territories, near the Yukon border, about 135 miles north of Watson Lake.

Canadian Exploration, Limited, a subsidiary of Placer Development Limited, started tune-up operation in October of the 500-ton-a-day mill and concentrator at its tungsten property near Salmo, east of Trail, in southeastern British Columbia. The scheelite orebodies were estimated to contain 480,000 tons averaging 0.65 per cent tungstic oxide (WO_3). The estimated capital cost, including mine development, was $3.2 million. Annual production was expected to be approximately 90,000 short-ton-units of WO_3. The company made use of mill equipment previously used in treating ore from its Emerald and Dodger tungsten ore zones in the same area during an earlier operation that closed in 1958 when tungsten prices were very low.

The Buchans Unit of Terra Nova Properties Limited, subsidiary of The Price Company Limited, operated by American Smelting and Refining Company suspended underground development work at its tungsten (wolframite $FeMnWO_4$) deposit at Grey River on the south coast of Newfoundland while conducting metallurgical testing to determine grade and recovery for feasibility studies.

Burnt Hill Tungsten & Metallurgical Limited did underground development work and prepared for bulk sampling and testing its tungsten property in York County, New Brunswick.

MARKETS AND SOURCES OF SUPPLY

Published prices for tungsten, c.i.f. European ports, reached their low range for 1970 in mid-October at 520-550 shillings a long-ton-unit ($56 to $59 per s.t.u.) of WO_3 and recovered to 550-610 shillings ($59 to $65 per s.t.u.) in mid-December.

Some 38.3 million pounds of tungsten were sold from United States stockpile surplus material at an average price of $41.75 a short-ton-unit of WO_3 during 1969. Stockpile sales in 1970 were 11.8 million pounds of tungsten at an average price of U.S. $51 a short-ton-unit of WO_3.

The United States General Services Administration (GSA) announced in October 1970 its tungsten disposal plan under a two-part program with an excess of about 71 million pounds of tungsten available for sale.

*Mineral Resources Branch.

**A short-ton-unit is 20 pounds of WO_3 and contains 15.862 pounds tungsten (W).

TABLE 1

Canada, Tungsten Production, Imports and Consumption, 1969-70

	1969		1970p	
	Pounds	$	Pounds	$
Production (WO_3)	4,060,940[1]	..	3,854,800[1]	..
Imports				
Tungsten in ores and concentrates				
United States	279,700	653,000	181,700	559,000
Thailand	–	–	500	1,000
South Korea	130,200	285,000	–	–
New Zealand	16,600	37,000	–	–
Total	426,500	975,000	182,200	560,000
Ferrotungsten[2]				
Britain	210,000	561,000	152,000	452,000
United States	–	–	48,000	151,000
Total	210,000	561,000	200,000	603,000
Consumption W content				
Tungsten metal and metal powder	695,419	..	..	..
Tungsten wire	28,374	..	..	..
Other[3]	327,031	..	..	..
Total	1,050,824	..	..	..

Source: Dominion Bureau of Statistics and company reports.
[1]From company reports; [2]Gross weight; [3]Includes tungsten ore, tungsten carbide powder, ferrotungsten and tungsten chemicals.
pPreliminary; – Nil; .. Not available.

TABLE 2

Canada, Tungsten Production, Trade and Consumption, 1961-70
(pounds)

	Production[1]	Imports		Consumption
	WO_3 Content	Tungsten Ore[3]	Ferrotungsten[4]	W Content
1961	–	501,800	518,300	843,228
1962	3,580	2,854,300	285,600	1,039,628
1963	–	645,500	624,100	903,924
1964	–	389,800	172,000	740,410
1965	3,736,324	357,400	354,000	877,614
1966	4,260,440[2]	523,600	192,000	941,207
1967	–	233,600	192,000	891,411
1968	3,600,000[2]	131,700	118,000	1,181,541
1969	4,060,940[2]	426,500	210,000	1,050,824
1970	3,854,800[2]	182,200	200,000	..

Source: Dominion Bureau of Statistics.
[1]Producers' shipments of scheelite (WO_3 content); [2]From company reports; [3]Prior to 1964 reported in gross weight, commencing in 1964 in W content; [4]Gross weight.
pPreliminary; .. Not available; – Nil.

TABLE 3

World Tungsten Production in Ores and Concentrates, 1960-70
(thousands of pounds of contained tungsten)

	Including China USSR and N. Korea	Excluding China USSR and N. Korea	Releases from Gov't-held Stocks	
			United States	Britain
1960	68,343	29,306		
1961	73,854	34,445		
1962	69,004	29,921	1,593	
1963	60,186	21,085	419	
1964	61,508	24,363	758	866
1965	59,745	24,883	926	3,526
1966	62,610	27,434	8,272	604
1967	62,766	26,866	6,392	
1968	70,144	34,244	3,433	
1969	72,060	35,420	38,200	
1970[e]	72,330	35,630	11,800	

Sources: United Nations Conference on Trade and Development, Tungsten Statistics; U.S. Bureau of Mines, Minerals Yearbook.

[e]Estimated.

The disposal program was comprised of two types of offerings:

1. Domestic consumers were offered tungsten concentrates at a base price of $55 a short-ton-unit of contained WO_3 and the agency reserved the right to adjust the price and to limit sales to not more than 7 million pounds through June 30, 1971.
2. The GSA indicated that it contemplates the sale for export, at prices not less than the price for domestic sales, of about 4 million pounds of tungsten through June 30, 1971. The agency may increase this offering for export sales to not more than 6 million pounds of contained tungsten in the period to mid-1971 in the event of heavy oversubscription for the offerings.

World production of tungsten in ores and concentrates of approximately 72 million pounds a year includes an estimated 36 million pounds produced by China, USSR, and North Korea. It is of interest to note that: sales from United States stockpile in 1969 at 38.8 million pounds of contained tungsten exceeded the annual production of either the non-communist or the communist countries; stockpile sales in 1970 were 11.8 million pounds of tungsten; the United States had, in 1969, reversed its position from that of a principal importer to that of a substantial net exporter of tungsten. Tungsten content in export of ores and concentrates from the United States were 7.15 million pounds in 1969 and an estimated 22 million pounds in 1970. Tungsten imports in 1970 were about 1.4 million pounds; consumption of tungsten in concentrates was about 17 million pounds compared with 13 million pounds in 1969*.

OUTLOOK

The sustained demand and relatively high prices for tungsten indicates wider use and more diversified applications. The growing demands of the world's major industrial countries are principally due to the metal's use in the tools of production, in other established applications, and in advanced industrial products.

The resumption of tungsten exports in quantities by China to non-communist countries and continued sales of large amounts from government-held material would generate a situation of oversupply and a consequent reduction of prices. The possibility of these influences coinciding for a prolonged period is unlikely. Considerable stocks of tungsten-bearing materials are available to, or in the hands of, users and distributors. The United States will likely remain a net exporter for three or four years. New mines are being developed for production in the near future.

The prime interests of government and industrial organizations involved and participating in the tungsten market are the maintenance of reasonable returns to producers and an adequate industrial supply. A period of sustained attractive returns to producers and stimulation of new production developments appears reasonably assured.

*United States, Bureau of Mines, Mineral Industry Surveys.

TABLE 4

Tungsten Production in Ores and Concentrates by Countries, 1968-70
(thousands of pounds of contained tungsten)

	1968	1969	1970[e]
China[e]	17,600	17,600	17,600
USSR[e]	13,600	14,300	14,380
United States	10,188	9,405	10,000
North Korea[e]	4,720	4,720	4,720
South Korea	4,602	4,336	4,500
Bolivia	3,984	4,050	4,100
Canada	2,855	3,223	3,057
Portugal	2,889	2,706[e]	2,900
Australia	2,565	2,946	2,975
Japan	1,175	1,335	
Peru	1,278	1,478	
Thailand	1,093	1,437	
Brazil	958	1,910	(8,098)
Rwanda	708	374	
Mexico	586	636	
Burma	307	249	
Other countries[e]	1,317	1,355	
Total	70,145	72,060	72,330

Sources: U.S. Bureau of Mines, Minerals Yearbook, and Commodity Data Summaries; company reports.

[e]Estimated; (8,098) average of 1968 and 1969.

CONSUMPTION AND USE

The growing demand for tungsten, so evident in recent years, was similar to trends in consumption of several other alloying metals (e.g. columbium, molybdenum, titanium, vanadium). Increased demand for tungsten indicates more widespread and diversified applications as well as strong economic conditions in the world's major industrial economies, particularly those of Japan and countries in western Europe.

United States consumption of tungsten in 1970 was an estimated 17 million pounds, approximately 4 million pounds more than 1969 and well above the average annual consumption 13.5 million pounds of the years 1964 to 1969, which include the 1966 high of 18 million pounds and the low of 11 million pounds consumed in 1968. Tungsten was used in the form of: tungsten carbide – 40 per cent, metal powder – 32 per cent, ferrotungsten – 10 per cent, tungsten chemicals, scheelite and scrap – 18 per cent. Additional consumption data also published in the *Bureau of Mines Mineral Yearbook, 1969,* United States Department of the Interior, are listed in Table 5.

Tungsten carbide (WC) is the basic material for a great variety of cemented (or sintered) carbide cutting tools, dies and wear-resistant parts. The carbides are used for such tools as milling cutters, reamers, punches and drills; in dies for wire- and tube-drawing; and for wear-resistant parts of gauges, valve seats and guides. Large amounts are used by the mining industry in carbide-tipped rock-drill bits. The use of sintered carbide tire studs is contributing to the growing market for tungsten products. Flameplating and plasma-plating of coatings of tungsten carbide and cobalt are used to provide wear-resistant facings on metal parts. Tungsten carbide in tiny spherical pellets is used in ballpoint pens. Tungsten metal powder, made by hydrogen or carbon reduction of chemically produced oxide of tungsten, is used in making tungsten wire, rod, sheet, tungsten alloys, and cast tungsten carbides.

In high-temperature nonferrous and superalloy fields, where temperature resistance requirements are beyond the ability of high alloy steels, tungsten is used as a base-alloy with varying amounts of cobalt, chromium, molybdenum, nickel or other refractory metals to produce a series of hard, heat- and corrosion-resistant alloys. High-temperature alloys are used in structural components in temperature environments of 1,700°F and higher. High-tungsten alloys are used in jet and rocket engine parts, missile nose cone inserts, nozzle inserts, guidance vanes, turbine blades and combustion chamber liners. Examples of such applications are nose cone insert castings made of an alloy containing 85 per cent tungsten and 15 per cent molybdenum and rocket engine nozzle inserts of 98 per cent tungsten and 2 per cent molybdenum. Stellite, a nonferrous alloy containing from 5 to 20 per cent tungsten with cobalt and chromium, is used in welding rods for hard-facing and in high-speed tools.

Ferrotungsten, used as an additive in the manufacture of alloy steels, usually contains from 70 to 80 per cent tungsten. Alloy tool steel classifications range through relatively low-alloy tool steels to intermediate and high-speed tool steels. The low-alloys generally contain little or no tungsten, the intermediate class contains from 2 to 4 per cent tungsten and the high-speed tool steels contain from 1.5 to 18 per cent tungsten and other carbide-forming elements such as chromium, molybdenum and vanadium.

Pure, or substantially pure, tungsten is important in electric lighting, electronics and electrical contact applications. Tungstic acid, sodium tungstate, ammonium paratungstate, and tungstic oxide are chemical forms produced at intermediate stages in manufacturing tungsten metal powder. Tungsten chemicals are used in textile dyes, paints, enamel, and glass making.

Scheelite concentrate of sufficiently high grade and low in undesirable impurities can be used for direct addition to steel melts. Copper, arsenic, antimony, phosphorus, sulphur and manganese are the impurities that most often present a problem in meeting concentrate specifications. Some scheelite contains chemically combined copper and/or molybdenum which can be removed only by chemical treatment.

Scheelite concentrates for direct addition to steel should have a minimum tungstic oxide (WO_3) content of 70 per cent. United States stockpile specifications for scheelite concentrates are outlined in *Bulletin 630*, issued by the U.S. Bureau of Mines in 1965; they call for a minimum WO_3 content of 65 per cent and low limits on the allowable content of many unwanted elements.

TABLE 5

Consumption of Tungsten by End Uses in the United States, 1969
(thousands of pounds of contained tungsten)

	1969	
	Total	Per Cent
Steel:		
Stainless and heat resisting	345	2.1
Alloy	594	3.7
Tool	1,951	12.2
Superalloys	381	2.4
Alloys (excluding alloy steel and superalloy):		
Cutting and wear resistant material	7,275	45.3
Other alloys	1,028	6.4
Mill products made from metal powder	2,898	18.1
Chemical and ceramic uses	406	2.5
Miscellaneous and unspecified	1,175	7.3
Total	16,053	100.0

Source: United States Bureau of Mines Minerals Yearbook.

TABLE 6

Consumption of Tungsten in Canada, by Use, 1968-69
(pounds of contained tungsten)

	1968	1969
Carbides	887,034	791,021
Alloy steels	239,101	195,244
Electrical and electronic	26,298	30,524
Other[1]	29,108	34,035
Total	1,181,541	1,050,824

Sources: Compiled in Mineral Resources Branch from data supplied by Dominion Bureau of Statistics.
[1]Includes nonferrous alloys, chemicals and pigments.

Among the principal consumers of tungsten in Canada are: *in Quebec,* Colt Industries Canada Ltd., Sorel; Shawinigan Chemicals Division of Gulf Oil Canada Limited, Montreal; *in Ontario,* Altas Steels Division of Rio Algom Mines Limited, Welland; Canadian General Electric Company Limited, Toronto; A.C. Wickman, Limited, Toronto; Canadian Westinghouse Company Limited, Hamilton; Fahralloy Canada Limited, Orillia; *in British Columbia,* Macro Division of Kennametal Inc., Port Coquitlam; Staymet Alloys Limited, Pitt Meadows.

Macro Division of Kennametal Inc. is the only Canadian manufacturer of tungsten-carbide powders, matrix powders for diamond cutting-tools, cemented carbide alloy powders and tungsten carbide hardfacing and cutting granules. The company specializes in a refining process in which hard metal carbides are precipitated from a high-temperature metal melt and recovered by leaching the acid-soluble metal binder. The raw materials used are scheelite and wolframite concentrates. Other Canadian consumers use partially processed and semi-fabricated tungsten products.

MINERALS AND OCCURRENCE

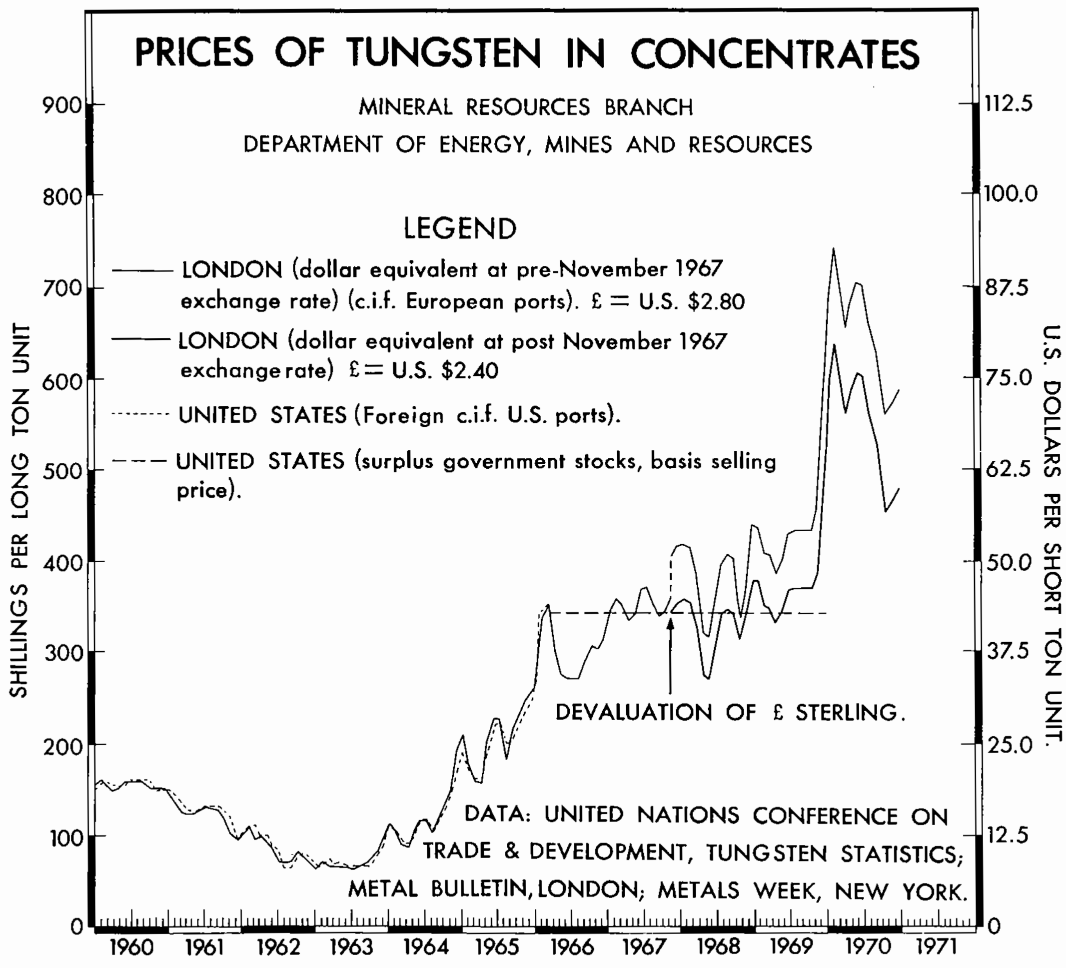
The most important ore minerals of tungsten are wolframite which is the collective name of a series of iron-manganese tungstates ($FeMnWO_4$), and the mineral scheelite which is nearly pure calcium tungstate ($CaWO_4$). Wolframite ($FeMnWO_4$) contains varying amounts of iron and manganese; the end-member of the series having less than 20 per cent manganese is the iron-tungstate called ferberite ($FeWO_4$) and the opposite end-member with less than 20 per cent iron is the manganese tungstate, hubnerite ($MnWO_4$). Wolframite varies in colour from dark grey to brown to black and contains from 76.3 to 76.5 per cent tungsten trioxide. Scheelite ($CaWO_4$) has an opaque waxlike appearance varying from white to pale yellow to brown and when pure contains 80.6 per cent tungsten trioxide. Scheelite is fluorescent in ultraviolet light, the colour varying from blue through white to yellow depending on the content of molybdenum which frequently replaces some of the tungsten in the mineral.

Tungsten is estimated to comprise about 0.0069 per cent of the earth's crust or about the same relative abundance as copper (0.0070 per cent) and more than lead (0.0016 per cent) or molybdenum (0.0015 per cent).

In many tungsten-bearing mineral occurrences tungsten is the only valuable mineral constituent but tungsten, in important amounts is also found associated with tin, molybdenum, gold, copper and silver-lead-zinc ores.

Tungsten mineral occurrences are found mostly in quartz veins and in contact-metamorphic deposits but pegmatite and placer deposits have also been productive. Disseminations of tungsten minerals in igneous rocks occur in many parts of the world but are rarely sufficiently concentrated to be of economic interest for tungsten alone. The tungstic oxide (WO_3) content of tungsten ore deposits seldom exceeds 2 per cent and is usually about 0.5 per cent.

Scheelite, occurring with pyrrhotite and chalcopyrite, is the ore mineral at Canada Tungsten's mining operation; the orebody occurs as a partial replacement body in a flat-lying, almost tabular skarn zone, about 70 feet thick, with altered limestone above and ribbon-chert below. Scheelite, and less frequently wolframite, occurrences in contact metamorphic skarn zones are numerous in northern British Columbia, the Yukon and Northwest Territories. Wolframite has been found in stream gravels and in quartz veins in Yukon Territory and British Columbia. Scheelite is found in many parts of Canada in association with gold-bearing quartz veins but usually in minor amounts. Scheelite, wolframite, hubnerite and tungstite have been found in quartz veins, pegmatites and greisen in the Atlantic Provinces.



PRICES

Metals Week, December 28, 1970, published the following tungsten prices; the listed prices for December 1969 are also shown.

	(1969)	1970
Tungsten ore: 65% minimum WO_3, per stu of WO_3, duty included, GSA for US market only,	\$US	\$US
Wolfram	(43.00)	55.00
Scheelite	(43.00)	55.00
(\$6.34 duty per stu of WO_3 in 1969 reduced to \$5.55 in 1970)		
Ferrotungsten, per pound W, f.o.b. shipping point,		
Low-molybdenum	(3.65)	3.75
High-molybdenum	(3.65)	3.75
"UCAR" high-purity	(3.86)	4.00
Dealer (export)	(3.25-3.45)	(nom.)4.50
Tungsten metal, per pound, c.i.f. U.S. ports,		
Carbon red, 98.8%, 1000 pound lots	(3.06)	4.50
Hydrogen red, depending on		
Fisher No. range	(4.91-5.75)	5.43-6.36
Typical Fisher No. 400	(4.91)	5.43

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, ingots, sheets, strip, plates, bars, rods, tubing, wire scrap (Expires October 31, 1971)	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

601.54	Tungsten ore	
	On and after Jan. 1, 1970	35¢ per lb on W content
	On and after Jan. 1, 1971	30¢ per lb on W content
	On and after Jan. 1, 1972	25¢ per lb on W content
	Tungsten metal-unwrought other than alloys	
629.28	Lumps, grains, powders	
	On and after Jan. 1, 1970	29¢ per lb on W content + 17.5% ad val
	On and after Jan. 1, 1971	25¢ per lb on W content + 15% ad val
	On and after Jan. 1, 1972	21¢ per lb on W content + 12.5% ad val
629.29	Ingots and shot	
	On and after Jan. 1, 1970	14.5%
	On and after Jan. 1, 1971	12.5%
	On and after Jan. 1, 1972	10.5%
629.30	Other tungsten unwrought metal	
	On and after Jan. 1, 1970	17.5%
	On and after Jan. 1, 1971	15%
	On and after Jan. 1, 1972	12.5%
	Tungsten metal waste and scrap	

TARIFFS (Cont'd)

629.25	Not over 50% of tungsten	
	On and after Jan. 1, 1970	29¢ per lb on W content + 8.5%
	On and after Jan. 1, 1971	25¢ per lb on W content + 7.5%
	On and after Jan. 1, 1972	21¢ per lb on W content + 6%
629.26	Over 50% of tungsten	
	On and after Jan. 1, 1970	14.5%
	On and after Jan. 1, 1971	12.5%
	On and after Jan. 1, 1972	10.5%
629.35	Tungsten metal, wrought	
	On and after Jan. 1, 1970	17.5%
	On and after Jan. 1, 1971	15%
	On and after Jan. 1, 1972	12.5%
	Tungsten unwrought alloys	
629.32	Not over 50% tungsten	
	On and after Jan. 1, 1970	29.4¢ per lb on W content + 8.5%
	On and after Jan. 1, 1971	25¢ per lb on W content + 7.5%
	On and after Jan. 1, 1972	21¢ per lb on W content + 6%
629.33	Over 50% tungsten	
	On and after Jan. 1, 1970	17.5%
	On and after Jan. 1, 1971	15%
	On and after Jan. 1, 1972	12.5%
422.40	Tungsten carbide	
	On and after Jan. 1, 1970	29.4¢ per lb on W content + 17%
	On and after Jan. 1, 1971	25¢ per lb on W content + 15%
	On and after Jan. 1, 1972	21¢ per lb on W content + 12.5%
422.42	Other tungsten compounds	
	On and after Jan. 1, 1970	29¢ per lb on W content + 14%
	On and after Jan. 1, 1971	25¢ per lb on W content + 12%
	On and after Jan. 1, 1972	21¢ per lb on W content + 10%
607.65	Ferrotungsten	
	On and after Jan. 1, 1970	29.4¢ per lb on W content + 8.5%
	On and after Jan. 1, 1971	25¢ per lb on W content + 7.5%
	On and after Jan. 1, 1972	21¢ per lb on W content + 6%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

Tariff Schedules of the United States Annotated (1970)
TC Publication 304.

Uranium and Thorium

R.M. WILLIAMS*

Uranium

Uranium continued to be in oversupply in world markets in 1970, and events during the year did little to offer encouragement to Canadian producers for the short-term. Indeed, one producer ceased operations altogether, a second was seriously considering suspending operations for a two-year period, and a third completed the second year of a planned five-year program of production at 50 per cent capacity; only one producer was operating at near-full 'in-service' capacity. Despite the trials being experienced by existing producers, one new company announced production plans, based on a guaranteed annual market, beginning tentatively in 1974.

The year 1970 also marked the end of the federal government's five year uranium stockpiling program. However, in view of the continuing poor short-term market situation, the government announced that it was prepared to offer further assistance to individual producers, if their circumstances warranted it. Of particular significance was the government's announcement, early in 1970, that it intended to limit the extent of foreign ownership of uranium producing enterprises in Canada.

An upturn in orders for nuclear power plants, however, was one promising sign that the lull in the uranium market may be nearing an end. The upturn was particularly evident in the United States where, due to rapidly increasing costs and critical shortages of fossil fuels, utilities were choosing nuclear rather than conventional thermal power plants to provide their much needed additional electrical generating capacity. In addition, there was some indication that the United States Atomic Energy Commission (USAEC) was re-examining its policy which restricts the enrichment of foreign uranium for domestic use. With respect to the longer-term future, the European Nuclear Energy Agency (ENEA) predicted that the world† will, by 1985, require annually some 130,000 short tons of uranium oxide(U_3O_8)**, more than five times present production levels.

Consequently, while little change is expected in Canadian uranium output during the next three or four years, expansion should begin in the mid-1970's. It is not unrealistic to expect that Canadian uranium production capacity will increase threefold by the end of the decade and severalfold again before the end of the century.

PRODUCTION, PRESENT AND PLANNED

Production of uranium in Canada increased slightly in 1970 to about 4,580 tons of U_3O_8 in concentrates. Producer's shipments were 4,010 tons of U_3O_8, valued at $50,237,000. Almost 85 per cent of production came from three producers: Denison Mines Limited, Rio Algom Mines Limited and Stanrock Uranium Mines Limited, which produced from quartz-pebble conglomerates in the Elliot Lake area of Ontario. Canada's fourth producer, Eldorado Nuclear Limited, produced from pitchblende vein-type deposits in the Uranium City area of northern Saskatchewan.

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*Mineral Resources Branch.

†World, as used throughout, excludes USSR, Eastern Europe and China, except where noted.

**1 short ton U_3O_8 = 770 kilograms of uranium metal.

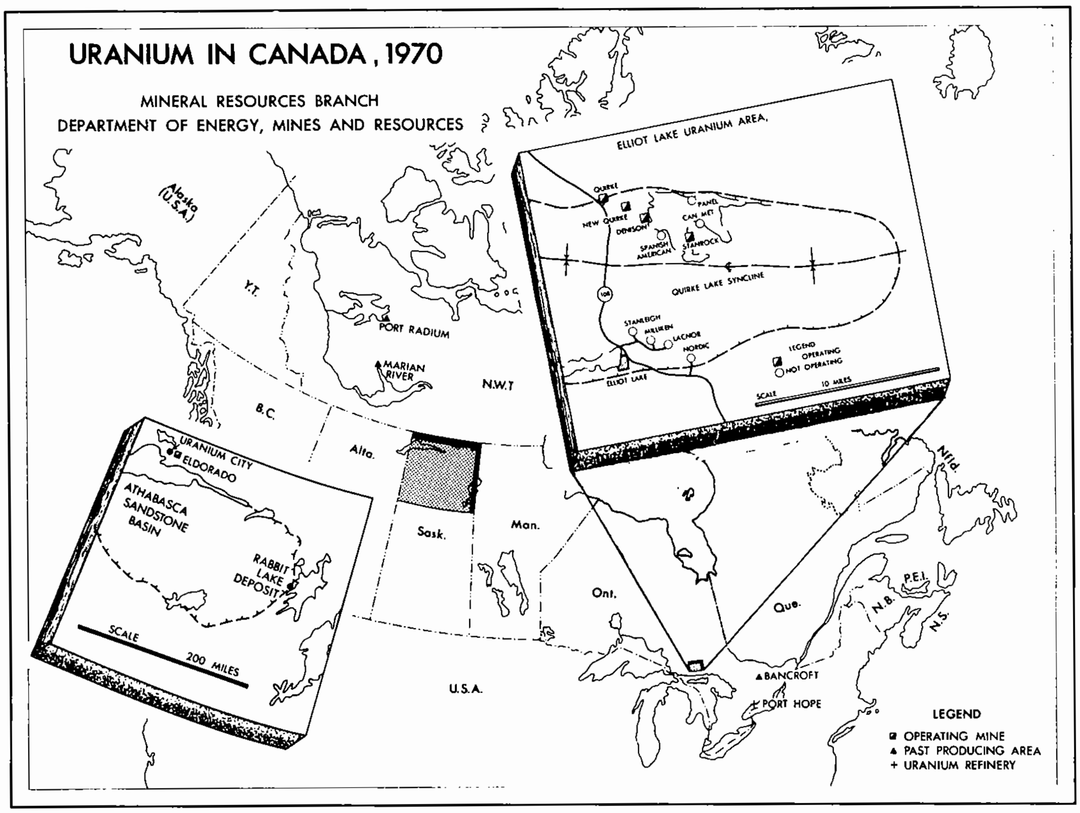
TABLE 1

Uranium Production in Canada, by Province, 1969-70

	1969		1970P	
	Pounds	$	Pounds	$
Production (U_3O_8 shipments)				
Ontario	. .	40,307,489	. .	40,687,000
Saskatchewan	. .	12,843,168	. .	9,550,000
	7,707,735	53,150,657	8,021,000	50,237,000

Source: Dominion Bureau of Statistics.

PPreliminary; . . Not available for publication.



Denison continued to operate its 6,000-ton-a-day mill at some two-thirds capacity throughout the year; 1,178,000 tons of ore, averaging 3.15 pounds U_3O_8 a ton, were treated to produce a total of 3,628,163 pounds of U_3O_8. Mining was again concentrated in the northeast section of the mine, and appreciable supplementary production was obtained through a rather extensive bacterial leaching and mine-water recovery program carried out in mined-out areas. Further changes in underground equipment and mining methods were made in line with the company's long-range plans for maximizing efficiencies of its underground operation; already an extremely high degree of mechanization has been achieved. Improvements in ventilation were also made and others were planned to make use of the Can-Met openings which are now accessible through the Denison Mine via the eastward Can-Met development drive.

Some modifications and modernization of elements of several mill circuits were completed resulting in improved efficiencies and reduced costs. Further reductions in cost are expected in 1971 through the availability of industrial lime* from the new plant of Reiss Lime Company of Canada, Limited (49 per cent controlled by Denison) near Spragge, some 25 miles south of Elliot Lake; deliveries to Denison began on a regular basis in late 1970. Although Denison maintained its byproduct production of yttrium oxide during the first half of the year, operations were later suspended due to the lack of markets.**

Due to a production level in excess of commitments during the last four years, Denison had built up a sizable inventory of uranium concentrates. Consequently, the company was in a position to cease operations temporarily and still meet its commitments. This possibility dissolved at year-end when the federal government announced a plan of assistance for Elliot Lake, which will permit Denison to continue operations over the near-term critical period.

Rio Algom operated its Quirke mill at an average of 4,231 tons of ore a day in 1970. A total of 1,443,000 tons were milled, with an average recovered grade of 2.8 pounds of U_3O_8 per ton, to produce 3,995,000 pounds of U_3O_8; average mill recovery was 94.4 per cent. The mill was supplied with ore from both the old and the New Quirke mines. The mining rate at New Quirke was increased and is expected to reach full capacity in 1971, at which time reserves at old Quirke will have been exhausted. As announced in 1969, the Quirke mill, with certain adjustments to the grinding circuit, is capable of operating at a level of 4,500 tons a day, a rate which will be fully utilized as production from New Quirke is increased. Tests completed early in 1970 confirmed this capability.

During the second half of 1970 assessment of a new mining method began at New Quirke. The method will employ accurate long hole drilling, several items of newly designed equipment, and back filling with a mixture of mill tailings and cement. Success of the method will permit increased mechanization and increased recovery from pillars where thickness of ore exceeds 10 feet. New equipment for monitoring mine ventilation was also being tested, to determine the extent of cost saving and mine environment improvement.

In the fall of 1970, Rio Algom's programs of miner training and experimental mining were transferred from the Nordic to the old Quirke operation, and Nordic was placed on a care-and-maintenance basis. Since reopening old Quirke in 1968, a small portion of the company's production has been met through these programs, as well as through the recovery of Nordic mine water. The closure of Nordic reflects a possible change in Rio Algom's forward planning for expansion of its Elliot Lake production facilities, in that future expansion will likely be restricted initially to orebodies on the north limb of the Quirke Lake syncline (see map).

Stanrock's underground leaching program was suspended in early 1970, following completion of its sales contract with a United States reactor manufacturer. Recoveries under the program, then in its second phase, had fallen to about 2,000 to 3,000 pounds of U_3O_8 a month. In the autumn, the company took steps to place the operation on a care-and-maintenance basis and to further reduce administrative and operating expenses. Sales of U_3O_8 for the year were valued at $143,641.

Considerable activity was evident in the Elliot Lake area in 1970 in the field of environmental control. Both Denison and Rio Algom constructed new tailings dams to improve the retention of tailings from their respective mills. The dams incorporated anti-pollution design features recommended by the Ontario Water Resources Commission. Stanrock also constructed a new dam and made improvements to its waste disposal area in connection with its program to shutdown its operation. Of particular interest were programs undertaken by both Denison and Rio Algom to develop effective methods of revegetating abandoned tailings areas.

Eldorado completed the second year of its planned five-year program of reduced production with a view to keeping the unit cost of U_3O_8 within forecast price ranges in that period, and to minimizing cash requirements. The 2,000-ton-a-day mill operated at about 50 per cent capacity throughout the year, processing ore from the Fay mine and the nearby Bolger open pit. The latter, which was mined on a contract basis, was mined-out at year-end. A total of 333,906 tons of ore were treated to produce 1,531,893 pounds of U_3O_8; average recovery was 4.59 pounds of U_3O_8 a ton. Although operating costs per ton milled increased by some 11 per cent over 1969, the cost per pound of U_3O_8 produced decreased about 17 per cent due to the higher grade of ore milled.

Preparations continued for the sinking of an internal production shaft to develop downward extensions of the Fay orebody. The shaft will be collared at the 24th level (3,475 feet) and sunk, beginning in 1971, to the 34th level and a vertical depth of 5,451 feet. Development work also proceeded at Eldorado's Hab mine, located 7 miles northeast of the Fay complex, with a production target of late 1971. Total ore reserves, including the Hab mine, stood at 3,915,300 tons averaging 0.24 per cent U_3O_8 at

*Lime is one of the principal reagents used in the uranium milling process. See 1970 Mineral Review No. 25, by D.H. Stonehouse.

**See 1970 Mineral Review No. 37, Rare Earths, by D. Pearson.

TABLE 2

Uranium Production by Major Producing Countries, 1960-1970
(short tons U_3O_8)

Year	Canada	United States	South Africa	Other[1]	Australia	France[2]	Total[3]
1960	12,748 $269,938,192	17,760	6,409	1,450[d]	1,300	1,379	41,046
1961	9,641 $195,691,624	17,399	5,468	223	1,400	2,141	36,272
1962	8,430 $158,183,669	17,010	5,024	80	1,300	2,603	34,447
1963	8,352 $136,909,119	14,218	4,532	86[e]	1,200	2,692	31,080
1964	7,285 $ 83,509,429	11,847	4,445	144	370	2,113	26,204
1965	4,443 $ 62,361,377	10,442	2,942	179	370	2,210	20,586
1966	3,932 $ 54,334,787	9,587	3,286	162	330	2,223	19,520
1967	3,738 $ 53,021,936	9,125	3,214[r]	273	330	2,272[r]	18,952
1968	3,701 $ 52,284,580	12,338	3,883[r]	295	330	2,235[r]	22,782
1969	3,854[r] $ 53,150,657[r]	11,873[r]	3,979[r]	295	330	2,300[r]	22,631
1970[p]	4,010 $ 50,237,000	12,800	4,000	320	330	2,250	23,710

Sources: U.S. Bureau of Mines (USBM) Minerals Yearbooks and 1969 Preprint; USBM Commodity Data Summaries, January 1971; for Canada, Dominion Bureau of Statistics, producers' shipments; for South Africa, Chamber of Mines Eightieth Annual Report, 1969.

[1]Includes Argentina, Congo (1960 only), Finland (1960 and 1961 only), Portugal, Spain and Sweden; [2]Includes Gabon, and Malagasy Republic (until 1967); [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 years 1964 and earlier, in tables of this series in previous reviews.

[p]Preliminary; [r]Revised; [d]Estimate for Portugal, 1,200 tons for Congo; [e]Estimate for Spain.

year-end for a net increase during the year of 5.5 per cent; they stood at the highest in the mine's history.

Of particular importance to Eldorado's operation was the conversion of the mill's pachuca circuit from an air to a mechanical agitation system, with oxygen injection. The new system, together with leaching at higher temperatures, has considerably improved recoveries, which had fallen due to the increasing proportion of ore encountered at depth in the Fay orebody, which had proved more difficult to leach.

In August 1970, Gulf Minerals Company announced that it would proceed with the development of its Rabbit Lake uranium deposit, in northern Saskatchewan, in partnership with a West German company, Uranerzbergbau GmbH & Co. KG (Uranerz-Bonn). The latter company, which is connected to a large electric utility group in West Germany, has guaranteed a market for 4 million pounds of U_3O_8 a year, sufficient to provide a base-load for a 2,000-ton-a-day mill; Uranerz-Bonn will acquire a 49 per cent interest in the operation. In late 1970, a new company, Gulf Minerals Canada Limited, was formed, which will operate the project. Detailed engineering studies were under way at year-end and work on the $50 million project was scheduled to begin in 1971, with a tentative production date set for 1974; the operation will employ some 450 men when completed. The Saskatchewan government has indicated that it will build a $17 million all-weather road to the site, and that it is also considering plans for a townsite at nearby Wollaston Lake.

The deposit was discovered by Gulf in late 1968 and by mid-1970 some 130,000 feet of drilling had been completed. Grades ranging up to 0.65 per cent

U_3O_8 a ton have been reported, although the announced yearly production rates suggest an average grade in the order of 0.3 per cent U_3O_8; reserve information has not been released by the company. The deposit is of the pitchblende replacement-type and occurs in highly altered metasediments; it is an open-pit proposition requiring the drainage of Rabbit Lake, which overlies the deposit.

Development work continued throughout 1970 at Agnew Lake Mines Limited's property, 30 miles west of Sudbury, Ontario. Crosscutting and drifting was carried out on six levels, the deepest being the 3,100 foot level. In addition, several underground installations and some 20,000 feet of underground diamond drilling were completed. At year-end estimated undiluted reserves to a depth of 3,500 feet were reported at 2.5 million tons grading 2.10 pounds U_3O_8 a ton over a 6.3 foot width in Zone 3* and 4.3 million tons grading 1.53 pounds U_3O_8 a ton over a 9.0 foot width in Zone 5*; an additional 1.4 million tons grading 2.27 pounds U_3O_8 a ton over a 6.0 foot width were reported in Zone 3 on adjoining Kerr Addison Mines Limited claims. Late in 1970, however, the company announced that operations would be suspended pending negotiation of a sales contract; some 60 people will be affected. Production was originally scheduled for 1971 or 1972, however construction of the planned $15 to $20 million, 3,000-ton-a-day mill had not begun; to year-end a total of $15.4 million had been spent on buildings, equipment, exploration and development. Kerr Addison, which controls 80 per cent of the project, will likely concentrate its uranium efforts on the development of its uranium orebodies in the Grant's area of New Mexico.

Consolidated Canadian Faraday Limited's property, near Bancroft, Ontario, remained on a care-and-maintenance basis throughout 1970. Of significance, however, was the announcement that Federal Resources Corporation Limited of Salt Lake City, Utah, had exercised its option, prior to July 1, 1970, to gain 51 per cent interest in the property by financing its return to production. Production capacity and timing are contingent on negotiating a sales contract.

GOVERNMENT AFFAIRS

On March 2, 1970 Prime Minister Trudeau announced in the House of Commons that the government proposed to limit, by regulation, the extent of ownership of uranium producing enterprises in Canada by non-residents of Canada. Details of this proposal were outlined by the Minister of Energy, Mines and Resources on March 19 and May 5, 1970. Briefly, it was proposed that the extent of foreign ownership of established uranium producers be limited in the aggregate to 33 per cent and, for any single investor, to 10 per cent. Certain exceptions to the basic rule were also proposed, namely; that a single foreign investor which carried a property through the exploration and development phase be allowed to hold the full permissible 33 per cent of ownership; that, with regard to existing producers, present foreign owners will be allowed to retain their existing holdings; and that, foreign investors, holding proprietory rights to specific mineral lands prior to March 2, 1970, could be classed as existing producers provided that they develop a commercially viable uranium deposit or deposits on these lands within six years. Under all these exceptions, any transfer of ownership subsequent to March 2, 1970 would necessarily be to Canadian residents, until the basic ownership limits of 33 and 10 per cent respectively are reached.

On September 18, 1970 the Minister announced that implementation of the ownership policy would be carried out through new legislation rather than through regulations under the established Atomic Energy Control Act. In addition, he announced that it had been determined that British Newfoundland Exploration Limited, Consolidated Canadian Faraday Limited, Gulf Minerals Company, and Kerr-McGee Corporation had binding legal agreements relative to transfers of interest which predated March 2, 1970, and that consummation of these agreements would be permitted prior to December 31, 1970. Preparation of the legislation to implement the new ownership policy was still under way at year-end.

As a result of the government's announcement on ownership in the industry, negotiations which were under way early in 1970 between Roman Corporation Limited and Hudson's Bay Oil and Gas Company Limited, as to the possibility of HBOG acquiring a substantial interest in Denison Mines Limited, were suspended. HBOG is controlled 65.8 per cent by Continental Oil Company of the United States.

The federal government's five-year uranium stockpiling program came to an end on June 30, 1970. This was the second such program designed to assist the industry, the first being for a one-year period in 1963-64. Under these two programs the government accumulated some 9,600 tons of U_3O_8 at a total cost of some $101 million including care and maintenance. Of this total Denison received about $80 million, Rio Algom $14 million, Eldorado $3 million, Consolidated Canadian Faraday $1.6 million and Stanrock $500,000.

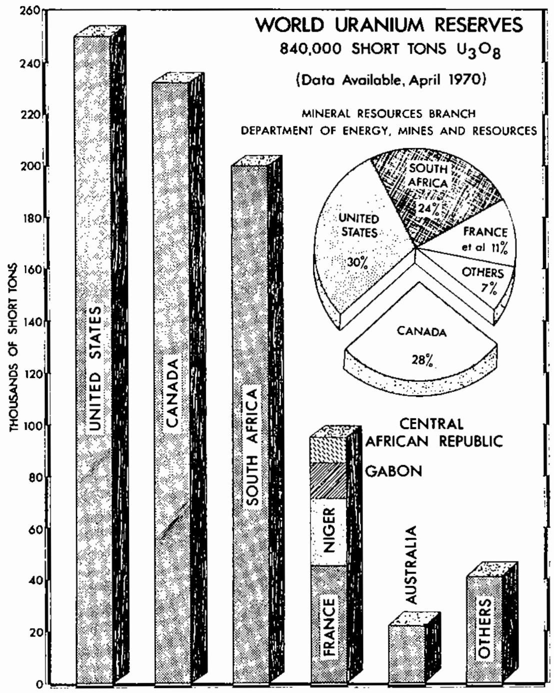
In view of the continuing poor short-term marketing situation, the government announced, on July 24, 1970, that it was prepared to consider a further program of assistance for the uranium industry, if it could be demonstrated that such a program was essential to the continuation of mining operations in established uranium communities. The

*Four steeply dipping parallel zones of arkose are known, only two of which contain economic thicknesses and values of uraniferous conglomerate.

nature of the assistance was to be determined after an investigation of the circumstances of any applicant producer.

On December 23, 1970 it was announced that the federal government and Denison Mines Limited would enter into an agreement which will involve a government expenditure of $29.5 million over the next four years, and will assure Denison a production level of 4 million pounds of U_3O_8 a year over the period. The agreement will provide for the stockpiling of 6,467,000 pounds of U_3O_8 from Denison's production during 1971 to 1974 with related expenditures of $6 a pound U_3O_8, to be provided 75 per cent by the government and 25 per cent by Denison. Denison will be responsible for sales from the joint stockpile; after recovery of costs, sales revenue will be shared equally.

On the international scene, the Non-Proliferation Treaty (NPT) entered into force on March 5, 1970, following ratification by the required number of countries. By year-end the NPT had been ratified by some 60 countries, of which Canada was one of the earliest. The NPT is intended to prevent the transfer of nuclear weapons into the national control of any non-nuclear-weapon state and to prevent any non-nuclear-weapon state from itself acquiring ownership or control of nuclear weapons through manufacture. Canada's ratification of the NPT reaffirms its policy that Canadian uranium be used only for peaceful purposes.



SOURCE: ENEA/IAEA, SEPTEMBER 1970; WORLD EXCLUDES U.S.S.R., EASTERN EUROPE & CHINA; RESERVES DEFINED AS REASONABLY ASSURED RESOURCES, AVAILABLE UP TO $10 A POUND U_3O_8

RESERVES AND EXPLORATION

In September 1970, the European Nuclear Energy Agency (ENEA) released a report, prepared jointly with the International Atomic Energy Agency (IAEA), which updated world uranium resources, reflecting the success of exploration programs over the past two to three years. World uranium reserves (see chart) have increased 20 per cent over the period to 840,000 tons of U_3O_8. (The assessment did not include recent Australian discoveries.) Canadian reserves were reported at 232,000 tons of U_3O_8, an increase of 16 per cent over previous figures. The new figure was developed by the Department of Energy, Mines and Resources, in co-operation with the industry, and is the first official revision of Canadian uranium reserves since 1964.* The increase is a reflection of several factors, foremost among which are first, the efforts of the principal producers to prepare for the expected increases in production, and second, the first positive results of the new exploration programs begun in Canada in 1966 and 1967.

There was a significant decline in uranium exploration activity in Canada during 1970. This trend began late in 1969 and was due to a number of factors, foremost of which were the poor short-term market outlook, the increasing cost of exploration, and the intense competition for the exploration dollar relative to the demand for other minerals. The trend accelerated sharply, however, following the government's announcement relative to foreign ownership in the industry. During 1970, the Atomic Energy Control Board (AECB) issued only 17 exploration permits, in contrast to 82 permits in 1969; moreover, some 50 permits were cancelled during the year in contrast to only 15 in 1969.

Perhaps one of the most significant reports from the Elliot Lake area was the results of the drilling program of Canuc Mines Limited on ground immediately south of Denison's property. The company completed two deep drill holes and reported that an estimated 7 million tons of material averaging 2 pounds of U_3O_8 a ton were indicated in two quartz-pebble conglomerate reefs. Existing mine workings of Denison and Spanish American lie within 4,000 feet of the discovery. Some activity continued to be evident west of the Quirke Lake syncline but little of significance was reported.

In eastern Canada, one of the more substantial programs continued to be that of British Newfoundland Exploration Limited (Brinex) in the Makkovik-Kaipokok area of Labrador. The Brinex program is

*ENEA/IAEA, "Uranium-Resources, Production and Demand", September 1970 – see pages 16 to 20.

being carried out jointly with Urangesellschaft M.B.H. of West Germany. Two new areas of eastern Canada were also of interest, namely, the Burin Peninsula of southeastern Newfoundland and Quebec's Eastern Townships, near Phillipsburg, on the border of Vermont. In the former area Radex Minerals Limited reported the discovery of six very promising uraniferous prospecting areas, one of which had an ore-grade occurrence of pitchblende. The latter is an area where considerable staking followed the discovery of a sedimentary uranium occurrence by Quebec Mining Exploration Company (SOQUEM), the provincial government's exploration company.

In western Canada, while some activity was reported in the Grand Forks area of southern British Columbia, the focus of attention continued to be northern Saskatchewan and the Wollaston Lake-Athabasca sandstone basin area. Gulf Minerals carried out one of the larger exploration programs, investigating 17 mineral permits along a 150 mile length of the northeasterly trending Wollaston Lake structural belt. Numerous other companies were conducting similar programs in the area, searching for another 'Rabbit Lake-type' deposit. Also of interest was activity in the area of the Carswell dome, some 70 miles south of Uranium City, where pitchblende occurrences in basement rocks were being examined by Mokta (Canada) Ltée and others.

Several areas of the Northwest Territories were being investigated with varying success. Fairly extensive programs were being carried out by New Continental Oil Company of Canada Limited in the Christopher Island area, at the east end of Baker Lake, and in the Kazan Falls area, some 40 miles south of Baker Lake. These programs followed uranium discoveries made in 1969. Both Denison and Falconbridge Nickel Mines Limited carried out drilling programs, to investigate uraniferous quartz-pebble conglomerates in the Padlei area, northeast of the Henik Lakes. In addition, a rather extensive drilling program was carried out in the Amer Lake area, some 90 miles north of Baker Lake by Aquitaine Company of Canada Ltd., which was investigating several uranium occurrences in the Hurwitz Group.

Of particular interest is a uranium prospect on the Simpson Islands in the east arm of Great Slave Lake, Northwest Territories, which is being investigated by Vestor Explorations Ltd. The uranium mineralization occurs within the Hornby Channel Formation, a thick sequence of quartzites and conglomerates in the lowest member of the Sosan Group; the conglomerates are reported to be analogous to uraniferous conglomerates in the Elliot Lake area. A drilling program was launched in late 1970, following an extensive geological investigation, which is to continue in 1971.

INTERNATIONAL DEVELOPMENTS

Perhaps the most significant uranium exploratory activity anywhere in 1970 was that in Australia's Northern Territory, where a sizable discovery was announced at mid-year by Queensland Mines Ltd. The strike, made at Nabarlek, some 170 miles east of Darwin, was reported to contain 55,000 tons of U_3O_8 in ore averaging 540 pounds of U_3O_8 a ton. The deposit consists of lenticular pitchblende lodes occurring in Archaean metamorphic rocks. Later in the year, Peko-Wallsend Ltd. announced that it too had a major discovery in the same general area, which contained an estimated 70,000 tons of U_3O_8 in ore with average grades in the order of 6 to 10 pounds of U_3O_8 a ton. Numerous other companies were working in the same area, which could prove to be one of the world's major producing districts.

Several Canadian companies were actively exploring for uranium in other countries, primarily the United States. As noted last year, Rio Algom has been successful and is proceeding with production plans at its property in the Lisbon Valley area of Utah. Kerr Addison has also been successful in the Grant's area of New Mexico, in outlining significant reserves of uranium in sandstone deposits. The company has a 26 per cent interest in the 'Fernandez Joint Venture' and Noranda Mines Limited a 25 per cent interest. Kerr Addison was also active at year-end in the Northern Territory of Australia.

REFINING

Eldorado Nuclear Limited continued to be Canada's only producer of refined uranium products with its refinery at Port Hope, Ontario. In past years, the refinery's principal product has been nuclear pure uranium trioxide (UO_3). More recently, the production of natural ceramic uranium dioxide (UO_2) powder has become important and in 1970, in response to the growing demand for this material in the manufacture of nuclear fuel for CANDU reactors, the capacity of the circuit was further enlarged. Significant quantities of other products have also been produced for the nuclear industry* including uranium metal, some high density oxide and alloy fuels such as uranium carbide (UC) and uranium silicide (U_3Si), and a variety of depleted and enriched uranium products.

Construction of Eldorado's uranium hexafluoride (UF_6) plant, which had begun in late 1968 at its Port Hope facilities, was completed in April 1970, and the first shipment of UF_6 left the plant on October 22. Production targets were revised upwards late in the year as customers rushed to have conversion services

*Beginning in 1970, Eldorado is also able to produce zirconium metal and alloys at its Port Hope refinery; see 1970 Mineral Review No. 54, Zirconium, by G.P. Wigle.

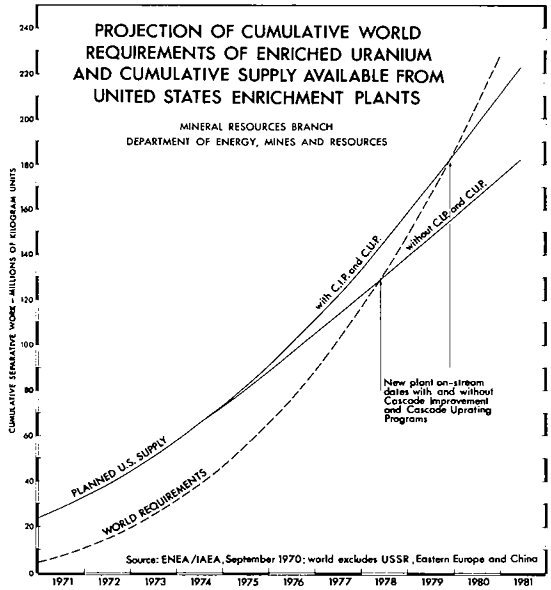
performed prior to the scheduled increase in price for uranium enrichment at USAEC enrichment plants. All targets were successfully met and plans were set for doubling the capacity by mid-1972. The plant was designed to convert 2,500 tons of U_3O_8 (2,150 tons of U) to UF_6 a year, with provision for expansion as markets permitted. To the end of 1970, some $10.2 million had been spent on construction of the plant. With the growing demand for UF_6 as feed for uranium enrichment processes, it is expected that UF_6 will become the refinery's principal product in the 1970's.

URANIUM ENRICHMENT

The European Nuclear Energy Agency has estimated (September 1970) that by 1980 over 90 per cent of the nuclear power plants installed in the world will use enriched uranium fuel.† The majority of these will be fuelled with uranium enriched from its natural state (0.711 per cent of the fissionable isotope ^{235}U) to between 2 and 4 per cent ^{235}U. (A few will use highly enriched uranium.) Although there are at least five known methods of uranium enrichment, only one, *the gaseous diffusion process,* has been fully developed and is currently serving the nuclear fuel market. The cost of the uranium enrichment service represents about one third of the total cost of the fuel core for these reactors, and will amount to an estimated total of $7,000 million over the decade.

Development of the gaseous diffusion process began in Britain as early as 1940, and in the United States in 1942 in connection with the Manhattan Project of World War II. As a result of this work the United States constructed three gaseous diffusion plants at a cost of $2.3 billion at Oak Ridge, Tennessee, Paducah, Kentucky, and Portsmouth, Ohio; the first unit at each plant went into service in 1945, 1953 and 1955 respectively. Parallel engineering development work began in Britain in the late 1940's and a relatively small scale plant was later constructed at Capenhurst for military purposes. In response to the growing commercial market, a £15.5 million modification of the Capenhurst plant was completed in 1970 and further modifications and expansion have been planned but not yet implemented. France also has constructed a small gaseous diffusion plant at Pierrelatte, primarily for military purposes, which became fully operational in 1967.

The gaseous diffusion method of isotopic separation is based on the fact that gas atoms or molecules with different masses will diffuse through a porous barrier or membrane at different rates. In the case of the diffusion method uranium hexafluoride (UF_6) gas is used. The degree of separation which can be accomplished in a single 'stage' is a function of the square root of the ratio of the masses of the com-



ponent molecules ($U^{235}F_6$ and $U^{238}F_6$ in this case). Consequently, it follows that literally hundreds of stages of equipment connected in series are required, consisting primarily of diffusion chambers (convertors), compressors to circulate the gas, and gas coolers to remove the heat of compression.

To illustrate the magnitude of the operations, the USAEC's Oak Ridge facility consists of five interconnected process buildings, covering 105 acres and containing approximately 5,000 diffusion stages. Operating at full capacity to produce predominately low-assay material, such as that required for light water reactors, the plant requires 1,700 MWe of electrical power and 400 million gallons a day of recirculating cooling water. The plant cost $815 million to build excluding the cost of the electrical power supply. In the late 1950's all three of the USAEC's plants operated at full capacity and were utilizing 52,000 million kilowatt hours a year of electrical energy, equal to about 10 per cent of the total electric energy being used in the United States at that time.

A second method of uranium enrichment, *the gas centrifuge process,* has recently entered the limelight. British and United States studies date back to 1940 and 1942 respectively, although the process was later abandoned when it became clear that the machines being developed could not compete with the diffusion process. Work resumed in the late 1950's however, and a new centrifuge design was developed by the German physicist, Dr. G. Zippe. Fresh programs were launched in Britain, the Netherlands, and West Germany and

†Reactors of the Canadian CANDU and the British Magnox design use natural uranium fuel.

continued throughout the 1960's with considerable success.

In March 1970 the three countries signed a trilateral agreement to proceed with the joint development of industrial scale centrifuge separation. Under the agreement, two separate industrial organizations will be set up, each owned in equal parts by British, German and Dutch companies respectively. The 'Enrichment Organization' (EO) will be headquartered in London and will own and operate the enrichment facilities and market the enrichment services. The 'Prime Contractor' will be headquartered in West Germany and will, under contract from the EO, develop and manufacture centrifuges and ancillary equipment. Demonstration plants are currently under construction at Capenhurst and Almelo, Netherlands. The latter is scheduled for full capacity operation at the end of 1971.

The gas centrifuge process is attractive for a number of reasons. Power requirements are less and, therefore, the cost of separative work is less sensitive to the cost of electricity. Moreover, it is expected that centrifuge enrichment plants will not need to be as large as diffusion plants have been, thus plant growth can be more easily tailored to meet enrichment demand. It is difficult, if not impossible, to assess the the relative economics of the two processes, however, the economies of scale associated with gaseous diffusion plants may also prevail for the centrifuge process. In short, a great deal of development work has yet to be done on the process to achieve the current level of technology provided by 25 years of operating experience in the United States gaseous diffusion plants. Enrichment research is also being carried out in Italy, Japan and South Africa but the level of technology appears to be at a much lower level than the work of the trilateral group. In addition to its activity in the tripartite project, West Germany is also working on a project aimed at developing the *jet-nozzle* process for enriching uranium.

The ENEA has estimated that annual world requirements for enriched uranium will rise from 4 million kilogram units of separative work (SWU)* in 1970 to 42 million SWU's in 1980, and that cumulative world requirements will reach 226 million SWU's by 1980. Britain's existing Capenhurst plant, with an annual capacity of about 400,000 SWU's will be sufficient to satisfy British needs into the early 1970's. However, requirements will exceed an estimated 1 million SWU's a year by 1975 and 3 million SWU's by 1980, and it is expected that additional British capacity may be provided either through expansion of the existing plant or through building a new gas centrifuge plant under the tripartite agreement. Total capacity of demonstration plants being built by the tripartite partners is 350,000 SWU's a year, one third of which is expected to be in operation by 1972. France's Pierrelatte plant, with an estimated capacity of 200,000 to 300,000 SWU's a year, is largely devoted to military requirements and is likely economically unsuited for low enrichment fuel production. Pilot installations were under construction in 1970 in connection with French plans, for a possible 6 million SWU a year, multi-national, $600 million gaseous diffusion plant based on French technology envisaged for construction beginning in 1973.

Present capacity of the three United States plants totals 17.1 million SWU's a year based on a total power level of 6,000 MWe. A $500 million 'Cascade Improvement Program' (CIP) has been proposed which would increase capacity to an estimated 21.7 million SWU's a year. A further $130 million 'Cascade Uprating Program' (CUP) has been proposed which would permit the plants to operate at a total power level of 7,400 MWe and thereby increase capacity to 25.9 million SWU's a year.

Enrichment of uranium on a toll basis in United States enrichment plants began in January 1969. In addition, in April 1969, a program of *in situ* toll enriching was begun whereby parties which had leased enriched uranium from the USAEC could convert it to private ownership by delivering an equivalent amount of normal UF_6 to the USAEC and paying for the equivalent amount of toll enrichment; all previously leased enriched uranium must be converted to private ownership through this program by June 30, 1973 and on December 31, 1970 the practice of leasing enriched uranium was suspended. The USAEC offers its toll enrichment services to domestic and foreign customers alike, except that services to foreign customers are limited to that required to provide the customer with a moving five-year inventory. The USAEC's charge for toll enriching was initially $26 a SWU, but was to be increased to $28.70 a SWU on February 22, 1971. Due primarily to the rising cost of electrical power, a further increase in price, to $32 a SWU, was proposed at year-end, to become effective in late 1971. By the end of 1970 the USAEC had completed deliveries of enriched uranium under 9 contracts, and had yet to complete 20 domestic and 23 foreign contracts to provide approximately 81 million SWU's.

SALES

Only three uranium sales of significance were made by Canadian companies in 1970. First, was the confirmation, in January, of Denison's extended contract with The Tokyo Electric Power Co., Inc. for

*The capacity and production rate of uranium enrichment plants is expressed in terms of separative work units (SWU). An SWU is a measure of effort expended in the plant to separate a quantity of uranium of a given assay into two components, one having a higher percentage of ^{235}U and one having a lower percentage. Separative work is generally expressed in kilogram units and it is common practice to refer to a kilogram unit of separative work simply as a separative work unit (SWU.)

TABLE 3

Exports of Uranium Concentrates from Canada, 1960-70
(thousands of dollars)

Year	United States	Britain	West Germany	Japan	Switzer-land	India	Others	Total
1960	236,594	25,905	294	147	1	570	30[a]	263,541
1961	173,914	18,256	513	40	–	–	–	192,723
1962	149,165	16,598	206	40	–	–	–	166,009
1963	96,879	40,509	–	130	–	–	13[b]	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[p]	17,031[c]	8,990	–	–	–	–	–	26,021

Source: Dominion Bureau of Statistics, exports of radioactive ores and concentrates that cleared customs.

[a]Includes Sweden ($27,720); [b]Brazil; [c]almost entirely destined for a third country, following enrichment – primarily West Germany, and Japan.
[p]Preliminary; – Nil.

an additional 16,750 tons of U_3O_8 for delivery over a 10-year period, beginning in 1974. Later, in March, Rio Algom announced the sale of 477.5 tons of U_3O_8 to be delivered in 1972 to Kernkraftwerk Brunsbüttel GmbH, a West German utility. The sale was made through RTZ Mineral Services Limited of London. Finally, there was Gulf's agreement with Uranerz-Bonn, mentioned earlier, for 2,000 tons of U_3O_8 a year, beginning tentatively in 1974, for an unspecified period.

Consequently, as of March 1970, Canadian producers had committed almost 55,000 tons of U_3O_8 under contracts negotiated since 1966. About 86 per cent of this total was for export markets, primarily in Japan, Britain and West Germany; at the end of 1970, some 4,300 tons of U_3O_8 had been delivered under these contracts. Gulf's announcement, later in the year, increased this total commitment significantly, although at the time of writing, a total quantity had not been defined under the agreement.

Several foreign sales of uranium were announced in 1970, the following of which were of particular interest. First, in July, it was announced that the United Kingdom Atomic Energy Authority (UKAEA) had signed two contracts with Rio Tinto Finance and Exploration Limited (Riofinex) for the delivery of 7,500 tons of U_3O_8, valued at £40 million, beginning in 1976; Riofinex will supply the uranium from its Rossing deposit in South West Africa. Second, in September, Australia's Mary Kathleen Uranium Limited announced two contracts totalling 2,700 tons of U_3O_8, valued at $35 million (Australian). RTZ Mineral Services will purchase 575 tons destined for West Germany's Kerkraftwerk Brunsbüttel and Commonwealth Edison, a United States utility, will purchase 2,125 tons at the rate of 500 tons a year beginning in 1974; this sale is contingent on the USAEC lifting its uranium import restrictions. Mary Kathleen has been inactive since 1963, and now plans to reactivate its 1,200-ton-a-day mill on the basis of these contracts. The company is controlled by Conzinc Rio Tinto Australia Ltd. (51 per cent) and Kathleen Investments Australia Ltd. (35 per cent). It is interesting to note that the latter company owns 50 per cent of Queensland Mines Ltd. Third, at year-end, it was reported that Kansai Electric Power Co. of Japan had completed negotiations with Nuclear Fuels Corporation of South Africa (Pty.) Ltd. (NUFCOR) for the purchase of 2,800 tons of U_3O_8, valued at 20,000 million yen, over a ten-year period beginning in 1974. Finally, Rio Algom announced that it would supply 250 tons of U_3O_8 in 1973 for the first core of Sweden's Sydsvenska Kraftaktiebolaget plant at Barsebeck, from its mine near Moab, Utah.*

Japan, and to a lesser degree, Britain, West Germany, Sweden, Italy and Spain continue to be

* Development work, which began in March 1969, continued in 1970; mill construction began in September for scheduled production in early 1972. Planned output is 600 tons of U_3O_8 a year, most of which has been committed to 1980.

TABLE 4

Major Canadian Uranium Sales, Announced Since 1966 (As of December 1970)

Producer	Customer	Country	Total Quantity (short tons U_3O_8)	Delivery Period
Denison	Tokyo Electric et al.	Japan	10,500	1969 to 1978
	Urangesellschaft M.B.H.	West Germany	400	1968
	Tokyo Electric Power Co.	Japan	16,750	1974 to 1983
Eldorado	Tokyo Electric Power Co.	Japan	500	1971 to 1975
	Kernkraftwerk Obrigheim	West Germany	1,000	1969 to 1980
	Ontario Hydro	Canada	1,300	1968 to 1977
	Kerkraftwerk Lingen	West Germany	212	1969 to 1973
	Oskarshamnsverkets Kraftgrupp	Sweden	150	1971 to 1973
	Chugoku Electric	Japan	119	1971
Gulf Minerals	Uranerz-Bonn	West Germany	2,000/yr	unspecified
Rio Algom	UKAEA	Britain	1,100[a]	1971
	UKAEA	Britain	11,500[b]	1973 to 1980
	Ontario Hydro	Canada	6,300	1970 to 1983
	Tokyo Electric et al.	Japan	5,000	1969 to 1978
	Canadian Westinghouse	Canada	93	1969 to 1970
	Kyushu Electric Power Co.	Japan	200	1972
	Mitsubishi Atomic Power	Japan	28	1969
	Kernkraftwerk Brunsbüttel	West Germany	478	1972
	Canadian Westinghouse	Canada	14	1971
Stanrock	Unnamed reactor manufacturer	United States	total prod.	1967 to 1970

[a]Remaining under old master contract (1962 UKAEA option); [b]Includes delivery options.

good potential markets for Canadian uranium. The United States market continues to be restricted to United States producers, although United States producers are free to compete in the world market. French and South African production is marketed through semi-governmental marketing agencies and United States producers have access to financial export assistance through Export-Import Bank loans. The unavailability of the United States market and the various government, producer and consumer stockpiles which overhang the market, continue to be principal obstacles to Canadian marketing efforts in the short-term.

By year-end Eldorado had negotiated several contracts for conversion of uranium concentrates to UF_6, which more than filled half the rated capacity of its refinery operation for 1971; as noted earlier, expansion of the facility is scheduled for completion by mid-1972. All five of Eldorado's own major export sales of U_3O_8 will be converted to UF_6 and, in addition, three significant contracts had been negotiated for conversion on a custom basis. A total of 680 tons of U_3O_8 will be converted for the Swedish State Power Board (Vattenfall), as well as 430 tons of U_3O_8 for the first core of Sweden's Barsebeck plant, and about the same amount for a reload. Finally, General Public Utilities Corp. of New York, has contracted for conversion of 1,205 tons of U_3O_8 over the period 1970 to 1973; options under the contract provide for the total to be increased to 2,000 tons and possibly 2,250 tons. Sales of ceramic grade UO_2, both natural and enriched, from Eldorado's refinery reached an all time high in 1970. Contracts were also signed for supply of enriched uranium carbide for Atomic Energy of Canada Limited's WR-1 research reactor at Whiteshell, Manitoba, and for the supply, in 1971, of uranium metal for the Taiwan research reactor.

Competition in the UF_6 conversion business is also fairly strong with four plants, in addition to Eldorado's, vying for markets. These include Allied Chemical Corporation's plant at Metropolis, Illinois, which was expanded in 1970 to a capacity of 10,000 tons of U (in the form of UF_6) a year, and Kerr-McGee Corporation's plant at Sequoyah, Oklahoma, which came on stream in the second half of 1970, with a conversion capacity of 5,000 tons of U a year; capacity of the latter plant will be doubled as markets permit. In addition, the UKAEA has a new plant at Springfields with a 3,300-ton-a-year capacity, and the Commissariat a l'Energie Atomique (CEA) of France has a plant at Pierrelatte, which was expanded in 1969 to a reported capacity of 3,800 tons of U a year. To date the British plant, with a capacity estimated at some four times Britain's requirements in the near-term, is one of Eldorado's strongest competitors.

NUCLEAR DEVELOPMENTS

At the end of 1970 there were seven nuclear power stations (14 reactors) of Canadian design (natural uranium-fuelled and heavy water-moderated) either in operation, or under construction, representing a total capacity of 6,043 MWe (Table 5). Ontario Hydro's Douglas Point Station, Canada's first full-scale plant, was operated successfully on a regular basis at high power throughout the year; first *on-power* refuelling was attempted in December 1969 and the fuelling machines were in regular service by the end of March 1970. Perhaps the highlight of the year was the start-up, on November 13, 1970, of Hydro Quebec's Gentilly Station on the south shore of the St. Lawrence River, thus meeting the tight, four and a half year, construction schedule. First power was expected in early 1971. The year 1971 will be particularly important for Canada's nuclear program with the expected start-up of two units at Pickering*, Ontario as well as RAPP I and KANUPP in India and Pakistan.

Commercial production of reactor-grade heavy water began at Canadian General Electric Company Limited's (CGE) $75-million plant at Point Tupper, Nova Scotia, in October 1970. The 400-ton-a-year plant is scheduled to reach full capacity in 1971; CGE has a contract with Atomic Energy of Canada Limited (AECL) covering the first 12 years of production. Meanwhile, construction continued on AECL's heavy water production plant at the Bruce Nuclear power complex, adjacent to Douglas Point. The 800-ton-a-year, $115 million heavy water plant is scheduled for completion in 1972. Efforts were continuing at year-end to arrange for the rehabilitation of Deuterium of Canada Limited's 400-ton-a-year plant at Glace Bay, Nova Scotia, now three years behind schedule.

AECL continued its efforts during the year to sell Canadian nuclear power plants abroad on behalf of Canada's nuclear industry. Disappointment was felt in mid-1970 when Rumania postponed indefinitely its negotiations for a 600 MWe CANDU-type nuclear steam supply system. Heartening, however, was news that AECL was on the 'short-tender' list for a 500 MWe unit for Australia; the bids were still being considered at year-end. A bid was also pending at year-end for a 600 MWe unit for Mexico, and interest was being shown by a number of other countries in the Canadian system as a choice for their nuclear power programs.

In June 1970 the House of Commons passed a bill which provides that nuclear power plants, fuel processing plants and other installations of a non-military nature handling nuclear material maintain liability insurance to a maximum of $75 million.

TABLE 5

Canadian Natural Uranium Heavy Water Power Reactors
in Operation or Under Construction

Name	Type	Capacity	Location	Status
NPD	BHW	22 MWe	Rolphton, Ontario	Operating since 1962
Douglas Point	PHW	208 MWe	Kincardine, Ontario	Operating since 1967
Pickering	PHW	4x508 MWe	Pickering, Ontario	First unit critical, 1971
Gentilly	BLW	250 MWe	Gentilly, Quebec	Critical November 1970
Bruce	PHW	4x750 MWe	Kincardine, Ontario	Under construction
RAPP	PHW	2x203 MWe	Rajasthan, India	First unit critical, 1971
KANUPP	PHW	125 MWe	Karachi, Pakistan	Critical, 1971
	Total	6,043 MWe		

*Pickering I went critical on February 25, 1971.

TABLE 6

Nuclear Power Reactors in the World as of January 1, 1971
(electrical megawatts)

Country	Operating	Ordered	Planned	Total
Canada	475	5,000	–	5,475
United States	3,404	73,573	10,872	87,849
Britain	4,145	10,290	3,700	18,135
France	2,176	1,640	–	3,816
West Germany	984	3,452	2,650	7,086
Soviet Union	2,088	880	–	2,968
Japan	817	9,469	3,050	13,336
Switzerland	350	1,476	1,050	2,876
Italy	607	735	866	2,208
Spain	153	1,460	3,600	5,213
Sweden	504	2,329	5,280	8,113
India	380	400	400	1,180
Others	118[a]	5,166[b]	9,302[c]	14,586
Total	16,201	115,870	40,770	172,841

Source: Canadian Nuclear Association, January 1, 1971.
[a]East Germany, Netherlands; [b]Czechoslovakia, Pakistan, Bulgaria, Argentina, Hungary, Belgium, Netherlands, Finland; [c]UAR, Austria, Mexico, Argentina, Australia, Taiwan, Korea, Rumania, Greece, Brazil, Yugoslavia, Czechoslovakia, Finland.
– Nil.

OUTLOOK

Forecasts of uranium requirements have changed little in the past year. In September 1970, the ENEA/IAEA released a revised forecast which predicts that annual world demand will increase to 37,000 tons of U_3O_8 by 1975, 73,000 tons in 1980 and possibly 130,000 tons in 1985 (Table 7). However, most uranium requirements for nuclear plants either in operation or committed for operation during the next three years have been met, and consequently opportunities for sales during this period are few. Uranium demand continues to be affected by a variety of construction, equipment and licencing delays involving nuclear reactors already committed. These problems are particularly evident in the United States where environmentalists, worried about the twin threats of thermal pollution and radiation emissions, have been causing delays through interventions in licencing proceedings. Hopefully, co-operative efforts on the part of both government and industry toward solving their differences will be successful, and the longer-term electrical requirements will be met.

An upturn in orders for nuclear power plants was evident in 1970, particularly in the United States where the USAEC reported that during the year 14 plants totalling 14,336 electrical megawatts (MWe) were ordered, about twice that ordered in all of 1969. This brought the total to 86,894 MWe (109 units) representing an investment of almost $18,000 million. It was estimated by the Federal Power Commission

TABLE 7

Estimated World Uranium Demand

Year	Annual Demand	Cumulative Demand
	(short tons U_3O_8)	
1970	12,000	12,000
1971	15,000	27,000
1972	21,000	48,000
1973	26,000	74,000
1974	30,000	104,000
1975	37,000	141,000
1976	44,000	185,000
1977	50,000	235,000
1978	57,000	292,000
1979	65,000	357,000
1980	73,000	430,000
1985[a]	130,000	960,000

Source: ENEA/IAEA, September 1970.
[a]Reliability significantly less than for earlier years since no allowance made for plutonium recycling.

that by 1990 almost 40 per cent of all electrical generating capacity in the United States will be nuclear. This turn around in nuclear orders is partly attributed to shortages of oil, gas and low-sulphur coal in 1970 which prompted utilities to choose the nuclear rather than conventional thermal route for their much needed additional electrical generating capacity. While the coal shortage was less critical at year-end in the United States, it continued to be severe in Britain and continental Europe.

Another factor which may significantly affect the demand picture is the possibility of an increased market for natural uranium as a result of a re-evaluation and reoptimization of USAEC gaseous diffusion plant operations. As rising power costs tend to drive the costs of separative work upward, the optimum tails assay (^{235}U content) shifts upward, thus increasing the amount of feed that is required to produce the same quantity of enriched uranium. The possibility of setting a higher tails assay was under study by the USAEC in 1970, and was seen as one method of easing the impact of the disposal of its uranium stockpile and of beginning the process of removal of restrictions on the enrichment of foreign ores for domestic use. For example, a change in the tails assay from the present 0.20 per cent ^{235}U to 0.25 per cent would increase requirements of natural uranium feed by about 9 per cent.

In the short-term, uranium continues to be in oversupply, due partly to the delays in nuclear programs mentioned earlier and partly to increases in production capability over the past two or three years. The ENEA/IAEA reported in its recent report that some 38,000 tons of annual U_3O_8 production capacity was planned for 1973, in contrast to a 1969 production level of 23,000 tons. Moreover, some 13,000 tons of additional annual capacity could be made available, based on known reserves. In view of the ENEA's projections, some of this additional capacity will be required after about 1975. Further, after about 1977 new capacity will have to be based on low-cost reserves yet to be developed, unless higher-cost reserves are to be utilized.

Several events occurred in the last half of 1970 which tend to outdate somewhat the ENEA's projections of supply. In particular, some of the planned capacity which was to be available by 1973 has been postponed, and new discoveries, particularly in Australia, will soon contribute to an increase in reserves. Of more significance to the short-term situation, however, is the uranium surplus, available in various government stockpiles, and in consumer and producer inventories, which overhangs the market. In this regard, some 68,600 tons of U_3O_8 are held by the United States, Canadian and South African governments alone. Although disposal of these stockpiles will, hopefully, be in a way which will not severely affect the normal growth of the market, their existence has been a major factor contributing to the oversupply situation. Consequently, some prices being quoted in the world market were well below \$7 a pound U_3O_8, even for deliveries in the mid-1970's. It is expected that prices will recover, however, and increase over the latter part of the decade, as demand comes more in line with available supply.

Despite the short-term situation, Canadian producers are looking forward to obtaining additional contracts, for deliveries beginning in the mid-1970's, which will enable them to proceed with plans for expansion of their production facilities. As noted earlier, one future producer has been successful in making sales and others are hopeful of doing so. Should markets develop as projected, it is not unrealistic to expect that Canadian uranium production capacity, estimated at about 5,500 tons of U_3O_8 a year in 1970, will increase threefold by the end of the decade. An increase much beyond a level of 13,000 tons a year, however, will require the timely discovery of new low-cost reserves, the geological potential for which is considered excellent.

It is clear that world uranium enrichment capacity will not be sufficient to meet requirements after the end of the decade. Existing British and French facilities are relatively small and fully committed to domestic needs. Should the USAEC's two proposed modification programs be carried out with appropriate timing and provided the USAEC's planned preproduction is carried out on schedule, cumulative world requirements should be satisfied until 1979. This date can be extended to 1980, however, should the recycling of plutonium in light water reactors be introduced. Other factors could advance or delay this timing slightly. However, in view of an estimated lead-time of 6 to 8 years required to build a new enrichment plant, it is clear that a decision must be reached by 1972 or 1973. Canada is one of several countries that has been named as a possible site for such a plant.

Thorium

There was no production of thorium in Canada again in 1970. Until mid-1968, the Nuclear Products Department of Rio Algom Mines Limited had produced thorium concentrates as a byproduct of uranium at its Nordic mill in Elliot Lake, Ontario; the plant had a capacity to produce 150 to 200 tons of thorium oxide (ThO_2)* a year. Production was suspended in July 1968 with the closure of the Nordic mill. Due to poor market conditions for thorium it was decided that a transfer of the thorium recovery circuit from Nordic to Quirke was not justified at that time. However, shipments of thorium concentrate were made in 1969 from the company's inventory; the concentrate was a thorium sulphate ('thorium cake') and graded from 35 to 40 per cent ThO_2.

Since thorium production began at Elliot Lake in March 1959, Rio Algom's principal customer has been Thorium Ltd., in Britain. Small quantities have also been delivered from time to time, in the form of metallurgical-grade thorium oxide (99.8+ per cent ThO_2), to Dominion Magnesium Limited, Haley, Ontario, which produces sintered pellets of pure (98 per cent) thorium and thorium powder (98.8+ per cent).

Canadian resources of thorium are associated with both the conglomeratic ores of the Elliot Lake-Agnew Lake areas and the pegmatitic ores of the Bancroft area. Data compiled in connection with a recent assessment of Canada's uranium reserves, made by the Department of Energy, Mines and Resources, suggests that reasonably assured resources of ThO_2, associated with uranium reserves in the $10 a pound U_3O_8 category, conservatively exceed 100,000 tons of ThO_2. Further details concerning Canada's production of thorium can be found in previous issues of this series.

Present world production of thorium is primarily as a byproduct of the chemical processing of monazite beach sands for their rare earth content. The leading producers of monazite are Australia, Brazil, India, Malaysia and the United States. The principal non-energy uses of thorium continue to be in the manufacture of gas light mantles (50 per cent), of thorium-magnesium alloys (30 per cent), and of dispersion-hardened alloys of nickel, cobalt, tungsten and molybdenum (10 per cent). ** Demand for thorium for industrial uses has changed little in recent years and, although some growth can be expected in the 1970's through new uses, is expected to remain relatively small, perhaps rising to no more than a few hundred tons a year.

The greatest potential use for thorium, however, is as a nuclear fuel for advanced converter and breeder-type reactors. Although thorium (^{232}Th) is not a fissile material like ^{235}U, it is a fertile material and can be converted into fissionable uranium-233 (^{233}U) under irradiation. The use of this '$^{232}Th-^{233}U$ fuel cycle' has many potential advantages and research programs are under way in a number of countries, including Canada, to develop this technology. Of particular interest as potential users of this fuel cycle are the Canadian CANDU reactor and the high-temperature, gas-cooled reactor (HTGR) being developed in the United States. A 40 MWe demonstration HTGR has been in operation at Peach Bottom, Pennsylvania since 1966 and a 330 MWe commercial HTGR is under construction at Fort St. Vrain, Colorado, for start-up in 1972. By way of illustration, the latter reactor will have a fuel core

TABLE 8

Thorium Production in Canada, 1969-70

	1969		1970	
	Pounds	$	Pounds	$
Production (shipments of ThO_2 in concentrates)	29,014	55,087	–	–

Source: Dominion Bureau of Statistics.
– Nil.

* 1 short ton ThO_2 = 795 kilograms of thorium metal.

** Woodmansee, W.C., *Thorium*, Engineering and Mining Journal, March 1971.

made up of 25 tons of ThO_2 and 2,710 pounds of fully enriched uranium.

Despite the advantages of the $^{232}Th-^{233}U$ fuel cycle and the probable ultimate success of the fuel technology, the growing availability of plutonium from conventional reactors will dictate its use either for recycling or, in the 1980's, as fuel (with uranium) for fast breeder reactors. Consequently, while successful penetration of reactors like the HTGR into the nuclear power market can be expected to increase the demand for thorium significantly, requirements will probably rise to no more than a few thousand tons of ThO_2 a year by the latter part of the century.

Vanadium

G. P. WIGLE*

The principal vanadium-producing countries are the United States, Republic of South Africa, South-west Africa, Finland and Norway. The production of these countries in 1970 was an estimated 12,000 tons of vanadium in ores, concentrates and vanadium pentoxide (V_2O_5). Increased production was expected from the Republic of South Africa in 1971.

Vanadium is recovered in Canada, in small amounts from crude oil, in the form of vanadium pentoxide (V_2O_5) by Petrofina Canada Ltd. at its oil refinery near Pointe-aux-Trembles, Quebec. The Petrofina byproduct plant recovers vanadium from fly-ash, collected from the burning of petroleum coke produced and used in the oil refining process.

Prices of vanadium in the United States increased in 1969 from 95 cents a pound of V_2O_5 in January to $1.51 a pound in December. In December 1970 the published price of 98 per cent fused vanadium pentoxide was $1.94 a pound, f.o.b. producer's plant site. Standard 70 to 80 per cent grade ferrovanadium was increased from U.S. $3 to U.S. $4.12 a pound of contained vanadium on July 1, 1970.

Sales of vanadium pentoxide for domestic use from surplus United States government stocks in 1969 were 1,217 tons at prices varying from U.S. $1.26 to $1.65 a pound. Sales from U.S. stockpile in 1970 to mid-year were approximately 1,602 tons of V_2O_5 at prices from $1.55 to $1.64 a pound. The General Services Administration increased the price of V_2O_5 for its monthly offering of 800,000 pounds of contained vanadium in V_2O_5 to $1.94 a pound of V_2O_5 on July 1, 1970. No sales from stockpile were made during the latter half of the year.

OUTLOOK

Increased production of vanadium and assurance of availability of supply have contributed to a high growth rate and diversification in the use of this alloying metal. Due to the growing demand for high strength low-alloy steels, structural steels, and steel for oil and gas transmission pipe lines it is expected that the major part of increased consumption will come from increased use in steel. There are factors of growth, as well, in the projected use of vanadium in fast breeder nuclear reactors, in vanadium-titanium alloys for use at high temperatures, and in catalyst form for use in the chemical and synthetic rubber industries.

Oversupply of vanadium is unlikely because of the time required to enlarge existing production facilities and to place new supply on the market. A period of near-balanced supply and demand should extend through 1972 with prices of $1.50-$2 a pound of vanadium pentoxide. New large producers of by-product vanadium will establish their advantages of scale production and distribution with resultant price stability. An adequate supply base should extend a period of expanding use for vanadium.

PRODUCTION AND CONSUMPTION

CANADA

Petrofina Canada Ltd. started vanadium recovery in 1965. The fractional distillation step in the oil refining process removes the lighter components of the

*Mineral Resources Branch.

crude and leaves a residual fuel that can be used as bunker oil or for asphalt production or the manufacture of petroleum coke. Most of the vanadium occurring in some crude oils is concentrated in the residual fuel product. The part in the coke can be recovered from the fly-ash formed in burning the powdered coke as a fuel component, with oil or gas, used in producing steam for the fractional distillation process. The fly-ash, which may contain 10 per cent or more V_2O_5, is recovered in electrostatic precipitators and then leached in sulphuric acid. The slurry formed is filtered and vanadium pentoxide is separated from the filtrate by oxidation with sodium chlorate and precipitation with ammonia. The V_2O_5 is dried, fused, and cast into flakes containing 99 per cent vanadium pentoxide.

Masterloy Products Limited, near Ottawa, Ontario, completed its first full year of operation at its new, larger ferroalloy plant; its annual production capacity includes 150,000 pounds of ferrovanadium. The company completed in 1970 another new building and installed equipment for the recovery of vanadium in the form of vanadium pentoxide from fly-ash and other waste materials obtained from industrial plants. Production of vanadium pentoxide was expected to start in January 1971.

Canada's imports of ferrovanadium in the six years 1964-69 were 2,407 tons valued at $7.9 million. Imports of ferrovanadium dropped to 188 tons in 1970 compared with the annual average of 401 tons during the prior six years.

TABLE 1

Canada, Imports and Consumption of Vanadium, 1969-70

	1969		1970[p]	
	Short Tons	$	Short Tons	$
Imports				
Ferrovanadium				
United States	118	477,000	188	937,000
Austria	48	223,000	–	–
USSR	110	183,000	–	–
Belgium and Luxembourg	39	137,000	–	–
Other countries	76	194,000	–	–
Total	391	1,214,000	188	937,000
Consumption				
Ferrovanadium				
Gross weight	313	..	..	..
Vanadium content	206	..	..	..

Source: Dominion Bureau of Statistics.
[p]Preliminary; – Nil; . .Not available.

TABLE 2

World Production of Vanadium in Ores and Concentrates, 1967-70
(short tons)

	1967	1968	1969	1970[e]
United States	4,963	6,483	5,577	6,000
Republic of South Africa	2,115	2,498	2,873	3,000
Southwest Africa	1,080[r]	560	450	700
Finland	1,292	1,321	1,484	1,400
Norway	816	937	965	900
Total	10,266	11,799	11,349	12,000[e]

Source: U.S. Bureau of Mines, Minerals Yearbook Preprint, 1969.
[e]Author's estimate; [r]Revised.

UNITED STATES

Estimated non-communist world production of vanadium in 1970 was 12,000 tons. The United States is the largest producer and consumer of vanadium. Consumption in 1970 was down to 10 million pounds (V content) compared with 12 million pounds in 1969. Exports of ferrovanadium increased from 644 tons (gross weight) in 1969 to 2,154 tons in 1970. Exports of vanadium in ore, concentrates, pentoxide, oxide and vanadates increased to 972 tons (V content) in 1970 from an average of 665 tons a year during the years 1965 to 1969 inclusive. The iron and steel industry used about 80 per cent of the vanadium consumed, nonferrous alloys used 10 per cent, and chemicals, catalysts and other uses the balance.

United States production of vanadium is a byproduct of uranium recovery from mines in Colorado and New Mexico, of phosphorus production from phosphate rock in Idaho, and as a primary product from the new vanadium mining and milling operation at Wilson Springs, Arkansas.

REPUBLIC OF SOUTH AFRICA

The Republic of South Africa produced 3,625 tons of vanadium pentoxide in the first nine months of 1970 compared with 4,003 tons in the same period of 1969. The Vantra Division of Highveld Steel and Vanadium Corporation Limited near Witbank in Eastern Transvaal has a capacity of 6.5 million pounds a year of V_2O_5 recovered by chemical treatment of vanadium-bearing titaniferous magnetite. Highveld's integrated iron, steel and vanadium production complex, also near Witbank, came into operation during 1968. It is expected that production will reach rated capacity during 1971 and it is estimated that 480,000 tons of vanadium-bearing hot metal will be produced annually from which 23 million pounds of vanadium pentoxide in a slag containing 28 per cent V_2O_5, 10 per cent TiO_2, 42 per cent FeO and 20 per cent SiO_2 will be recovered. Ore reserves were reported to be about 200 million tons containing 55 to 57 per cent iron, 12 to 15 per cent titanium dioxide and 1.4 to 1.9 per cent vanadium pentoxide.

TABLE 3

Vanadium Consumed in the United States, 1969-70
(pounds of vanadium)

	1969	1970
Ferrovanadium	10,233,042	8,501,373
Oxide	221,019	217,208
Ammonium metavanadate	229,180	87,367
Other	1,368,775	1,223,178
Total	12,052,016	10,029,126

Source: U.S. Bureau of Mines, Mineral Industry Surveys.

TABLE 4

Vanadium Consumed in the United States
by End-Use, 1969-70
(short tons of vanadium)

	1969r	1970*
Steel		
High-speed tool	648	439
Stainless	37	40
Alloy (excluding stainless and tool)	2,739	2,198
Carbon	1,296	964
Other steel	63	32
Cast iron	55	42
Welding and hardfacing rods and materials	12	8
Magnetic alloys	7	1
Nonferrous alloys	618	422
Chemical and ceramic uses	196	93
Miscellaneous and unspecified	484	413
Total	6,155	4,652*

Sources: U.S. Bureau of Mines, Minerals Yearbook, Preprint, 1969, and U.S. Bureau of Mines, Mineral Industry Surveys.

rRevised; *1st 11 months 1970.

PRODUCTS AND USES

Vanadium is a steel-grey metallic element with a melting point of 1,900°C (3,450°F). Technical-grade vanadium pentoxide (V_2O_5) is the common product of primary vanadium producers. It is available as a fused black oxide containing 86 to 99 per cent V_2O_5 and as an air-dried powder containing 83 to 86 per cent V_2O_5. Chemical grades of vanadium pentoxide have typical V_2O_5 contents of 99.5, 99.7, and 99.94 per cent. Ammonium metavanadate (NH_4VO_3) and sodium vanadate are supplied to the chemical industry.

Vanadium is used principally as ferrovanadium, an additive, in the iron and steel industry. Its function is to reduce and control grain size, to impart toughness and strength, and to maintain hardness at elevated temperatures. Different grades of ferrovanadium are available with the vanadium content varying from 35 per cent to 85 per cent, carbon from 0.15 to 2.0 per cent, and silicon from 0.50 to 11 per cent. Union Carbide Corporation produces "Carvan" which contains 83 to 86 per cent vanadium, 10 to 13 per cent carbon and only one to three per cent iron. Ferrovanadium is produced by a reducing process using such reducing agents as carbon, silicon and aluminum in electric furnace or aluminothermic processes. Vanadium is generally used with other alloying elements in iron and steel rather than alone. Titanium-base vanadium alloys, having high-temperature strength qualities and good weldability, are used in the aircraft industries.

Compounds of vanadium are used in the chemical industry as catalysts in such processes as the production of sulphuric acid and the catalytic cracking of petroleum products. Other uses include such applications as the colouring of glass and ceramic glazes, driers in paints, and varnishes, processing coloured film, in welding rod, and cutting and wear-resistant materials.

MINERALS AND OCCURRENCES

The more important of many known vanadium-bearing minerals are the complex sulphide, patronite; the vanadium-bearing mica, roscoelite; a potassium uranium vanadate, carnotite, the lead vanadates, vanadinite, descloizite, and mottramite. Patronite with asphaltite was an important source of vanadium at Mina Ragra in the Peruvian Andes until 1955 when mining of the high grade deposit was completed. Vanadates of lead, zinc, and copper found in the oxidized zones of base-metal deposits have been sources of vanadium production in several countries. Vanadium-bearing titaniferous magnetites in South Africa and Finland have become important sources, and similar deposits are known in the USSR, Canada and the United States. Vanadium occurs in some clays, shales and phosphate rocks, and is found in association with asphaltum, coal, chromium, copper, iron, lead, titanium, uranium, and petroleum. Vanadium has not been produced commercially from deposits in Canada, but many occurrences are know. A typical analysis of ilmenite from the Allard Lake area of Quebec shows 0.27 per cent vanadium pentoxide (V_2O_5).

The Athabasca tar sands in northern Alberta contain an estimated 240 parts per million (0.024 per cent) of vanadium, part of which could be recovered from the coke residue of the distillation process.

A recent publication of the Geological Survey of Canada, Paper 68-74, describes occurrences of uranium and vanadium in Prince Edward Island. Uranium vanadates, rauvite and rancevillite, have been identified in greyish-green sandstones which have similarities in their geology and geochemistry to uranium deposits in sandstones in the Colorado Plateau.

PRICES

United States vanadium prices published in *Metals Week* of December 29, 1969, and December 28, 1970, were:

	December 29, 1969	December 28, 1970
Vanadium pentoxide per lb, f.o.b. mine or mill		
98% fused	$1.51	$1.94
Air dried (technical)	1.54	2.02
Dealers (mainly export)	1.75-1.80	2.00
Ferrovanadium per lb V, packed, f.o.b. shipping point, freight equalized to nearest main producer		
Standard grade	3.00-3.12	4.12
Carvan	2.70	3.48
Solvan	2.70	3.48
Dealers (mainly export)		4.50

TARIFFS

		British Preferential	Most Favoured Nation	General
CANADA				
Item No.				
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%

TARIFFS (Cont'd)

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 and waste and scrap suspended to June 30, 1971)	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 (1970), TC Publication 304.

Zinc

D.B. FRASER*

Canadian zinc mine output continued to rise in 1970, reaching a total of 1,375,938 short tons of contained zinc, nearly 7 per cent more than in 1969. Canada remained the world's leading mine producer, accounting for 29 per cent of the total production of non-communist countries. Production of refined zinc declined to 460,663 tons, from 466,351 tons produced in 1969. Output was at 86 per cent of the total rated capacity of the four primary zinc plants. Consumption of primary refined zinc fell off to 105,712 tons, 11 per cent less than in 1969. A 45 per cent drop in the consumption of zinc die-cast alloy was the main reason.

Canadian zinc exports increased in some markets and declined in others. In the United States, Canada's principal export market, the demand for zinc was 15 per cent less in 1970 than in 1969, due to a general slackening in manufacturing activity. The use of zinc was lower in diecasting, galvanizing, brass products, and rolled zinc. United States smelter production was 13 per cent less in 1970 than in 1969. Canadian exports to the United States accordingly were lower both in the case of refined zinc and zinc concentrates. Exports of zinc concentrates to Japan rose sharply from 66,873 tons in 1969 to 103,166 tons in 1970. Those to continental Europe were also higher. Exports of refined zinc to Britain and India rose as well. Total exports rose by 8 per cent in 1970 over the 1969 total.

DOMESTIC PRODUCTION

MINE PRODUCTION

Table 2 gives information on the operations of the 36 mining companies that produced zinc-bearing ore on a regular basis during 1970.

Two mines increased output significantly. Anvil Mining Corporation Limited, which opened a 5,500-ton mill in Yukon Territory in 1969, expanded its mill to 6,600 tons daily capacity. Production in 1970 was 83,031 tons of contained zinc, 68,000 tons more than in 1969. Heath Steele Mines Limited, near Bathurst, New Brunswick, doubled its mill capacity to 3,000 tons daily early in 1970, and production increased to 37,870 tons of contained zinc from 7,809 tons in 1969.

Sherritt Gordon Mines, Limited, which discovered the Fox mine, 30 miles southwest of Lynn Lake, Manitoba in 1961, completed construction of a 3,000-ton mill at the mine site and began tune-up operations in May, 1970. Ore reserves at December 31, 1970 were 13,100,000 tons averaging 1.84 per cent copper and 2.70 per cent zinc. The company in 1969 discovered a second copper-zinc orebody, the Ruttan mine, 65 miles southeast of Lynn Lake. Production plans are for operations to begin in July 1973 at a 10,000-ton concentrator to be built at the mine site. Ruttan ore reserves at December 31, 1970 were 51,000,000 tons averaging 1.61 per cent zinc and 1.47 per cent copper. Zinc concentrates from the Fox mill are shipped to Flin Flon for treatment; copper concentrates go to Japan. The zinc concentrates from the Ruttan mine are to be sold to Japanese smelters, the copper concentrates are to be smelted and refined in Canada by Noranda Mines Limited, both under 10-year contracts.

Two mines were opened during 1970 in British Columbia (Copperline and Silmonac), and one in the Yukon Territory (Venus).

Hudson Bay Mining and Smelting Co., Limited opened two new mines near Snow Lake in Manitoba, the Anderson Lake (copper only) and the Dickstone

*Mineral Resources Branch.

TABLE 1

Canada, Zinc Production, Trade and Consumption, 1969-70

	1969		1970p	
	Short Tons	$	Short Tons	$
Production				
All forms[1]				
Ontario	360,286	109,743,049	331,471	105,606,700
Northwest Territories	224,148	68,275,481	225,000	71,685,000
Quebec	198,532	60,472,654	197,969	63,073,100
New Brunswick	152,728	46,521,013	156,488	49,856,800
British Columbia	148,333	45,182,389	129,577	41,283,200
Yukon	16,531	5,035,385	77,988	24,846,900
Manitoba	48,890	14,891,672	39,525	12,592,800
Newfoundland	32,903	10,022,171	32,126	10,235,300
Saskatchewan	25,142	7,658,414	21,154	6,739,800
Nova Scotia	132	40,124	–	–
Total	1,207,625	367,842,352	1,211,298	385,919,600
Mine output[2]	1,290,136		1,375,938	
Refined[3]	466,351		460,663	
Exports				
Zinc, blocks, pigs and slabs				
United States	147,685	38,586,000	121,308	33,098,000
Britain	82,894	19,358,000	95,149	24,297,000
India	6,213	1,253,000	28,859	6,369,000
West Germany	13,107	2,967,000	10,187	2,453,000
Italy	3,711	751,000	9,672	2,000,000
Japan	2,645	640,000	8,598	1,924,000
Philippines	3,457	752,000	6,427	1,552,000
Brazil	11,178	2,237,000	5,690	1,236,000
Sweden	4,584	1,156,000	4,626	1,203,000
Pakistan	1,411	282,000	5,933	1,197,000
Malaysia	1,081	247,000	4,840	1,178,000
China	–	–	5,629	1,127,000
Argentina	3,438	688,000	4,962	1,078,000
Taiwan	1,603	373,000	3,948	1,006,000
Venezuela	2,784	576,000	4,873	989,000
Other countries	21,603	4,699,000	30,753	7,174,000
Total	307,394	74,565,000	351,454	87,881,000
Zinc contained in ores and concentrates				
United States	383,180	46,157,000	338,876	42,436,000
Belgium and Luxembourg	156,397	19,387,000	188,845	27,320,000
Japan	66,873	9,271,000	103,166	16,000,000
Netherlands	5,001	695,000	84,217	12,636,000
France	45,307	6,310,000	37,860	5,716,000
West Germany	110,954	15,259,000	35,102	5,563,000
Britain	21,373	2,765,000	29,300	3,207,000
India	5,804	287,000	13,799	2,010,000
Norway	4,248	519,000	9,615	1,281,000
Italy	5,528	750,000	5,211	743,000
Total	804,665	101,400,000	845,991	116,912,000

TABLE 1 (Cont'd)

	1969		1970P	
	Short Tons	$	Short Tons	$
Zinc fabricated materials n.e.s.				
United States	4,388	1,787,000	5,009	2,067,000
Britain	1,026	352,000	1,674	576,000
Singapore	97	31,000	337	109,000
West Germany	–	–	214	59,000
Italy	109	37,000	137	56,000
Other countries	152	77,000	549	207,000
Total	5,772	2,284,000	7,920	3,074,000
Zinc and alloy scrap, dross and ash (gross weight)				
United States	6,320	1,016,000	3,449	627,000
Netherlands	219	24,000	1,367	150,000
Belgium and Luxembourg	1,711	118,000	993	109,000
West Germany	–	–	745	83,000
Britain	428	29,000	357	61,000
Yugoslavia	–	–	315	23,000
Other countries	143	24,000	175	32,000
Total	8,821	1,211,000	7,401	1,085,000
Imports				
In ores and concentrates	60	5,000	403	23,000
Dust and granules	1,312	540,000	712	302,000
Slabs, blocks, pigs and anodes	772	177,000	368	115,000
Bars, rods, plates, strip and sheet	564	381,000	634	434,000
Slugs, discs, shells	56	27,000	328	165,000
Zinc oxide	2,559	900,000	2,183	679,000
Zinc sulphate	2,594	319,000	1,658	200,000
Lithopone[4]	..	..	..	..
Zinc fabricated material n.e.s.	740	887,000	484	539,000
Total	8,657	3,236,000	6,770	2,457,000

	1969			1970P		
	Primary	Secondary	Total	Primary	Secondary	Total
Consumption						
Zinc used for, or in the manufacture of:						
Copper alloys (brass, bronze, etc.)	16,369	..	..	12,038	..	..
Galvanizing						
electro	911	..	..	1,017	..	..
hot-dip	46,099	..	..	52,648	..	..
Zinc die-cast alloy	32,268	..	..	17,674	..	..
Other products (including rolled and ribbon zinc, zinc oxide)	23,034	2,016	25,050	22,335	2,390	24,725
Total	118,681	2,736	121,417	105,712	2,685	108,397
Consumers stocks on hand at end of year	12,699	434	13,133	10,035	645	108,397

Source: Dominion Bureau of Statistics.
[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. [4]Effective January 1, 1969, no longer a separate class, included with "Pigments, colour lakes and toners, n.e.s."
PPreliminary; .. Not available for publication; – Nil; n.e.s. not elsewhere specified.

TABLE 2

Principal Zinc Mines In Canada, 1970 and (1969)

Company and Location	Mill or Mine Capacity (tons ore/day)	Grade of Ore: Zinc (%)	Lead (%)	Copper (%)	Silver (oz/ton)	Ore Produced (tons)	Contained Zinc Produced (tons)	Remarks
NEWFOUNDLAND								
American Smelting and Refining Company,	1,250	12.68	7.02	1.11	3.73	359,000	41,960	
Buchans	(1,250)	(12.78)	(7.07)	(1.12)	(4.01)	(371,000)	(43,272)	
NOVA SCOTIA								
Dresser Minerals, Division of Dresser Industries, Inc.,	125	0.5	6.3	0.33	3.58	27,263	117	
Walton	(125)	(0.6)	(5.5)	(0.28)	(5.50)	(49,870)	(153)	
NEW BRUNSWICK								
Brunswick Mining and Smelting Corporation Limited, Bathurst	3,500	5.86	2.12	0.33	1.84	1,100,703	50,650	Closed by a 41-day strike in
No. 6 Mine	(2,500)	(5.78)	(2.28)	(0.35)	(1.87)	(1,134,224)	(51,257)	March and April.
No. 12. Mine	6,500	7.54	2.93	0.32	2.19	1,519,981	82,424	
	(5,000)	(8.05)	(3.04)	(0.33)	(2.13)	(1,696,408)	(100,085)	
Heath Steele Mines	3,000	5.40	2.26	0.97	2.20	1,030,899	37,870	Mill capacity raised from
Limited, Newcastle	(3,000)	(4.00)	(1.33)	(1.46)	(1.71)	(321,403)	(7,809)	1,500 to 3,000 tons effective January 1970.
Nigadoo River Mines	1,000	. .	. .	. .	. .	313,354	6,931	
Limited, Robertville	(1,000)	(. .)	(. .)	(. .)	(. .)	(. .)	(. .)	
QUEBEC								
Bell Allard Mines Limited,	900	9.26	–	0.58	1.11	61,265	5,015	Open-pit operation terminated
Matagami	(370)	(8.50)	(–)	(0.88)	(0.95)	(97,354)	(7,353)	November 1970.
Delbridge Mines Limited,	(Custom Milled)	10.29	–	0.71	3.48	196,844	17,889	Production started October
Noranda	(500)	(10.30)	(–)	(0.70)	(3.25)	(57,494)	(4,575)	1969.
Lake Dufault Mines Limited,	1,300	1.82	–	1.36	0.53	419,171	5,324	Developing new orebody.
Noranda	(1,300)	(2.21)	(–)	(1.71)	(0.77)	(405,790)	(6,125)	
Manitou-Barvue Mines	1,600	2.19	0.36	0.59	4.66	362,170	5,007	
Limited, Val d'Or	(1,300)	(. .)	(. .)	(. .)	(. .)	(. .)	(. .)	

TABLE 2 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Grade of Ore: Zinc (%)	Lead (%)	Copper (%)	Silver (oz/ton)	Ore Produced (tons)	Contained Zinc Produced (tons)	Remarks
Mattagami Lake Mines Limited, Matagami	3,850	9.1	(–)	0.59	0.86	1,430,864	119,247	
	(3,850)	(9.6)	(–)	(0.62)	(1.02)	(1,413,651)	(122,276)	
New Hosco Mines Limited, Matagami	900	0.76	–	0.94	0.38	64,248	148	Completed mining May 1970.
	(900)	(1.79)	(–)	(0.94)	(0.33)	(277,768)	(3,596)	
Normetal Mines Limited, Normetal	1,000	6.72	–	1.77	1.47	348,100	20,354	
	(1,000)	(6.65)	(–)	(1.67)	(1.48)	(355,495)	(20,566)	
Orchan Mines Limited, Matagami	1,900	11.10	–	1.03	1.36	414,521	42,411	
	(1,900)	(11.53)	(–)	(1.04)	(1.09)	(308,732)	(32,403)	
Quemont Mines Limited, Noranda	2,300	1.89	–	0.78	0.91	299,636	3,957	Scheduled to complete mining in 1971.
	(2,300)	(1.96)	(–)	(0.78)	(0.74)	(334,432)	(5,112)	
Sullivan Mining Group Ltd., Stratford Centre, (Solbec, Cupra, D'Estrie and Weedon mines)	1,500	2.95	0.57	1.78	1.14	375,447	8,554	Mining completed at Solbec December 1970; start-up at D'Estrie and Weedon 1970-71.
	(1,500)	(3.53)	(0.65)	(1.77)	(1.48)	(431,297)	(14,763)	
ONTARIO								
Big Nama Creek Mines Limited, Manitouwadge	...	3.76	0.06	0.80	0.99	88,965	2,729	Ore custom milled by Willroy Mines Limited.
	(350)	(3.90)	(0.09)	(0.88)	(1.08)	(57,472)	(1,917)	
Canadian Jamieson Mines Limited, Timmins	575	3.07	–	1.77	..	207,885	4,505	
	(450)	(4.40)	(–)	(2.50)	(..)	(196,140)	(6,551)	
Ecstall Mining Limited, Timmins	9,000	..	..	..	..	3,584,124	304,036	Began development for underground mining; electrolytic zinc plant under construction.
	(9,000)	(..)	(..)	(..)	(..)	(3,617,226)	(307,885)	
Kam-Kotia Mines Limited, Timmins	2,500	2.75	–	0.78	..	650,869	9,338	
	(2,500)	(3.22)	(–)	(1.21)	(..)	(817,716)	(15,625)	
Noranda Mines Limited, Geco Division, Manitouwadge	5,000	3.89	..	1.86	1.82	1,366,176	48,102	Closed by strike from Nov. 22, 1969 to Feb. 2, 1970. Mill capacity expanded.
	(4,000)	(4.90)	(..)	(2.48)	(2.34)	(1,320,000	(51,440)	
Willroy Mines Limited (incl. Willecho mine), Manitouwadge	1,700	4.02	0.20	0.85	1.99	388,005	15,412	
	(1,700)	(3.6)	(0.2)	(0.57)	(1.70)	(445,449)	(13,640)	

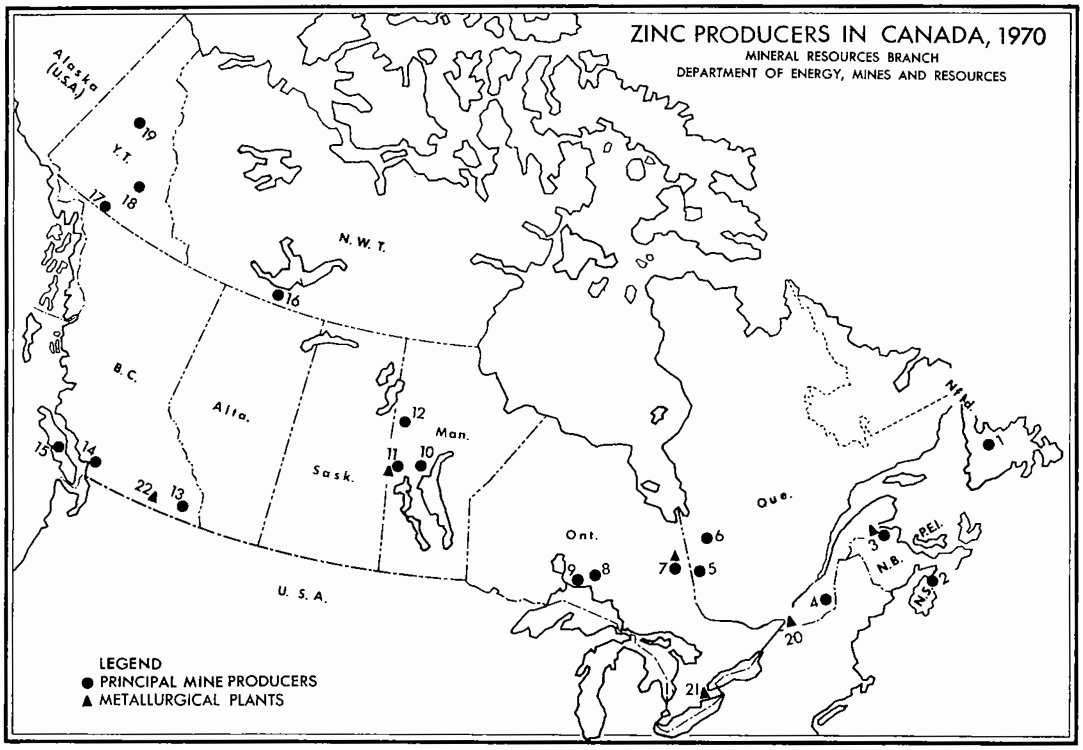
TABLE 2 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Grade of Ore: Zinc (%)	Grade of Ore: Lead (%)	Grade of Ore: Copper (%)	Grade of Ore: Silver (oz/ton)	Ore Produced (tons)	Contained Zinc Produced (tons)	Remarks
Zenmac Metal Mines Limited, Schreiber	Nil. (200)	. . (13.24)	– (–)	. . (. .)	. . (. .)	. . (35,283)	947 (4,313)	Mining completed April 1970.
MANITOBA AND SASKATCHEWAN								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon and Snow Lake (Flin Flon, Schist Lake, Flexar, Chisel Lake, Stall Lake, Osborne Lake, Anderson Lake, Dickstone)	6,000 (6,000)	3.9 (4.3)	0.2 (0.2)	2.7 (2.7)	0.6 (0.6)	1,709,000 (1,702,000)	67,429 (67,069)	Central mill treats ore from eight mines. Anderson Lake, copper only, Dickstone, copper-zinc, were opened in 1970.
Sherritt Gordon Mines, Limited, Lynn Lake, Fox mine	3,000 (–)	1.13 (–)	– (–)	3.07 (–)	. . (–)	389,000 (–)	96 (–)	Production started 1970.
BRITISH COLUMBIA								
Anaconda Britannia Mines Ltd., Britannia Beach	3,000 (3,000)	. . (0.17)	– (1.18)	. . (1.18)	. . (. .)	320,642 (605,273)	127 (267)	
Canadian Exploration, Limited, Salmo	1,900 (1,900)	2.7 (2.76)	1.2 (1.01)	– (–)	. . (0.05)	216,000 (517,648)	5,100 (13,162)	Jersey zinc-lead operations closed August 1970.
Cominco Ltd., Sullivan mine, Kimberley	10,000 (10,000)	. . (. .)	. . (. .)	. . (. .)	. . (. .)	2,194,743 (2,157,522)	104,238 (87,141)	
Bluebell mine, Riondel	700 (700)	. . (. .)	. . (. .)	. . (. .)	. . (. .)	245,529 (230,956)	12,614 (11,674)	
Copperline Mines Ltd., Golden	600	4.67 (–)	3.46 (–)	– (–)	4.62 (–)	36,228 (–)	1,381 (–)	New mine opened October 1970.
Mastodon-Highland Bell Mines Limited, Beaverdell	115 (115)	0.89 (0.9)	0.89 (0.8)	– (–)	13.37 (13.74)	33,225 (37,120)	296 (346)	
Reeves MacDonald Mines Limited, Remac Reeves mine	1,200 (1,200)	4.75 (4.69)	1.56 (1.43)	– (–)	. . (. .)	107,312 (201,215)	4,716 (8,728)	Adjoining Annex orebody brought into production August 1970.
Annex mine	1,000 (–)	9.0 (–)	1.07 (–)	– (–)	3.3 (–)	70,714 (–)	6,029 (–)	

TABLE 2 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Grade of Ore: Zinc (%)	Lead (%)	Copper (%)	Silver (oz/ton)	Ore Produced (tons)	Contained Zinc Produced (tons)	Remarks
Silmonac Mines Limited, Sandon	150 (–)	6.79 (–)	7.58 (–)	– (–)	19.0 (–)	13,232 (–)	837 (–)	Production started September 1970.
Western Mines Limited, Buttle Lake, V.I.	1,000 (1,000)	6.38 (. .)	0.75 (. .)	1.97 (. .)	1.36 (. .)	386,976 (. .)	21,961 (. .)	
YUKON TERRITORY								
Anvil Mining Corporation Limited, Faro	6,600 (5,500)	6.4 (5.6)	4.4 (3.5)	– (–)	. . (. .)	1,961,000 (. .)	83,031 (15,153)	Completed expansion of mill capacity to 6,600 tons a day.
United Keno Hill Mines Limited, Elsa	500 (500)	5.25 (4.67)	4.07 (4.56)	– (–)	27.30 (27.98)	93,215 (87,483)	4,078 (3,923)	
Venus Mines Ltd., Carcross	300 (–)	0.98 (–)	1.15 (–)	– (–)	5.30 (–)	23,796 (–)	124 (–)	Production started September 1970.
NORTHWEST TERRITORIES								
Pine Point Mines Limited, Pine Point	10,000 (8,000)	7.1 (7.4)	3.0 (3.2)	– (–)	. . (. .)	3,860,000 (3,605,000)	252,051 (246,000)	Also shipped 92,600 tons of ore grading 21.5% zinc and 14.5% lead.

– Nil; . . Not available.



PRINCIPAL PRODUCERS

(numbers refer to numbers on map)

1. American Smelting and Refining Company (Buchans Unit)
2. Dresser Minerals,
   Division of Dresser Industries, Inc.
3. Brunswick Mining and Smelting Corporation Limited
   Heath Steele Mines Limited
   Nigadoo River Mines Limited
4. Sullivan Mining Group Ltd.
5. Delbridge Mines Limited
   Lake Dufault Mines Limited
   Manitou-Barvue Mines Limited
   Normetal Mines Limited
   Quemont Mines Limited
6. Bell Allard Mines Limited
   Mattagami Lake Mines Limited
   New Hosco Mines Limited
   Orchan Mines Limited
7. Canadian Jamieson Mines Limited
   Ecstall Mining Limited
   Kam-Kotia Mines Limited
8. Big Nama Creek Mines Limited
   Noranda Mines Limited (Geco)
   Willecho Mines Limited
   Willroy Mines Limited
9. Zenmac Metal Mines Limited
10. Hudson Bay Mining and Smelting Co., Limited
    Chisel Lake, Osborne Lake, Stall Lake, Dickstone
11. Hudson Bay Mining and Smelting Co., Limited – Flexar, Flin Flon, Schist Lake
12. Sherritt Gordon Mines, Limited
    Fox Lake
13. Canadian Exploration, Limited
    Copperline Mines Ltd.
    Cominco Ltd.–2 mines; Sullivan, Bluebell
    Mastodon-Highland Bell Mines Limited
    Reeves MacDonald Mines Limited
    Silmonac Mines Limited
14. Anaconda Britannia Mines Ltd.
15. Western Mines Limited
16. Pine Point Mines Limited
17. Venus Mines Ltd.
18. Anvil Mining Corporation Limited
19. United Keno Hill Mines Limited

METALLURGICAL PLANTS

3. East Coast Smelting and Chemical Company Limited, Belledune
20. Canadian Electrolytic Zinc Limited, Valleyfield
21. Sherbrooke Metallurgical Company Limited, Port Maitland (Roasting plant only)
11. Hudson Bay Mining and Smelting Co., Limited, Flin Flon
22. Cominco Ltd., Trail
7. Ecstall Mining Limited (under construction)

TABLE 3

Prospective Zinc Producing Mines

Company and Location	Year Production Expected	Mill or Mine Capacity (tons ore /day)	Indicated Ore Reserves (tons)	Grade of Ore				Remarks
				Zinc (%)	Lead (%)	Copper (%)	Silver (oz/ton)	
QUEBEC								
Lake Dufault Mines Limited, Millenbach mine, Noranda	1971	..	2,675,000	3.6	–	3.5	..	
ONTARIO								
Mattabi Mines Limited, Sturgeon Lake	1972	3,000	12,866,000	7.6	0.84	0.91	3.13	Jointly owned by Mattagami Lake Mines Limited and Abitibi Paper Company Ltd.
South Bay Mines Limited, Uchi Lake	1971	500	..	14.11	–	2.24	3.64	Owned by Selco Exploration Company Limited.
MANITOBA								
Hudson Bay Mining and Smelting Co., Limited, Snow Lake area, Centennial Mine	..	..	1,400,000	2.6	–	2.06	..	
Sherritt Gordon Mines, Limited, Ruttan Mine, Lynn Lake district	1973	10,000	51,000,000	1.61	–	1.47	..	Open-pit operation planned.
BRITISH COLUMBIA								
Columbia Metals Corporation Limited, Ferguson	1971	125	100,000	6.7	6.0	..	6.9	

.. Not available; – Nil.

TABLE 4

Indicated Zinc Deposits Under Exploration

Company and Location	Indicated Ore Tonnage (tons)	Grade of Ore				Remarks
		Zinc (%)	Lead (%)	Copper (%)	Silver (oz/ton)	
NEWFOUNDLAND						
Newfoundland Zinc Mines Limited, Daniel's Harbour	5,400,000	7.70	..	..	..	Exploration continuing.
NEW BRUNSWICK						
The Anaconda Company (Canada) Ltd., Bathurst, Caribou property	50,000,000	..	..	..	..	Production of copper ore to start 1970. Pilot mill to test lead-zinc zone to be built.
Chester Mines Limited, Newcastle	5,000,000	0.80	0.36	0.80	..	Ore available for open-pit mining.
	13,000,000	..	..	0.77	..	Ore available for underground mining. Feasibility study in progress in mid-1970.
Key Anacon Mines Limited, Bathurst	1,950,000	5.87	2.18	0.24	2.31	Mine partially developed. Awaiting financing. Further study of production feasibility initiated early in 1970.
Teck Corporation Limited, Portage Lakes area, Restigouche property	3,270,000	5.90	4.60	..	2.50	Negotiations underway to bring property into production.
ONTARIO						
Falconbridge Nickel Mines Limited, Sturgeon Lake area	..	..	..	..	..	Discovered in 1970. Exploration continuing.
MANITOBA						
Stall Lake Mines Limited, Snow Lake	672,000	2.28	..	5.38	..	Falconbridge Nickel Mines is joint owner of this property. Exploration continuing for parallel deposits. Feasibility study being carried out.
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	5,100,000	8.00	8.00	–	2.73	Underground work through adit including diamond drilling in 1970.

TABLE 4 (Cont'd)

Company and Location	Indicated Ore Tonnage (tons)	Grade of Ore Zinc (%)	Lead (%)	Copper (%)	Silver (%)	Remarks
Kerr Addison Mines Limited, Swim Lake deposit, Vangorda Creek	5,000,000	9.50 (Pb+Zn)		..	1.50	Exploration continuing. Metallurgical testing is under way.
Vangorda Mines Limited, Vangorda Creek	9,400,000	4.96	3.18	0.27	1.76	Feasibility study made. No further exploration.
NORTHWEST TERRITORIES						
Buffalo River Exploration Limited, Pine Point	1,350,000	9.60	3.40	–	..	Production plans being considered. Arrangement made for joint feasibility study with Coronet Mines Limited.
Coronet Mines Ltd., Pine Point	1,372,735	10.2 (Pb+Zn)		–	..	Exploration continuing.
Texas Gulf Sulphur Company, Strathcona Sound	..	..	..	..	..	Underground exploration carried out. Work will continue.

.. Not available; – Nil.

mine (copper-zinc), and developed two new zinc-copper deposits for production in 1972. Selco Exploration Company Limited, a subsidiary of Selection Trust Limited, of London, England, continued to develop its zinc-copper-silver property at Uchi Lake, in the Red Lake district of northwestern Ontario, scheduling production from a 500-ton mill to begin in 1971.

Further progress was made in developing new zinc-copper-lead deposits at Sturgeon Lake, near Sioux Lookout in northwestern Ontario. Mattagami Lake Mines Limited and Abitibi Paper Company Ltd. formed a new company, Mattabi Mines Limited, to operate the property discovered by Mattagami Lake in 1969. Ore reserves at the end of 1970 were 12,866,000 tons averaging 7.60 per cent zinc, 0.91 per cent copper, 0.84 per cent lead, 3.13 oz silver and 0.007 oz gold per ton. About two-thirds of the tonnage will be mined by open-pit methods. Production at 3,000 tons daily is scheduled to begin in mid-1972. Three miles west of the Mattabi orebody Falconbridge Nickel Mines Limited during 1970 discovered a copper-zinc-silver deposit near the border of properties owned by Mattagami Lake Mines Limited and New Brunswick Uranium Metals & Mining Limited, on the latter's side. Drill results indicated that the deposit straddles the claim border.

TABLE 5

Canadian Mine Output, 1969-1970

	1969	1970p
	(Short Tons)	(Short Tons)
Newfoundland	37,921	37,240
Nova Scotia	247	118
New Brunswick	167,630	179,074
Quebec	224,352	227,456
Ontario	371,222	376,473
Manitoba-Saskatchewan	72,216	58,442
British Columbia	146,867	136,506
Yukon Territory	19,131	87,191
Northwest Territories	250,550	273,438
Total	1,290,136	1,375,938

Source: Dominion Bureau of Statistics.
pPreliminary.

The Anaconda Company (Canada) Ltd. began production from a copper zone, estimated to contain three-years' ore supply, at its Caribou property in the Bathurst district of New Brunswick, and continued exploration and development of the main Caribou zinc-lead-copper orebody. A feasibility study was in progress during the year, and it was planned to build a 300-ton pilot mill to test the concentration of the complex ore.

Lake Dufault Mines Limited developed the Millenbach mine, adjoining the original Norbec mine, with reserves totalling 2,675,000 tons averaging 3.6 per cent zinc and 3.5 per cent copper. Production is scheduled to start in the latter part of 1971.

Table 4 lists other zinc-bearing deposits in the exploration stage, which are of interest for zinc mine production after 1973.

METAL PRODUCTION

Production of refined zinc at the four Canadian zinc plants in 1970 was as follows:

	Production, Refined Zinc* (Short Tons)	Annual Capacity (Short Tons)
Canadian Electrolytic Zinc Limited, Valleyfield, Quebec	124,100	140,000
Cominco Ltd., Trail, B.C.	221,600	263,000
East Coast Smelting and Chemical Company Limited, Belledune, N.B.	31,300 4,800**	54,000
Hudson Bay Mining and Smelting Co., Limited, Flin Flon, Man.	78,622	79,000

*From company annual reports.
**Non-refined I.S.F. zinc shipped.

Production in 1970 was at 86 per cent of rated capacity compared with 89 per cent in 1969. Canadian Electrolytic Zinc Limited treated concentrates from Quebec (Mattagami Lake, Orchan, Quemont, Normetal, and New Hosco mines) and Ontario (Geco mine). Cominco's Trail plant, the largest in the world, was supplied by Cominco's Sullivan, Bluebell, and Pine Point mines, and to a small extent by custom shippers. Concentrates for the Hudson Bay Mining and Smelting Co., Limited plant at Flin Flon came mainly from Hudson Bay's own mill, but were augmented by purchased concentrates. East Coast Smelting and Chemical Company Limited, a wholly-owned subsidiary of Brunswick Mining and Smelting Corporation Limited, treated bulk zinc-lead concentrates from Brunswick's No. 6 mine in an Imperial Smelting Process (I.S.P.) furnace and produced high-purity zinc in a re-distillation plant at the same site and refined lead and silver.

Ecstall Mining Limited, a wholly-owned subsidiary of Texas Gulf Sulphur Company, began construction of an electrolytic zinc plant adjoining the copper-zinc-lead concentrator 15 miles east of Timmins, Ontario. The plant, scheduled to open at the beginning of 1972, will have a capacity of 120,000 tons of refined zinc, 1 million pounds of cadmium metal, and

TABLE 6

Canada, Zinc, Production, Exports and Consumption, 1961-70

	Production		Exports			
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total	Consumption[3]
1961	416,004	268,007	199,322	208,272	407,594	60,878
1962	463,145	280,158	242,457	210,723	453,180	65,320
1963	473,722	284,021	213,044	200,002	413,046	73,653
1964	684,513	337,734ʳ	403,102	238,076	641,178	88,494
1965	822,035	358,498	487,445	264,200	751,645	93,796
1966	964,106	382,605ʳ	591,322	256,153	847,475	107,052
1967	1,111,453	405,136ʳ	735,705	297,652	1,033,357	107,779
1968	1,159,392	426,915	855,818	318,707	1,174,525	115,978
1969	1,207,625	466,351	804,665	307,394	1,112,059	118,681
1970	1,211,298	460,663	845,991	351,454	1,197,445	117,291[4]

Source: Dominion Bureau of Statistics.
[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. [4]Producers' domestic shipments of primary refined zinc.
ᵖPreliminary; ʳRevised.

230,000 tons of sulphuric acid annually. Substantial quantities of silver and some copper and other metal values will also be recovered. The plant and related facilities will cost more than $70 million.

METAL CONSUMPTION

Canadian zinc consumption was reduced by a general decline in economic activity in 1970 and by the strike that closed motor vehicle plants of General Motors Corporation in Canada and the United States during much of the fourth quarter of the year. As a result the use of zinc in diecastings fell from 32,268 tons in 1969 to 17,674 tons in 1970; consumption in copper alloys was also lower. In galvanizing, more zinc was used in 1970 than in the previous year.

TABLE 7

Canada, Producers Domestic Shipments of Refined Zinc, 1969-70
(short tons)

	1969	1970
1st quarter	37,787	29,470
2nd quarter	33,765	33,072
3rd quarter	27,362	25,399
4th quarter	28,358	29,350
Total	127,272	117,291

Source: Dominion Bureau of Statistics.

WORLD INDUSTRY

MINE PRODUCTION

Mine production of zinc in 1970 in non-communist countries rose by 46,000 short tons over the 1969 figure to reach a total of 4,691,000 tons. Most of the rise was accounted for by Canada, but there were smaller increases by Yugoslavia, Spain and Peru. New mining projects now being carried forward will bring substantial increases in 1971 and 1972. Some of the larger, in addition to those shown for Canada in Table 3, are in the United States (Balmat expansion in New York and a new mine at Leadville, Colorado); Australia (EZ Industries Limited expansion and development at Beltana in Tasmania); Peru (the new Morococha mine of Cerro de Pasco Corporation and an expansion at Huanzala); Japan (expansion of a Hokkaido mine); Yugoslavia (expansion at Trepca); and Nicaragua (the new Neptune mine). Beyond 1972 the Prieska mine in South Africa, the Andaluza project in the Seville district in Spain, and the Hilton project in Australia are among the more important developments. A discovery late in 1970 at Navan, near Dublin, may add a third producer to Ireland's zinc-lead mining industry, which now consists of the Tynagh and Silvermines operations.

METAL PRODUCTION

World metal production in 1970 totalled 4,384,000 tons, 2 per cent less than in 1969. Producers' stocks rose from 302,000 tons at the beginning of the year to

429,000 tons at year-end. Zinc smelters generally curtailed production and operated at less than capacity.

Production in the United States was 13 per cent lower. In Japan, two zinc producers reduced output to avoid excessive air and water pollution, and total Japanese output was 33,000 tons, or 4 per cent, less than in 1969. European production rose by 27,000 tons to 1,518,000 tons, but this was due mainly to the opening of a new plant in Finland by Outokumpu Oy:n late in 1969. Output was lower in Belgium, France, Britain and Yugoslavia. It was higher in West Germany, where new capacity was installed late in 1968, and in Spain and Italy where capacity has also recently been increased.

Several smelter operators announced their intention to close uneconomic zinc plants. American Zinc Company closed its plant in East St. Louis in September, reopened it in November, and early in 1971 announced that this electrolytic plant, which has a capacity of 84,000 tons annually, and also a horizontal retort plant at Dumas, Texas, with capacity of 58,000 tons annually, would be closed at the end of 1971. Matthiessen & Hegeler Zinc Company announced that the vertical retort plant at Meadowbrook, West Virginia with capacity of 40,000 tons annually, would be closed in mid-1971. The New Jersey Zinc Company indicated its vertical retort plant at Depue, Illinois would likely suspend operations in July 1971. Imperial Smelting Corporation Limited intends to close an Imperial Smelting furnace at Swansea, Wales in May 1971. Plant capacity was 55,000 tons annually. Operators in Belgium, Holland and West Germany, planning to build new electrolytic plants, expect to phase out existing horizontal retort plants that have a combined capacity of approximately 150,000 tons annually. A Japanese smelter is planning a similar phasing out of horizontal retort capacity, amounting to 29,000 tons annually, concurrently with the opening of a large new electrolytic plant at Hikoshima.

These intended closures and actual curtailments of production are the result of a complex of factors, including the short-term slackening of economic activity in many countries during 1970, the difficulty of custom smelters obtaining zinc concentrates under severe competitive conditions, the obsolescence of some older smelting processes, and the cost-price squeeze as zinc prices fail to advance sufficiently to keep pace with increasing production costs at certain plants.

Over the longer term, zinc producers generally anticipate that demand for zinc will increase and new mines and additional smelter capacity will have to be

Year	Country	Type and Location	Increase In Capacity (tons per year)
1970	Finland	Electrolytic (new)	120,000
1971	Italy	ISF (new), Portovesme	75,000
	Australia	Electrolytic (expansion) Risdon	25,000
	Japan	Electrolytic (new) Hikoshima	65,000
		Vertical retort (expansion) Miike	25,000
	South Africa	Electrolytic (expansion) Vogelstuisbult	20,000
1972	West Germany	Electrolytic (new) Nordenham	100,000
	Belgium	Electrolytic (new) Liege	55,000
	Japan	Electrolytic (expansion) Hikoshima	26,000
		Electrolytic (new) Iijima	85,000
	Australia	Electrolytic (expansion) Risdon	22,000
	Canada	Electrolytic (new) Timmins	120,000
1973	Japan	Electrolytic (expansion) Hikoshima	40,000
		Electrolytic (expansion) Iijima	46,000
	Algeria	Electrolytic (new) Ghazaouet	44,000
	Mexico	Electrolytic (new) Torreon	115,000
	Netherlands	Electrolytic (new) Budel	66,000
	Yugoslavia	ISF (new) Titow Veles	55,000
	Peru	Electrolytic (new) Lima	44,000
	India	Electrolytic (expansion) Zawar	20,000
1974	India	Electrolytic (expansion) Kerala	22,000
	Japan	Electrolytic (expansion) Kamioka	12,000
1975	India	Electrolytic (new) Vizag	33,000
	Mexico	Electrolytic (new) San Luis Potosi	110,000

TABLE 8

World Mine Production of Zinc, 1969-70
(excluding communist-bloc countries)
(short tons)

	1969	1970p
Canada	1,290,136	1,375,938
United States	607,900	605,900
Australia	507,700	492,000
Peru	347,300	362,300
Japan	296,600	308,500
Mexico	277,400	290,000
West Germany	147,700	152,900
Italy	146,400	120,700
Ireland	107,400	106,400
Dem. Republic of the Congo (Kinshasa)	105,800	..
Sweden	94,200	98,200
Spain	89,100	102,400
Yugoslavia	83,900	110,300
Finland	78,100	69,100
Zambia	75,200	71,300
Other countries (mainly Morocco, South Africa, Argentina, Bolivia)	390,200	424,900
Total	4,645,036	4,690,838

Sources: International Lead and Zinc Study Group.
For Canada, Dominion Bureau of Statistics.
pPreliminary; .. Not available.

TABLE 9

World Production of Refined Zinc, 1969-70
(excluding communist-bloc countries)
(short tons)

	1969	1970p
United States	1,111,300	960,500
Japan	785,200	751,900
Canada	466,800	453,600
West Germany	307,800	331,900
Belgium	283,800	255,700
France	279,500	250,600
Australia	271,500	287,600
Britain	166,500	161,600
Italy	143,700	156,700
Mexico	91,700	89,000
Yugoslavia	89,300	70,900
Spain	88,400	95,700
Peru	70,600	76,100
Dem. Republic of the Congo (Kinshasa)	70,600	68,400
Other countries (mainly Finland, Netherlands, Norway)	265,000	374,000
Total	4,491,700	4,384,200

Source: International Lead and Zinc Study Group.
pPreliminary.

provided. The accompanying table shows new and expanded smelter capacity planned up to 1975. As noted in previous years, the trend toward establishing new capacity near industrial consuming centres is still apparent, with large new capacity planned in Japan, West Germany, Belgium, Netherlands, and India. There is at the same time considerable new smelter expansion planned by mining firms in Canada, Australia, Mexico, Peru, and South Africa.

CONSUMPTION

World consumption of zinc in 1970 totalled 4,310,000 tons, 155,000 tons, or 3½ per cent, less than in 1969. European consumption was down only slightly. In the United States, where deflationary measures and the General Motors strike from September to November combined to reduce manufacturing activity, zinc consumption was off by 15 per cent or 203,000 tons. Zinc used in Japan rose by 6 per cent, a much lower rate than in recent years.

WORLD TRADE

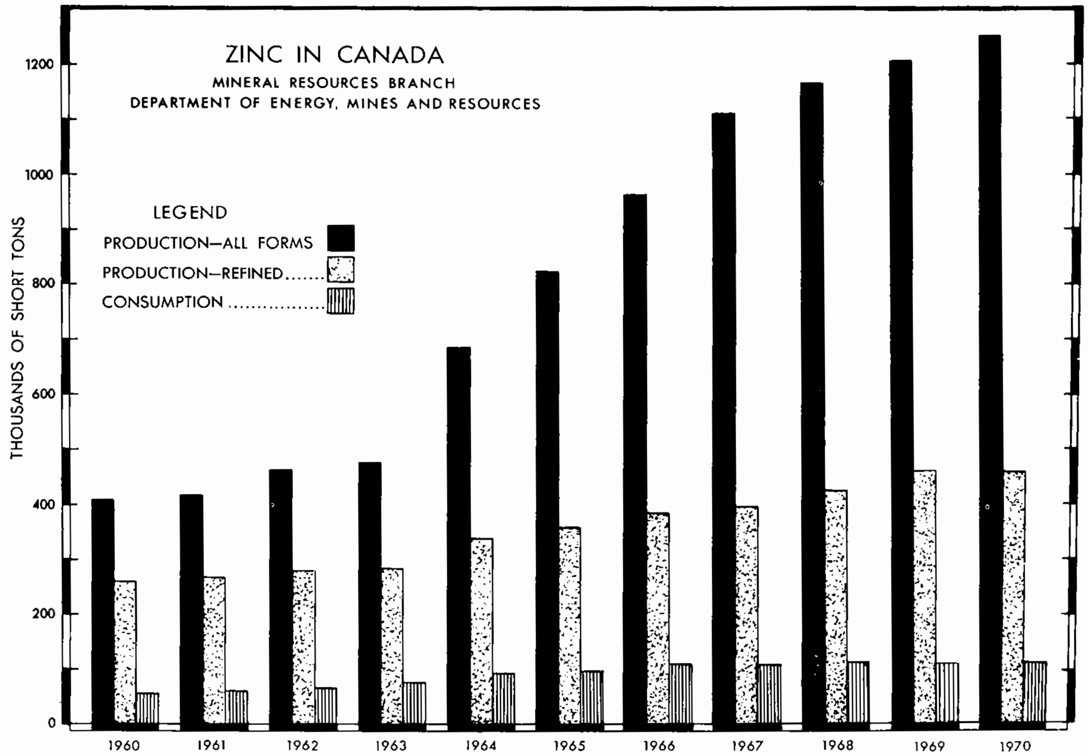
The major consuming areas in the non-communist world are western Europe, United States, and Japan, which between them in 1970 used 3.56 million tons of zinc and accounted for 83 per cent of total consumption. These areas produced only 37 per cent, or 1.75 million tons, of the world's mine output of zinc. Their remaining requirements or approximately 1.8 million tons, were imported as either zinc concentrates or as refined metal, but mostly as zinc concentrates.

TABLE 10

United States Consumption by End Use, 1969-70
(short tons)

	1969	1970p
Galvanizing	476,324	426,724
Brass products	179,469	125,945
Zinc-base alloy	576,391	446,666
Rolled zinc	48,650	39,307
Zinc oxide	41,447	44,196
Other uses	46,042	32,584
Estimated undistributed consumption	–	49,200
Total	1,368,323	1,164,622

Source: U. S. Bureau of Mines, Mineral Industry Surveys, Zinc Industry in December, 1970.
pPreliminary; – Nil.



As may be seen from the accompanying table, total imports into the large consuming areas, calculated from production-consumption data, were divided in 1970 in the ratio of 4½ to 1 between zinc concentrates and refined zinc. This ratio reflects the fact that three-quarters of the world's smelting capacity is in industrialized areas that depend heavily on imported raw materials. A correspondingly large part of the zinc trade of the main exporting countries (Canada, Australia, Mexico and Peru) is in the form of zinc concentrates, and a much smaller part is refined zinc.

	Mine Output	Smelter Output	Consumption
	(1,000's of short tons)		
Western Europe	840	1,518	1,710
United States	605	958	1,159
Japan	308	750	693
Other	2,990	1,148	750

OUTLOOK

Canadian mine production is expected to rise to 1,500,000 tons in 1971 and by 1973 to reach 1,600,000 tons. Smelter capacity will grow from the present level of 536,000 tons to 656,000 tons in 1972.

During the first quarter of 1971 world producers' stocks began to decline from the high level reached at the end of 1970 and prices firmed somewhat. The outlook for 1971 is for a rise in world consumption and some expansion of production, and rising prices.

Zinc demand in non-communist countries has grown since 1950 at an average annual rate of about 4½ per cent, with 1970 consumption totalling 4.3 million tons. The growth rate in the 1960's was nearly 6 per cent annually. Projecting world requirements through the 1970's indicates that substantial new mine and smelter production will be needed to keep pace with demand.

New smelter projects under construction or planned around the world, along with present installations, ensure that smelter capacity will be adequate to meet foreseeable demand. The installation of new smelters in both market and mining areas, if all projects are completed as planned, could lead to some over-capacity. Because of the steady growth of consumption projected for the 1970's and the growing deficiency of mine production in the main consuming areas, demand for zinc concentrates is expected to remain strong.

ZINC USES

Zinc is used to galvanize steel and to make diecastings, copper alloys, zinc sheet, and 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.

Diecastings 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. The average automobile contains about 100 pounds of zinc in these parts. It contains also some 190 pounds of galvanized steel whose zinc coating weighs about 13 pounds.

Zinc-base diecastings 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 diecastings 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.

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 as terrazzo strip and anti-corrosion 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 constitutent of the paper coating for coated paper electrostatic copiers. Zinc Oxide Company of Canada, Limited, a Montreal-based subsidiary of Hudson Bay Mining and Smelting Co., Limited, is the leading Canadian supplier. Zinc oxide is also used in compounding rubber and in making paint, rayon yarn, ceramic materials, inks, matches, and many other commodities. Zinc dust, which is a finely divided form of zinc metal, is used in the processes 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 diecastings and of improved zinc-base diecasting alloys has done much to expand the use of zinc as a diecasting metal in competition with alternative materials such as aluminum and plastics. A new alloy, called Prestal, has recently been developed. Prestal, 78 per cent zinc and 22 per cent aluminum, is reported to have a percentage elongation many times that of deep drawing steel. Because of this ductility, it is called a "superplastic" alloy that will find use in pressed parts for automobiles and appliances.

RESEARCH

Research on zinc at the Mines Branch (Department of Energy, Mines and Resources) was continued in the separate fields of hot-dip galvanizing and zinc alloy development.

Galvanizing. In the fundamental galvanizing study being made with the co-operation of the Canadian Zinc and Lead Research Committee, the object is to investigate the parameters which influence and control the reactivity of ferrous metal surfaces in contact with molten zinc and zinc alloys as used in galvanizing.

Extensive effort was required to achieve desirable levels of experimental control and cleanliness in operation of the hydrogen-atmosphere galvanizing apparatus specially built for the project. Work in the initial experimental phase has been concerned with the galvanizing of a range of iron-base binary alloys containing several levels of silicon, phosphorus and manganese. Evaluation of these experimental coatings is in progress. Preparatory work for the second phase of the project dealing with the effects of crystallographic orientation of the iron substrate was also initiated.

Zinc Alloy Development. Work in this period has been mainly on various aspects of the effects of impurities (lead chosen as a typical deleterious impurity) on zinc-aluminum alloys.

The program has included the location of lead in the micro-structure of the alloys using the electron microprobe, attempts to eliminate or neutralize the lead by combining it with other elements, and other related effects such as grain coarsening and the precise location of corrosion paths in the alloy micro-structure.

Another aspect of zinc alloy technology investigated in this period has been the low temperature impact strength of cast and wrought zinc-aluminum alloys. In particular, the marked difference in impact behaviour brought about by hot working and by various heat treatments has been examined.

PRICES

The Canadian price of Prime Western Zinc, f.o.b. Toronto and Montreal, during 1970 was as follows:

Jan. 1 to Aug. 23	15.50 cents per lb
Aug. 24 to end of year	15.00 " " "

The average for the year was 15.32 cents per lb. On April 1, 1971 and again on May 17, the price was raised by 0.5 cent to 16.00 cents a pound.

The Canadian price used in the calculation of the value of Canada's zinc production was 15.93 cents per lb, which was equivalent to the High Grade price.

The United States price, Prime Western, East St. Louis was as follows:

Jan. 1 to Aug. 20	15.500 cents per lb
Aug. 21 to end of year	15.000 cents per lb

The average for the year was 15.319 cents per lb. On March 22, 1971 and again on May 13, the price was raised by 0.5 cent to 16.00 cents a pound. The United States zinc industry on January 6, 1971 initiated a new pricing practice, abandoning the f.o.b. East St. Louis base price in favour of a delivered quotation for all domestic sales.

The Producer Basis price used as a base for most sales outside North America was £127.950 per metric ton (13.93 cents a pound U.S. equivalent) during the whole of 1970. It was raised to £150 per metric ton on June 17, 1971.

The price in 1970 on the London Metal Exchange moved from a monthly average of £126.1 during January to £120.6 per metric ton during December. The price on May 31, 1971 was £125.0 per metric ton.

TARIFFS

The following Canadian and United States tariffs apply for zinc in its various forms:

Item No.		British Preferential	Most Favoured Nation	General
CANADA				
32900-1	Zinc in ores and concentrates	free	free	free
34505-1	Zinc spelter, 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-per 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				
602.20	Zinc ores and concentrates	0.67¢ per lb on zn content		
	Unwrought zinc			
626.02	Other than alloys of zinc	0.7¢ per lb		
626.04	Alloys of zinc	19%		
626.10	Zinc waste and scrap	0.75¢ per lb		
603.30	Zinc dross and skimmings	0.75¢ per lb		
653.25	Zinc anodes			
	On and after Jan. 1, 1970	13%		
	On and after Jan. 1, 1971	11%		
	On and after Jan. 1, 1972	9.5%		

Canada
Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

United States
Source: Tariff Schedules of the United States Annoted (1970) T C Publication 304.

Zirconium and Hafnium

G.P. WIGLE*

Canada does not produce zirconium – or hafnium-bearing minerals but has many minor occurrences of zircon (ZrO_2SiO_2), the principal mineral source of zirconium. Hafnium is always associated with zirconium in zircon. Canada's use and consumption of imported zirconium metal, zirconium alloys, and zircon mineral concentrates have been increasing but no domestic sources of the mineral have been developed.

Canada's imports of zirconium alloys were 207,114 pounds valued at $3.7 million in 1970 compared with 208,695 pounds valued at $4.5 million in 1969, and 220,165 pounds valued at $6.3 million in 1968. These imports are principally of material required for the installation of nuclear power reactors already undertaken in Canada. Zirconium alloyed with 2.5 per cent columbium (niobium) was chosen for the pressure tubes in Canadian power reactors that are approaching completion.

Canada's nuclear power and related industries achieved a degree of integration with the completion and operation of the zirconium production plant of Eldorado Nuclear Limited at Port Hope, Ontario. The plant produces zirconium ingot metal and alloy for pressure tubes and fuel cladding tubes used in Canada's growing nuclear reactor power development. The unique process developed by Eldorado that bypasses the intermediate stage of making sponge metal in the process of producing zirconium ingot uses zircon sand concentrates from Australia as raw material.

Zircon (ZrO_2SiO_2), the principal mineral source of zirconium, has its major commercial use in the form of sand concentrates of the natural mineral in making foundry sand moulds, and in the manufacture of refractories, and abrasives. Zircon is also used to produce zirconium metal, alloys and compounds. The metal is highly resistant to corrosion, has strength at high temperature, and a *low* absorption capacity (or high transparency) for thermal neutrons that makes it and its alloys of particular importance as tubing used for fuel-cladding, pressure tubes, and structural material in thermal nuclear power reactors using natural uranium fuel.

Hafnium always occurs, in small amounts, with zirconium and is so similar chemically that it was not positively identified until 1922. It is recovered as a byproduct of reactor-grade zirconium which must be free of hafnium. Its principal importance is, at present, for neutron control rods in nuclear reactors because of its *high* neutron absorption capacity. Zirconium allows relatively free passage of neutrons whereas hafnium acts as a control barrier.

PRODUCTION AND TRADE

Australia became the world's leading producer of zirconium minerals soon after the start of the mineral-sands industry on its east coast in 1934. Its position has been maintained, except in 1938 when production was very low and in 1942 when Brazil's output of baddeleyite (ZrO_2) exceeded Australian production of zircon. Australia's production of zircon concentrates in the first half of 1970 was 198,393 tons with a zircon (ZrO_2SiO_2) content of 195,227 tons. Preliminary figures, subject to revision, reported by the Bureau of Mineral Resources, Geology and Geophysics, Canberra, indicate production of 413,611 tons of zircon concentrates and export of 348,591 tons in 1969.

The United States is the second largest producer of zircon and is the only substantial producer other than Australia. Zircon is recovered in the United States as a co-product of dredging for heavy-mineral sands in Florida and Georgia. Production statistics are not

*Mineral Resources Branch.

TABLE 1

Canada, Zirconium Imports, 1969-70

	1969		1970P	
	Pounds	$	Pounds	$
Imports				
Zirconium alloys				
United States	203,039	4,459,000	204,463	3,620,000
Sweden	3,575	64,000	2,161	41,000
France	289	7,000	195	3,000
Japan	1,792	5,000	193	2,000
Italy	–	–	102	1,000
Total	208,695	4,535,000	207,114	3,667,000
Consumption				
Ferrozirconium (gross weight)	60,000	..	..	..

Source: Dominion Bureau of Statistics.
PPreliminary; –Nil; ..Not available.

published but United States consumption was an estimated 160,000 tons in 1969 and imports of zircon concentrates, reported by the Bureau of Mines, were 95,414 tons in 1969 and estimated 100,000 tons in 1970.

Japan imported 79,416 tons of zircon concentrates from Australia in 1969; the United States imported 83,166 tons. Three Japanese metals firms, Kobe Steel, Sumitomo Metal Industries, and Mitsubishi Metal Mining planned to start, or expand, production of zirconium alloy cladding tubes.

The Phosphate Development Corporation, a government-controlled company mining apatite at Phalaborwa in the Transvaal, Republic of South Africa, began producing byproduct baddeleyite (ZrO_2) in 1969. Palabora Mining Co. Ltd., in the same area, planned to complete a zirconia (ZrO_2) recovery unit for its copper and uranium recovery plant in 1970.

TABLE 2

Australian Zircon Production, 1960-69
(short tons)

	Zircon Concentrates	Zircon (ZrO_2SiO_2 content)
1960	114,645	113,673
1961	152,859	150,642
1962	149,902	147,962
1963	207,010	203,965
1964	206,172	204,035
1965	254,087	251,612
1966	263,927	260,851
1967	317,724	313,962
1968	329,498r	325,829r
1969	413,611p	399,394p

Source: Australian Mineral Industry, Quarterly Review.
rRevised; pPreliminary.

TABLE 3

Australian Exports of Zircon Concentrates, 1967-69
(short tons)

	1967	1968	1969P
United States	70,870	64,340	83,166
Japan	62,704	66,232	79,416
Britain	34,627	44,552	38,840
Netherlands	23,885	..	..
Italy	23,268	..	..
France	16,299	28,455	26,686
Canada	10,993	..	..
Germany (F.R.)	9,755	..	..
Spain	6,191	..	..
Belgium	4,938	..	..
Others	13,310	94,476	120,483
Total	276,840	298,055	348,591

Source: Australian Mineral Industry, Quarterly Review.
PPreliminary; .. Not available at time of publication.

TABLE 4

World Production of Zircon Concentrates, 1968-70
(short tons)

Country	1968	1969	1970[e]
Australia	329,498	413,611[p]	410,000
United States	..	..	..
Brazil	3,083	3,874	
Malaysia	1,241	1,562	
Thailand	3,549	276	(5,000)
Ceylon	28	75	
Malagasy	..	..	
Total	337,399	419,398	415,000[e]

Sources: Australian Mineral Industry, Quarterly Review; U.S. Bureau of Mines Minerals Yearbook.

[p]Preliminary; [e]Author's estimate; ..Not available.

PRODUCTS AND USES

The principal use of zircon is in making steel and iron foundry sand moulds, mould facings and cores, and as milled flour for mould and core washes; it is used especially in steel foundry production of castings having exacting specifications. Foundry consumption of zircon in the United States is estimated to be more than 50 per cent of total domestic consumption of zircon sand concentrates. Silica sand, olivine and chromite are zircon's chief competitors in foundry use. The specifications for zircon sand supplied by Associated Minerals Consolidated Limited, of Southport, Queensland, Australia, are:

Zircon Sand Specifications

	per cent
ZrO_2 (including HfO_2)	66.0 minimum
SiO_2	33.3 maximum
TiO_2	0.10 maximum
Fe_2O_3	0.15 maximum
Al_2O_3	0.15 maximum

Zirconium is used for other refractory applications as zircon sand and as zirconia (ZrO_2) for the manufacture of bricks and refractory shapes. Milled zircon and zirconia are used as opacifiers in ceramic glazes, enamels, in electric insulators, pigments, abrasives, and in chemicals. The dioxide alone or mixed with other oxide carriers such as alumina, silica, magnesia, or clay is used as a catalyst in the production of gasolines, and in the cracking stage of refining crude oils. Zirconium tetrachloride is the principal intermediate chemical compound used in the manufacture of other zirconium compounds.

Zirconium metal, from which most of the small percentage of hafnium has been removed, is called 'reactor grade' and is used in nuclear power reactors. The important properties of zirconium in this application are its low neutron cross-section (0.18 barns), good mechanical strength, high heat conduction and corrosion resistance. A 500,000 kilowatt unit of the CANDU-PHW (pressurized heavy water) type of power reactor being installed at Pickering, Ontario, requires approximately 55 tons of zirconium in the initial installation and 7.6 tons a year for replacement fuel rods.

Hafnium, which is only recovered as a byproduct in the processing of zircon to reactor-grade zirconium, is used as a neutron control-rod material in nuclear power reactors. Its use in this application is because of its high neutron absorption cross-section (108 barns), which also makes necessary its removal from reactor-grade zirconium. The use of hafnium outside the field of nuclear technology is limited to specialized applications. These uses, developed or proposed, are as incandescent filaments, as a "getter" in vacuum tubes to absorb traces of oxygen and nitrogen, as electrodes in x-ray tubes, in rectifiers, photography flash powders, and as a component of explosive detonating caps.

MINERALS AND OCCURRENCES

Zirconium is widely distributed in nature, and although not one of the most abundant elements it is estimated to constitute 0.022 per cent of the earth's crust, which is more than the better known metals such as zinc, nickel, copper and lead. All zirconium minerals contain some hafnium. The two elements are very similar chemically and the presence of hafnium in zirconium minerals and purified compounds was not suspected for many years.

The most important zirconium mineral is the silicate, zircon (ZrO_2SiO_2). Due to its resistance to weathering, attrition, and high specific gravity, it is found in beach deposits of heavy minerals in association with ilmenite, rutile and monazite. The oxide, baddeleyite (ZrO_2), is the other important zirconium mineral; it is found in Brazil where it occurs as alluvial pebbles and in nepheline-bearing rocks and in South Africa where it is recovered as a byproduct of the processing of apatite ores. Zircon is theoretically 67.2 per cent ZrO_2 and 32.8 per cent SiO_2, but usually contains about 2 per cent hafnia (HfO_2). Baddeleyite is essentially pure zirconium oxide in crystalline form but usually contains about 1 per cent hafnia. Certain altered varieties of zircon, such as alvite and cyrtolite, contain hafnia in amounts varying from 5 per cent to over 10 per cent.

Zircon is an accessory mineral in igneous, sedimentary, and metamorphic rocks but is rarely found in minable concentrations except where weathering and reconcentration have occurred. It is a typical minor mineral constituent of pegmatites and nepheline syenites, occasionally appearing as local patches of crystalline zircon and cyrtolite. It usually occurs as shiny, stout, brownish crystals with low pyramids at the terminations.

Patches several square feet in area containing zircon crystals ranging from one-tenth to one inch in diameter have been found in Haliburton County, Ontario. Occurrences of scattered crystals of zircon and cyrtolite have been noted in Renfrew and Hastings Counties and in Henry Township, Parry Sound district, Ontario. Rich zones of zircon crystals associated with titanite in a large body of pyroxenite are reported in Harrington Township, Argenteuil County, Quebec. Small amounts of microscopic crystals, estimated at 0.2 per cent of the rock, occur in a band of mica-apatite-feldspar-pyroxene rock in Suzor Township near Parent, Laviolette County, also in Quebec.

The most important sources of zircon are natural concentrations of heavy minerals found in beach sands along the most easterly part of the Australian coast. Bulk concentrates made from Australian zircon-rutile-ilmenite sands range from 45 to 75 per cent zircon, 10 to 30 per cent rutile, and 10 to 20 per cent ilmenite. Other constituents are monazite, garnet, cassiterite, tourmaline and spinel. Zircon-bearing sands are found in many other countries including India, Republic of South Africa, USSR, Sierra Leone and the United States.

MINING AND CONCENTRATION OF MINERAL SANDS

Natural concentrations of mineral-bearing sands are mined by dredging to recover zircon, rutile and ilmenite. The mining plant usually used on the east Australian shorelines consists of a floating dredge and a concentrating plant. The concentrating plant is floated on pontoons in the dredge pond for large plants but is usually land-based for small plants working on small isolated deposits. A fully-floating plant described by Associated Minerals Consolidated Limited has a capacity of 600 tons an hour when operating in normal dredging ground having an average grade of about 2 per cent heavy mineral. A smaller plant is built in sections, each on skids, so they can be moved by tractors to follow the dredging. The larger, fully-floating plant, operating on an average feed grade of 1.9 per cent heavy mineral averaged 92.1 per cent recovery over a period of 10 months. The overall mining recovery was 85.3 per cent after allowing for mineral left in topsoil and on the pond bottom. Primary concentrates, assaying from 80 to 95 per cent heavy mineral, are trucked to a final product-separation plant for concentration and cleaning of the different mineral products to high-grade bulk and packaged concentrates. The products recovered by Associated Minerals Consolidated are Standard Zircon, Premium Zircon, Zircon Flour, Ilmenite, Rutile and Monazite. The zircon products contain a minimum of 66 per cent ZrO_2.

OUTLOOK

The production of zircon is a component of the mineral sands industry and has expanded with increased production of rutile and ilmenite. Zircon sands have remained relatively inexpensive because of their co-product nature; their major use in iron and steel foundries has expanded. Apparent consumption of zircon in non-communist countries has doubled since 1960 to an estimated 350,000 tons in 1968, of which 80 per cent, or more, goes into foundry, refractory, ceramic, and abrasive applications. Chromite sand is a strong competitor for use in foundry mould applications and substitution could change the uses and markets for zircon, making supplies more readily available for metallic uses. Zircon production capacity in non-communist countries was an estimated 450,000 tons a year at the beginning of 1970. It is unlikely that there will be any shortage of zircon concentrates prior to 1976.

PRICES

	US $, Dec./69	Dec. /70
Zircon ore[1]		
sand, per long ton, c.i.f. US ports, bags, 65% ZrO_2	70.00	70.00
Camden, N.J., bulk, 60% ZrO_2 per short ton	66.50-68.00	66.50-68.00
Starke, Fla., domestic, bags	56.00-57.00	56.00-57.00
Zirconium[1]		
per pound, f.o.b. shipping point, sponge, powder. platelets, low hafnium	7.00-14.00	7.00-14.00
commercial	5.00-10.00	5.00-10.00
Hafnium[2]		
sponge, per pound	75.00	75.00
rolled bar, plate, per pound	120.00	120.00

Sources: [1]*Metals Week;* [2]*American Metal Market.*

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General
34720-1	Sponge and sponge briquettes, ingots, blooms, slabs, billets and castings in the rough, of zirconium or zirconium alloys for use in Canadian manufacture (expires 30 June, 1971)	free	free	25%
34730-1	Bars, rods, sheet, strip, wire, gorgings, castings, and tubes, seamless or welded, of zirconium or zirconium alloys for use in the manufacture of nuclear power reactors, including fuel components (expires 31 Jan. 1970)	free	free	25%
33508-1	Zirconium oxide (effective 1 Jan. 1969)	free	5%	15%
92845-4	Zirconium silicate (effective 1 Jan. 1969)	free	free	free

UNITED STATES

Item No.		Effective on and after January 1 1970	1971	1972
601.63	Zirconium ore (including zirconium sand)	free	free	free
639.60	Zirconium metal, unwrought, other than alloys, waste and scrap (duty on waste and scrap suspended on or before 30 June 1971)	8.5%	7%	6%
629.62	Zirconium, unwrought alloys	10.0%	9%	7.5%
629.65	Zirconium metal, wrought	12.5%	10.5%	9%
422.80	Zirconium oxide	7%	6%	5%
422.82	Other zirconium compounds	7%	6%	5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
Tariff Schedules of the United States Annotated (1970), TC Publication 304.

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