MINERAL REPORT 19

CANADIAN MINERALS YEARBOOK 1969

MINERAL RESOURCES BRANCH

DEPARTMENT OF ENERGY, MINES AND RESOURCES

OTTAWA

1971

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Foreword

This issue of the Canadian Minerals Yearbook is a report of developments in the industry for 1969. The 56 chapters dealing with specific commodities, were issued in advance under the title Preprints, Canadian Minerals Yearbook 1969 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 67 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 1970

Editor: G.E. Thompson

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Readers wishing more recent information than that contained in the present volume should obtain the 1970 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:

TWO, 25-CUBIC YARD COAL SHOVELS at Kaiser Resources Ltd. surface mine at Sparwood, British Columbia.

(Photo by Hunter) 1970.

Contents

General Review

THE CANADIAN ECONOMY IN 1969

In 1969 the value of Canada's Gross National Product (GNP) reached $78.1 billion, an increase of 9.3 per cent.* This growth comprised a 4.8 per cent rise in real output and a 4.5 per cent increase in prices; it compares with growth the previous year in real output and prices of 4.7 per cent and 4.2 per cent respectively. Figure 1 shows the growth in GNP from 1949 to 1969 and the relationship between the national product in current and in constant dollars.

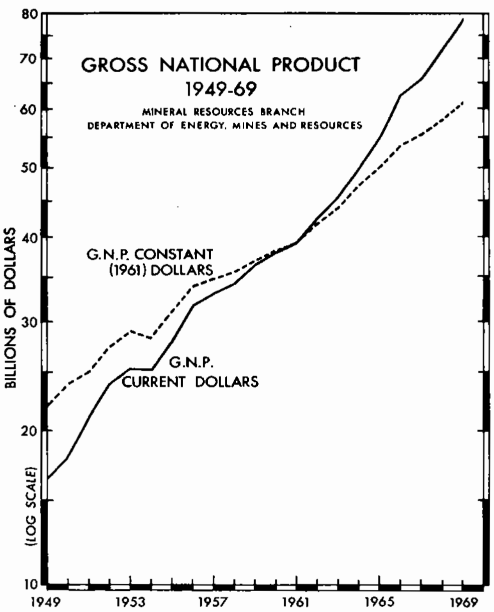

Figure 1

*All statistics used in the text and in diagrams have been taken from publications of the Dominion Bureau of Statistics, unless otherwise noted.

The average size of the labour force in Canada in 1969 was 8.16 million persons. This was an increase of 243,000 from the average in 1968. The number of people employed increased by the same amount; thus the overall rate of people unemployed fell by one tenth of a percentage point, to 4.7 per cent. The historical trend in the size of the Canadian labour force and the unemployment rate is shown in Figure 2.

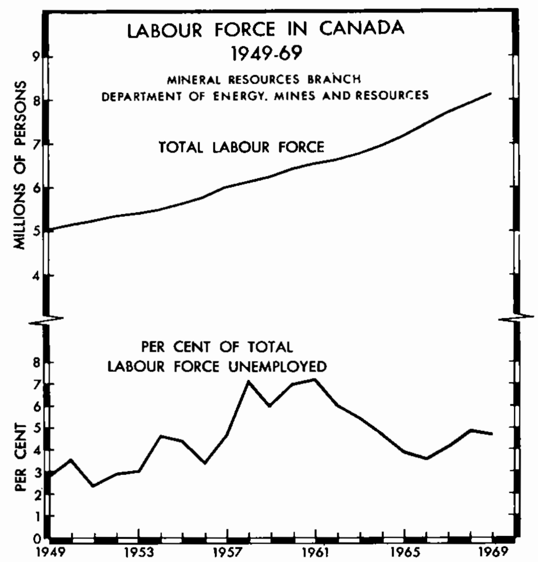

Figure 2

Expenditures on goods and services and investment on construction and machinery, as reported as part of Gross National Expenditure, all increased in Canada in 1969. Personal expenditures on goods and services rose to $46.4 billion an increase of 9.4 per cent; government expenditures on goods and services rose 13.8 per cent, to $13.7 billion. Total Fixed Capital

Formation by Business increased 9.2 per cent to $14.0 billion; of this, investment in new residential construction increased 16.3 per cent to $3.8 billion, new non-residential construction increased 4.8 per cent to $4.7 billion and investment in new machinery rose 8.6 per cent to $5.5 billion (Figure 3).

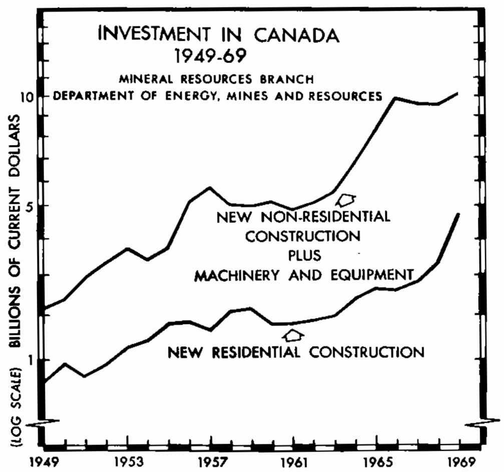

Figure 3

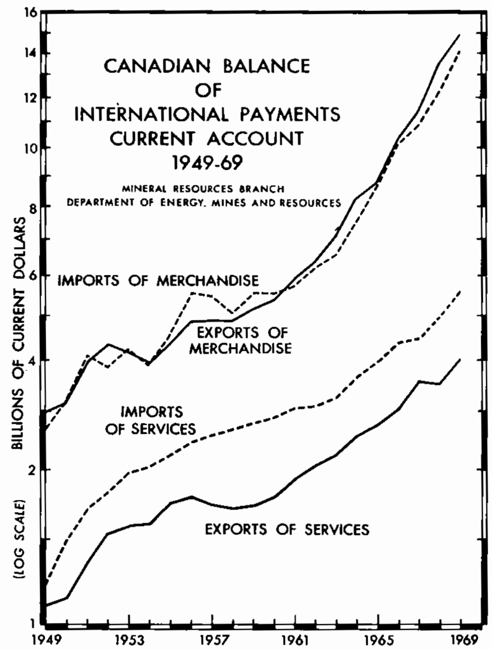

Figure 4

Trade between Canada and other nations rose sharply in 1969. Total current account exports were $18.9 billion, up 10 per cent; total current account imports were $19.6 billion, up to 13.5 per cent. Thus, the current account deficit rose from $60 million in 1968 to $722 million in 1969. The main components of the current account of Canada's Balance of International Payments are shown in Figure 4.

Exports of goods rose almost $1.3 billion to $14.9 billion and exports of services rose by about $0.5 billion to $4.0 billion. Among merchandise exports, trade in metals was lower than 1968 following the settlement of labour problems in the United States in 1968 coupled with extended strikes in the Canadian iron, steel, copper, and nickel industries in 1969. Wheat sales were also down. However, exports of automobile products, forest products, petroleum, and machinery were higher than in 1968. Imports of goods rose $1.7 billion to $14.0 billion and imports of services rose $0.6 billion to $5.6 billion. Increased domestic demand coupled with the Kennedy Round of tariff cuts introduced in mid-1969 led to general increases in merchandise imports. Among notable increases in imports were automobile parts, meat, sugar, petroleum, chemicals, and some metals.

On the services side of the current account, the deficit increased to $1.59 billion from $1.44 billion in 1968. Interest and dividends paid abroad increased by $80 million to $1.36 billion; receipts increased about $70 million to $406 million. Travel expenditures by Canadians abroad increased sharply in 1969 and reached $1.28 billion compared with $1.02 billion in 1968. Travel expenditures by foreigners in Canada also increased, reaching $1.08 billion; however, this was about $240 million less than the record reached in the year of Expo 67. The balance of merchandise trade, together with the chief components contributing to the deficit in non-merchandise trade are shown in Figure 5.

The deficit on Current Account must be balanced by capital movements and official transactions. Figure 6 shows the behaviour of Net Capital Movement and the major components of the Capital Account from 1949 to 1968. The large surplus in net capital movement indicates inflow of capital into Canada that was, in part, responsible for the rapid growth of the mineral industry. 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 Canadian Securities, i.e., Canadian bonds, debentures and stock delivered to non-residents, and payments to non-residents on the retirement of Canadian securities.

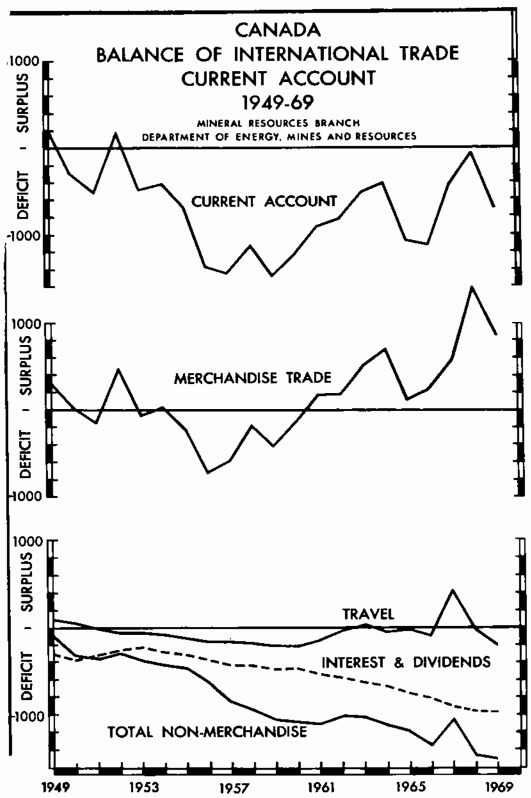

Figure 5

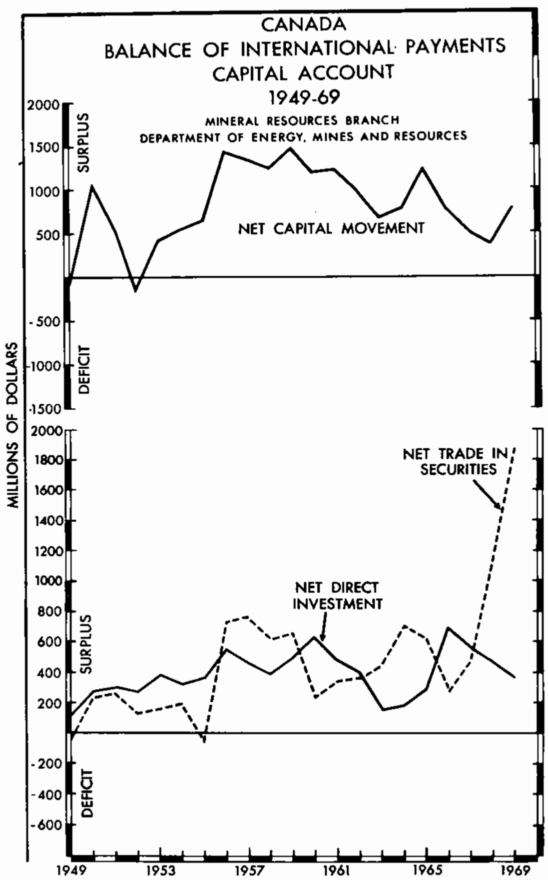

Figure 6

A REVIEW OF THE MINERAL ECONOMY

The value of output of the Canadian mineral industry in 1969 was $4,713 million*, lower by $14 million than the output in 1968. This was the first time in eleven years that mineral industry output declined. The following table shows that the fall in output was entirely within the metals sector, which declined 6.8 per cent as a result of prolonged strikes that affected output of copper, nickel, and iron ore. The mineral fuels industry continued its growth pattern with output increasing 9.5 per cent to a record $1,471 million. The historic pattern of growth in the main industry sectors is shown in Figure 7.

The index of the physical volume of output of the mining industry (mining, milling, and oil wells) declined 2.8 points to 149.9**. Within the various sectors of the industry, the metal mining index fell by 11 per cent to 126.9, the fuels index rose nearly 10 per cent to 180.0, and the nonmetals index rose 13.0 per cent to 221.6.

Production in Major Sectors of the Mineral Industry†, 1968-69
(millions of dollars)

	1968	1969	Per Cent Change 1968-69
Metals	2,493	2,324	-6.8
Industrial Minerals	890	919	3.3
Nonmetals	(447)	(458)	2.5
Structural Materials	(443)	(461)	4.1
Fuels	1,343	1,471	9.5

†Includes Clay Products, Cement and Lime.

*Mineral production measured on a commodity basis; for a description of the commodity basis of statistical reporting, as distinct from the mining industry basis, please see the Statistical Tables on page

**1961 = 100.

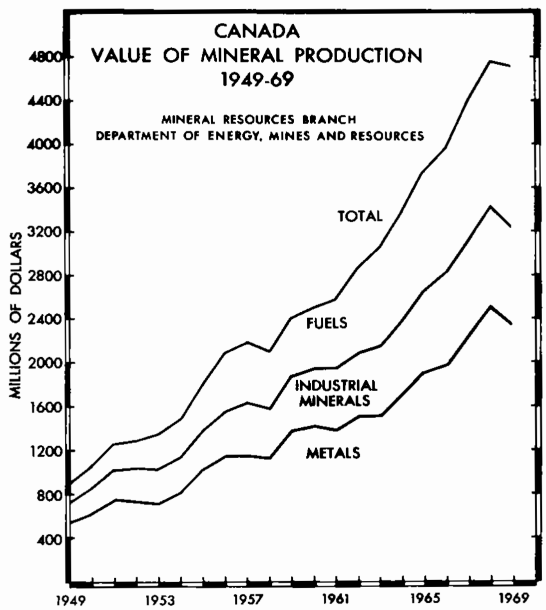

Figure 7

Crude petroleum maintained its position as the leading mineral commodity in terms of value. Output in 1969 at $1,020 million, exceeded $1 billion for the first time in any year; natural gas and natural gas byproducts both increased in value of output, but coal declined.

Copper was again the leading mineral in the metallics group, although output was lower than in the previous year as a result of labour stoppages. New production is scheduled from five provinces and the Yukon Territory. Of particular interest in the copper industry has been the development and continued discovery of large, low-grade deposits in British Columbia; similar deposits could well be found in the Yukon Territory. Nickel production, reduced in 1969 as a result of labour strikes, is scheduled to increase, as production facilities are expanded. Iron ore production fell sharply as mines were closed by work stoppages. Zinc production was again at a record and Canadian production remained the world's largest, in terms of mine output. Among nonmetallic minerals, output of asbestos, cement, and sand and gravel rose.

Figure 8 shows the distribution of Canadian mineral production, in terms of value of output, by provinces and by commodity in 1969. Ontario remained the leading mineral producer, although its share of total production fell from 28.3 per cent to 25.8 per cent. Alberta remained second in terms of value of output but increased its share from 22.9 per cent to 25.6 per cent. Rank and proportion of output for the other provinces remained much the same as in 1968 except for Manitoba, which moved from seventh to sixth position as its share increased from 4.4 per cent to 5.2 per cent.

Canada's mineral production and Gross National Product (GNP), both expressed in terms of dollars per head of the population, are shown in Figure 9. In 1969, the growth of these series was over 7 per cent for GNP per head, but -6 per cent for mineral value per head. Figure 9 also shows the comparable two series for the United States where, in terms of value per head, mineral production has fallen behind Canada's while GNP is considerably higher. In absolute

Canada's Ten Leading Minerals, 1965-69

	Value in Millions of Dollars					Per Cent of Total Mineral Production				
	1965	1966	1967	1968	1969	1965	1966	1967	1968	1969
Petroleum	722	792	865	938	1,020	19.3	19.9	19.7	19.7	21.6
Copper	381	454	583	596	575	10.2	11.4	13.3	12.5	12.2
Nickel	430	377	463	527	482	11.5	9.5	10.5	11.0	10.2
Iron ore	413	432	470	556	432	11.0	10.9	10.7	11.7	9.2
Zinc	248	291	322	330	365	6.6	7.3	7.3	6.9	7.8
Natural gas	187	178	198	233	263	5.0	4.5	4.5	4.9	5.6
Asbestos	146	164	165	190	198	3.9	4.1	3.7	4.0	4.2
Cement	142	156	143	157	171	3.8	3.9	3.2	3.3	3.6
Sand and gravel	134	152	144	128	131	3.6	3.8	3.3	2.7	2.8
Gold	136	125	113	104	94	3.6	3.1	2.6	2.2	2.0
Total	2,939	3,121	3,466	3,759	3,731	78.5	78.4	78.8	78.9	79.2
All others	806	852	933	1,004	992	21.5	21.6	21.2	21.1	20.8
Total	3,745	3,973	4,399	4,763	4,713	100.0	100.0	100.0	100.0	100.0

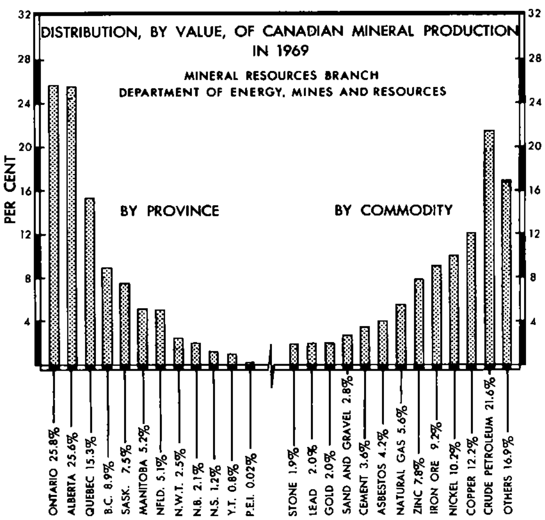

Figure 8

terms, in 1969, the value of the United States GNP was about $932 billion (U.S.) and the value of mineral production was about $27 billion (U.S.)*.

The indexes of production shown in Figure 10 are part of the series, "Real Domestic Product by Industry", defined according to the 1960 Standard Industrial Classification (SIC) with a 1961 base but recalculated to 1949 = 100. The Composite Index of Industrial Production has an annual compound rate of growth of 6.0 per cent for the period shown in the figure (1949 to 1969). The rate of growth for Electric Power Utilities is 9.0 per cent a year. For Total Mining, including milling, quarries, and oil wells the rate of growth is 7.5 per cent a year. For Total Manufacturing, the rate of growth is 5.3 per cent a year from 1949-1969.

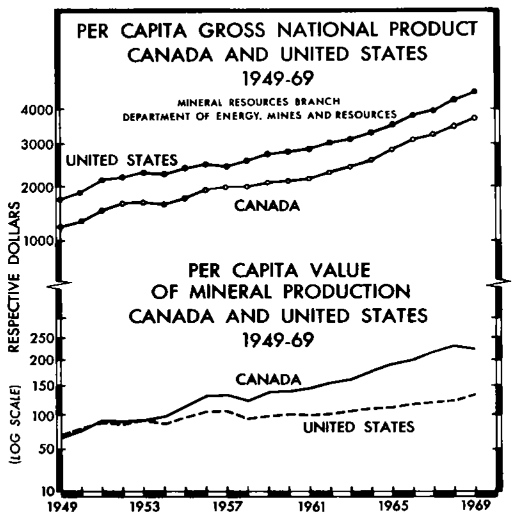

Figure 9

*United States, Department of Commerce, Bureau of the Census, Office of Business Economics, "Survey of Current Business", 1970. United States, Department of the Interior, Bureau of Mines, "News Release", January 1970.

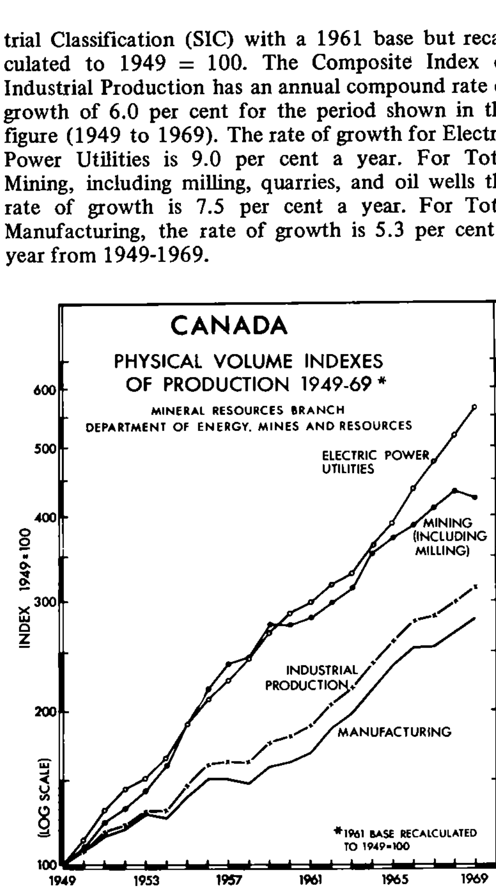

Figure 10

The relation between output and employment in mining and in manufacturing for Canada and for the United States is shown in Figure 11. Each graph represents the ratio:

$$\frac{\text{Index of Industrial Production, by Sector}}{\text{Index of Employment, by Sector}}$$

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. The growth rate in the mining series in both countries is higher than the rate in manufacturing, and the Canadian mining series has a higher rate of growth than the American series. The relationship between production and employment in the mining industries of both Canada and the United States remained the same in 1969 as in 1968, as did the ratio for United States manufacturing. This is the first time in more than a decade that these series have failed to increase. The ratio for Canadian manufacturing rose from 1.93 in 1968 to 2.00.

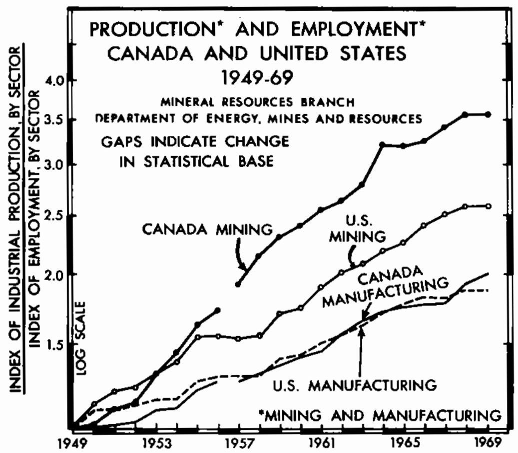

Figure 11

Capital expenditures in the Canadian mineral industry were $1,096 million in 1969, according to preliminary estimates, $70 million higher than spending had been initially forecast by the industry. Revised statistics indicated that expenditures in 1968 were also $30 million higher than estimated so that the peak and downturn shown in Figure 12, of the 1968 issue of the Canadian Minerals Yearbook did not, in fact, occur; investment in the mineral industry has been progressively greater each year since 1959. The fall in expenditures in Petroleum and Natural Gas in 1967 and 1968 was offset by the increase in all other mining. According to the industry canvass carried out by the Dominion Bureau of Statistics, investment in 1970 will be about $1,167 million, up nearly $70 million from the preliminary estimate for 1969. This is an indication that the high level of activity the industry has experienced in the past decade should continue.

METAL AND MINERAL PRICES

Mineral and metal markets were, for the most part, strong in 1969 and the prices of most mineral commodities rose. Notable exceptions to this trend were elemental sulphur, silver and potash. Price changes in the major mineral commodities are summarized below; for details on price behaviour, the individual commodity reviews in this Yearbook should be consulted.

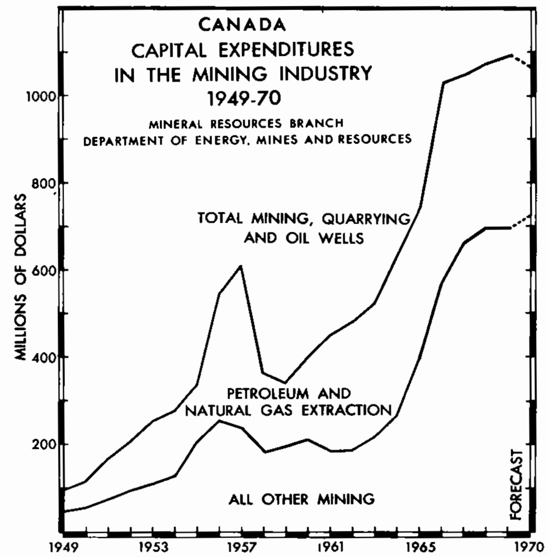

Figure 12

The Canadian producer's price of copper was 45 cents a pound at the beginning of 1969; it rose to 48-1/2 cents in January, to 50 cents in May, to 53 cents in August, and to 57 cents in September, remaining at that level the remainder of the year. Consumers purchasing copper at the London Metal Exchange (L.M.E.) price faced a more or less steady increase from 55 cents (U.S.) at the beginning of the year to 76 cents (U.S.) a pound at the end of the year. The price of nickel was maintained at $1.03 (U.S.) a pound by Canadian producers most of the year despite a severe shortage that saw European consumers paying a dealer's price of nearly seven dollars a pound. The Canadian producer's price was increased to $1.28 (U.S.) a pound in November 1969. The Canadian price of zinc rose in three stages from 13.5 cents a pound at the beginning of the year to 15.5 cents at the end. Lead prices also started the year at 13.5 cents a pound, but rose in six steps of one half cent each and ended the year at 16.5 cents. The Lake Erie base price for iron ore, which governs the price received by most eastern and central Canada producers, remained steady during 1969. Western producers, shipping mainly to Japan, have faced declining prices for several years. Some contracts in 1969 called for lower prices, but the declines were small and it would appear that prices in this market have levelled out. The price of silver in Canada was at a high of $2.178 a troy ounce in mid-January and fell to a low of $1.670 an ounce at mid-year. The average price for the year was $1.931 an ounce.

Substantial price advances occurred for many of the alloying, additive, reactive and less common metals in 1969. Notable price advances took place for columbium, cobalt, chromium, molybdenum, titanium, vanadium, tungsten, zirconium and many metals recovered as byproducts of base-metal smelting and refining. This latter group includes selenium, tellurium, bismuth and the platinum group metals.

Of the industrial minerals group, both potash and sulphur continued in oversupply with an accompanying decline in price, although the volume of production of each was higher in 1969. Asbestos remained in strong demand and prices were steady with further increases imminent as the year closed. The unit value of uranium production in Canada was again lower even though there was a modest increase in production.

Figure 13 shows the behaviour of price indexes of iron, nonferrous, and nonmetallic mineral products in juxtaposition with retail and wholesale price indexes. Iron products showed an increase of 3.25 per cent. The price of nonferrous products rose almost the same amount as the retail price index, about 4.6 per cent. Nonmetallic mineral product prices rose about 1.9 per cent.

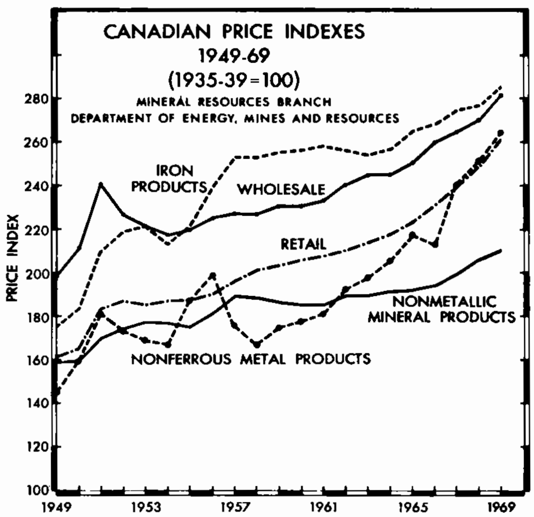

Figure 13

MINERAL TRADE

Labour stoppages in both the ferrous and the nonferrous metal industries were responsible for a decline in the total value of mineral exports in 1969 compared with the previous year, as shown in Figure 14. Table 12 in the Statistical Tables at the end of this review shows mineral exports by main group. In total, they declined by $81 million, or about 2 per cent. The decline in crude ferrous exports was $127 million; direct shipping ore to the United States fell by nearly one half to $30 million; iron ore concentrates fell one third to about $98 million; and exports of iron ore pellets fell by $51 million to $185 million. In the latter two cases the drop was almost all in trade to the United States. Fabricated ferrous exports fell $32 million, due chiefly to declines in value of exports of sheet and strip. This resulted in a fall of 15 per cent in the value of total fabricated ferrous group exports.

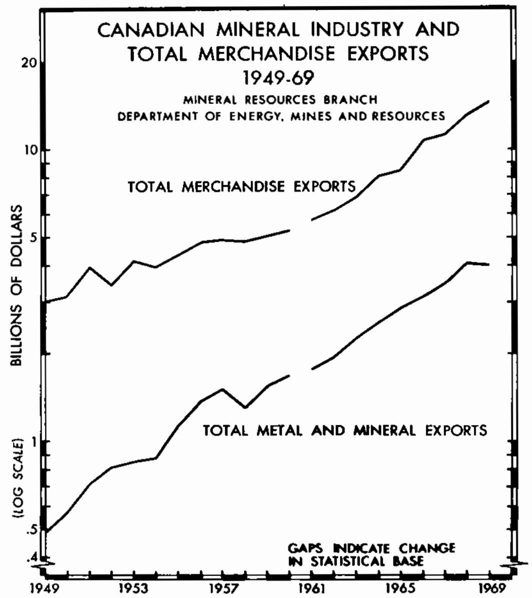

Figure 14

Total nonferrous metal exports fell by $81 million, or 3.8 per cent, compared with 1968. Exports of crude material were down by $29 million; declines were notable in the value of nickel and platinum to the United States and Britain, and in silver, especially to Japan. These declines were partially offset by increases in value of crude exports of molybdenum shipped to the European Economic Community (EEC) and the European Free Trade Association (EFTA)*, and of lead and zinc to the United States. Fabricated nonferrous exports fell by $52 million. Fabricated exports of copper to all major market areas fell a total of $77 million, and nickel exports, chiefly those to Britain, fell $20 million; these declines were offset by an increase of $30 million in fabricated aluminum

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*European Economic Community (Common Market) countries are: Belgium, France, Italy, Luxembourg, Netherlands and West Germany.

European Free Trade Association countries are: Britain, Austria, Denmark, Norway, Portugal, Sweden and Switzerland.

exports, notably to Japan, Brazil, and the Republic of South Africa, and in other fabricated nonferrous exports.

Total exports of nonmetals increased $28 million, or nearly 6 per cent. The increase of $16 million in crude material exports was almost entirely a result of increased exports of asbestos that rose $24 million to $216 million, including increases in shipments to Japan and Sweden. They were offset in part by a drop in sulphur exports in 1969 compared with 1968. The increase of $12 million in fabricated nonmetal products was accounted for by increases in exports of clay and asbestos products, and cement. There were offsetting declines in basic glass and other products.

The total increase in exports of mineral fuels was $99 million. This was comprised of increases of $79 million in crude oil and $19 million in natural gas, entirely made up of shipments to the United States, but there was a drop in coal shipments to Japan.

Total imports of crude and fabricated mineral products rose by $145 million, or 7.1 per cent in 1969. As a result, the favourable balance of mineral trade fell from $2,098 million in 1968 to $1,872 million in 1969. Almost all of the increase in imports was in fabricated materials. Ferrous fabricated product imports increased more than 34 per cent. Most steel product groups contributed to the rise: primary iron and steel rose from $4 million to $28 million; bars, rods, sheet, and strip rose from $145 million tc $223 million.

Nonferrous fabricated imports increased $30 million or 10 per cent, with copper imports more than doubling to $46 million. Nonmetallic mineral fabricated product imports increased $24 million or 17 per cent. The increase was reflected throughout the sector; most product groups, including clay, asbestos, and basic glass products all showing increases. Fabricated mineral fuel material imports increased slightly, but imports of crude fuel material fell sharply by $75 million, or 13 per cent. This represented a reduction of about $77 million in coal, and $19 million in natural gas, partially offset by an increase of about $20 million,to $393 million, in imports of crude petroleum.

As a proportion of total merchandise trade, mineral exports fell from 31.2 per cent in 1968 to 28.1 per cent in 1969. Imports fell from 16.4 per cent to 15.4 per cent.

The commodity distribution of Canadian mineral exports continued its historic trend in 1969, especially the tendency toward diversification as the "All Others" category increased to over 23 per cent of total mineral exports (Figure 15). The fuels continued as the largest single commodity group, comprising 19 per cent of the total; copper comprised 13 per cent, aluminum 12 per cent and nickel 11 per cent.

The United States remained the dominant market for Canadian mineral industry exports, 60 per cent of the total in 1969, almost exactly the same as in the

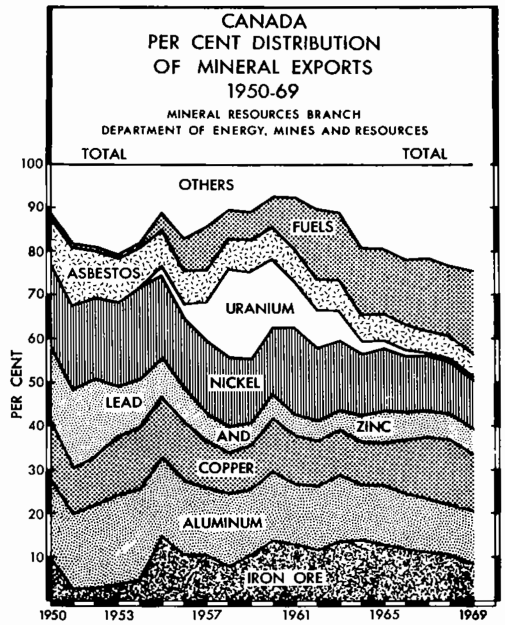


Figure 15

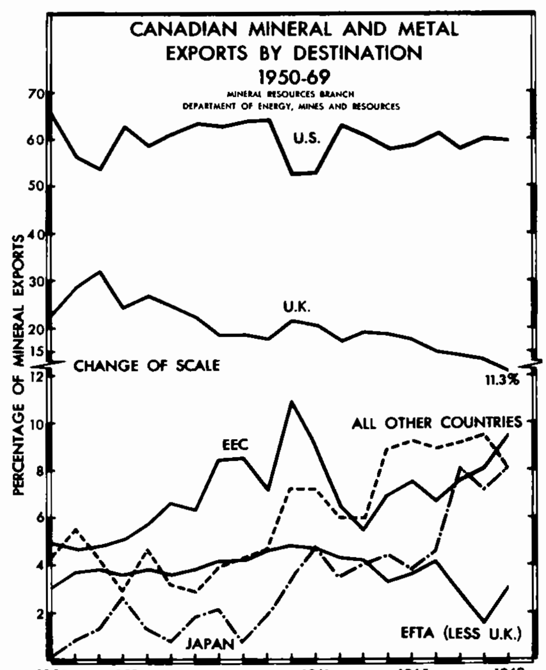


Figure 16

previous year (Figure 16). The proportion of mineral exports to the United Kingdom fell from 13.4 per cent in 1968 to 11.3 per cent in 1969; this represents an absolute fall of about $90 million. On the other hand, the share of mineral exports to the EEC rose from 8.2 per cent to 9.5 per cent and for the other EFTA countries from 1.5 per cent to 3.1 per cent. In total there was a net increase of about $55 million in mineral exports to the European market. Mineral exports to Japan rose to a record $328 million, or 8.1 per cent of the total.

REVIEW BY PROVINCES

BRITISH COLUMBIA

The value of mineral output in 1969 was $422.8 million compared with $389.1 million, a gain of 8.7 per cent. Copper again was the leading mineral in terms of value as it contributed nearly 20 per cent of the total, followed by crude petroleum with 13.7 per cent. Molybdenum experienced the largest percentage gain in output from 1968 and was nearly 45 per cent higher at $47.1 million.

Ten companies operating mines in the province reported production of copper in 1969 and there were an additional six properties being developed for production to begin in 1970-72. Four mines produced molybdenum, two of them as a co-product of copper output and the other two as only molybdenum producers. Extensive exploration for copper-molybdenum properties continued. Lead-zinc mines and metallurgical plants in the southeastern part of British Columbia continued to produce refined zinc, lead and silver and recover antimony, bismuth, cadmium, tin, and iron as byproducts.

YUKON TERRITORY AND NORTHWEST TERRITORIES

Production value of minerals in the Yukon Territory increased from $21.4 million in 1968 to $37.7 million with the metallics sector increasing from $12.7 million to nearly $25 million. The large increase was the result of mill start-up by Anvil Mining Corporation Limited's 5,500-ton-a-day zinc-lead operations at Ross River with shipments to Japan beginning late in the year. Plans were already under way to increase mill capacity to 6,700 tons a day. Copper and silver production also increased appreciably in value. Asbestos fibre production from Canada's most northerly open-pit mine, that of Cassiar Asbestos Corporation Limited at Clinton Creek, increased from 63,592 tons in 1968 to 88,000 tons valued at $12.7 million.

Mineral output in the Northwest Territories in 1969 increased only slightly to $116.5 million from $115.6 million the previous year. Metallics production was worth $115.4 million most of which was accounted for by lead, zinc and byproduct production from the Pine Point mine on the south shore of Great Slave Lake. Gold from Yellowknife area mines was valued at $12.9 million in 1969, down slightly from $13.3 million the previous year. Exploration for oil continued near the Arctic coast and on the Arctic Islands and drilling was undertaken at several promising locations.

ALBERTA

Of the province's total value of mineral production in 1969 of $1,193.3 million the mineral fuels accounted for $1,093.7 million with crude petroleum contributing 61.3 per cent of the total of all minerals; natural gas contributed 18.3 per cent and natural gas byproducts, 10.9 per cent.

The Prudhoe Bay oil discovery in Alaska and subsequent developments there and in Canada's far north have already had a significant impact on oil development and marketing plans in western Canada, particularly in Alberta whose mineral economy is closely linked to its oil and gas production and markets. Governments and regulatory Boards are making reappraisals of many development, production and marketing problems that are presently largely problematical but nevertheless must be considered in the total appraisal. Late in 1969, authorization was given to the second and larger project of Syncrude Canada Limited to build an 80,000-barrel-a-day plant for extracting oil at its Athabasca River oil sands site.

SASKATCHEWAN

The value of mineral production declined from $357.2 million in 1968 to $344.8 million with uranium, copper and zinc registering the largest percentage declines of 16.8, 12.8 and 8.3 per cent, respectively. Production was slightly higher in the industrial minerals group but lower in both the metallics and mineral fuels.

Eldorado Nuclear Limited, one of Canada's four remaining uranium producers, announced in May that it would reduce the milling rate at Beaverlodge to about 50 per cent of capacity from the rate then of about 85 per cent. The mill rate adjustment to 900 tons a day was based on sales commitments. Exploration for uranium in the Beaverlodge area continued strong but considerably more attention was paid to exploration in the Wollaston Lake area in northern Saskatchewan where Gulf Minerals Company discovered uranium in 1968 and on which it announced preliminary results in July 1969. Copper was produced at three mines in the province, two of which also produced zinc. One of the latter - Western Nuclear Mines Limited - closed its mine in July when ore reserves were exhausted. Potash production was higher both in quantity and value but the industry continued to experience problems in operating at reasonable rates because of marketing problems, particularly in the United States, as an oversupply situation existed throughout the world and prices were at their lowest point in history.

MANITOBA

The province's value of mineral production advanced to $245.6 million from $209.6 million in 1968. The largest gains were made by nickel (from $117.6 million to $147.7 million), copper ($33.3 million to $38.1 million), and zinc ($12.8 million to $14.9 million). Metallics output accounted for $205.8 million of the province's total.

Inco operated two nickel mines, a smelter, and a refinery in the Thompson area. Sherritt Gordon Mines Limited operated its Lynn Lake nickel mine. Dumbarton Mines Limited began production of 700 tons of nickel-copper ore a day at its Bird River location. Hudson Bay Mining and Smelting Co. Limited operated five mines in Manitoba, one in Saskatchewan, and processed its own and custom ores at the company's Flin Flon mill and copper-zinc smelter.

ONTARIO

Mineral output value declined from the record high of $1,355.6 million in 1968 to $1,214.5 million as a result mainly of losses incurred in the metallics because of plant shutdowns for prolonged periods resulting in substantial losses in nickel, copper and byproduct metals production. It was also lower because of labour strife at some iron ore production plants in the province that resulted in their closures at various periods in 1969. Nickel output was down 18.3 per cent from the previous year's record of $405.2 million and copper declined 15.4 per cent in value to $235.5 million. Metallics output in 1968 represented 83 per cent of the total value of provincial output; in 1969 it represented 81 per cent of the total.

QUEBEC

The province's mineral output in 1969 was worth $720.1 million, down slightly from the previous year's $728.8 million. The loss in value of iron ore production that declined in value about $28 million to $109.4 million, due to strike losses, was the main contributing factor as total metallics output value declined $25.7 million to $407.2 million. There were only minor losses or gains in value registered by most metallics.

Copper production, second only to Ontario in Canada, was about the same as in 1968 notwithstanding the long shutdown at the 11,000 ton-a-day plant and associated smelter of Gaspé Copper Mines Limited. Several new mines began production and other plants were being enlarged, developed, or planned for the years ahead. Iron ore shipping facilities at Sept-Iles and Pointe Noire are both being enlarged so that 150,000-ton iron ore carriers can be loaded; 200,000-ton carriers may be accommodated. Also of importance was the signing of sales contracts for iron ore concentrates to Japan and the announcement that Quebec Cartier Mining Company was studying the development of its Mt. Wright iron ore property, 75 miles north of Lac Jeannine, for production at 5 million tons a year to be increased to 10 million tons a year later.

Asbestos production from 10 mines, one of which closed in January 1969, totalled 1,336,000 tons of fibre valued at $154.4 million and was second only to copper in terms of value. Asbestos together with titanium-dioxide output valued at $29.1 million comprised about 93 per cent of total nonmetallics output value. Asbestos producers in the Eastern Townships continued to expand their mine and mill capacities and to improve recovery of fibre from material milled.

Quebec, like Ontario, has a relatively mature mineral industry that is large and well-diversified with the exception of the mineral fuels.

NEW BRUNSWICK

New Brunswick's mineral production value increased in 1969 to $98.4 million from $88.5 million the previous year; $81.3 million, or about 82 per cent of the total value, was composed of metallics. Zinc and lead output increased appreciably while copper and silver each declined slightly. Brunswick Mining and Smelting Corporation Limited, a subsidiary of Noranda Mines Limited, is by far the province's major base-metal mining operation and continued to operate two zinc-lead-copper mines and two mills near Bathurst and a zinc-lead smelter at Belledune, about 20 miles north of Bathurst. Two other companies - Heath Steele Mines Limited and Nigadoo River Mines Limited - operated zinc-lead-copper mines in the Bathurst area. Heath Steele was installing equipment at year-end to expand its mill capacity from 1,600 tons a day to 3,000 tons a day.

The industrial minerals sector of the province's mineral industry accounted for an output value of $11.1 million and mineral fuels accounted for $5.9 million, each of them being less than 1968's output value. There were no significant changes in the output value of any of industrial minerals or mineral fuels nor significant developments except for coal, which contributed 99 per cent of the output value of the mineral fuels; it contributed only 5.9 per cent of the total provincial mineral output value.

NOVA SCOTIA AND PRINCE EDWARD ISLAND

Coal, Nova Scotia's leading mineral in terms of value, again declined in both quantity and value in 1969 with production declining to 2.6 million tons valued at $21.6 million compared with 3.1 million tons and $25.1 million the previous year. The total value of mineral output in the province was $54.2 million, down slightly from $56.9 million in 1968.

Coal was produced from nine mines and development was begun of the Lingan mine, which will produce relatively low sulphur coal from a seam that dips below the ocean. Four inclined shafts will be driven; the mine will be highly mechanized and use the longwall system for extraction. Cape Breton Development Corporation (DEVCO), formed in 1967, took over the coal mines and related interests of Dominion Steel and Coal Corporation, Limited, in March 1968 and completed its first full year of operation in 1969. DEVCO offered voluntary pre-retirement to 1,000 older men of the 5,800 employees in coal operations and started to lower the present scale of operations to about 2 million tons a year. The Corporation closed the No. 20 Colliery at Glace Bay and transferred the work force to other collieries.

Of the total 1969 production value, the value of industrial minerals was higher than that of mineral fuels (coal) with nonmetallics worth $15.4 million and structural materials worth $15.8 million. The nonmetallics industry is composed almost entirely of gypsum, salt and barite production oriented largely to the export market in the United States.

Prince Edward Island's mineral production is confined to structural materials valued at about $1 million a year.

NEWFOUNDLAND AND LABRADOR

The value of mineral production decreased by 23 per cent to $239.1 million in 1969 because of the prolonged strikes that closed iron mining operations of Iron Ore Company of Canada Limited and Wabush Mines in Labrador. Output of iron ore declined as a consequence from 19.7 million tons to 14.7 million tons and in value from $246.5 million to $179.0 million respectively.

Metallic minerals production was $217.8 million, over 91 per cent of the total, with copper, zinc and lead following iron ore in that order. Copper was produced at four mines in the Island of Newfoundland with zinc and lead being the main products at the Buchans Unit of American Smelting and Refining Company. Asbestos, the major industrial mineral produced, declined in value to $10.1 million because of a two-month strike in mid-year at Advocate Mines Ltd.'s open-pit operation at Baie Verte. Fluorspar value was higher at over $3 million.

Statistical Tables

The statistics reported in these tables are compiled by the Statistics Section, Mineral Resources Branch, from a number of international and national sources, the chief source being the Dominion Bureau of Statistics (DBS).

The customary commodity basis of valuation is used in each section. Production value of each commodity is reported, the point of valuation being f.o.b. mine, smelter, refinery, or oil and gas field. The trade figures are valued in accordance with the Section 35 of the Customs Act, imports being at f.o.b. point of lading and exports at f.o.b. place of lading.

Most of the statistics, except in trade and transport sections, are reported on Canadian Standard Industrial Classification (SIC) basis. Under SIC the reporting unit is the establishment and the term 'mining industry' refers to mines (including milling), quarries and oil wells; not included are the activities of the mineral processing industry which are classified within manufacturing. Mineral processing activities include output of nonferrous smelting and refining products, iron and steel mill, pipe, tube and foundry products, other mineral products including cement, ready-mix concrete and some glass manufactures, coal products, and petroleum products. When production data excludes some material reported by DBS as manufactures, such as cement and lime, these exclusions are reported as footnotes to tables.

Trade and transport statistics are, in the main, based upon the Canadian Standard Commodity Classification (SCC) basis. Under SCC all mineral commodities are grouped within two sections, crude minerals and fabricated mineral products. Crude minerals are those which are obtained from nature and which have not undergone any processing (raw metals and minerals). They include, however, some products that have been subjected to preliminary processing for the purposes of cleaning or ease of shipping, e.g., ore milling. Fabricated minerals are those that have undergone some processing but are yet not in final form (iron and steel and alloys). At the same time crude minerals represent mainly the products of extractive industries while fabricated minerals are a result of manufacturing activity.

STATISTICAL TABLES

TABLE 1

Mineral Production of Canada, 1968 and 1969

	Unit of Measure	1968		1969p	
		Quantity	$000	Quantity	$000
Metals					
Antimony	000 lb	1,160	615	845	507
Bismuth	"	648	2,457	721	3,260
Cadmium	"	5,015	14,293	4,368	15,010
Calcium	"	469	451	888	926
Cobalt	"	4,030	8,688	3,204	6,922
Columbium (Cb_2O_5)	"	2,181	2,036	3,010	2,926
Copper	000 st	633	607,944	559	574,970
Gold	000 troy oz	2,743	103,439	2,502	94,332
Iron ore	000 lt	42,360	532,694	35,715	431,930
Iron remelt	000 st	..	22,023	..	23,475
Lead	"	340	91,439	635,074	96,150
Magnesium	000 lb	19,857	6,182	20,970	7,094
Molybdenum	"	22,464	37,318	30,292	52,623
Nickel	000 st	264	528,236	213	482,413
Platinum group	000 troy oz	486	46,200	266	26,449
Selenium	000 lb	636	3,082	711	4,376
Silver	000 troy oz	45,013	104,115	43,093	83,169
Tellurium	000 lb	71	459	104	671
Thorium	"	139	262	29	55
Tin	"	358	498	268	493
Uranium	"	7,402	52,284	7,710	49,666
Yttrium	"	113	936	86	676
Zinc	000 st	1,159	326,949	1,200	365,486
Total metals			2,492,600		2,323,579
Nonmetals					
Arsenious oxide	000 lb	689	49	700	50
Asbestos	000 st	1,596	185,025	1,596	196,759
Barite	"	138	1,263	141	1,420
Diatomite	st	521	17	487	11
Feldspar	000 st	11	244	12	309
Fluorspar	"	..	2,603	..	3,036
Gemstones	000 lb	55	115	45	107
Gypsum	000 st	5,927	11,825	6,872	13,433
Magnesitic dolomite and brucite	000 lb	..	3,046	..	3,000
Nepheline syenite	000 st	427	4,738	503	5,882
Peat Moss	000 st	294	8,658	314	8,717
Potash (K_2O)	"	2,918	65,121	3,532	75,344
Pyrite, pyrophyllite	"	314	2,286	323	2,111
Quartz	"	2,555	5,704	2,368	6,117
Salt	000 st	4,864	31,170	4,629	32,340
Soapstone, talc, pyrophyllite	"	81	1,081	81	1,191
Sodium sulphate	"	460	7,082	508	8,389
Sulphur, in smelter gas	"	666	8,915	551	8,222
Sulphur, elemental	"	2,581	79,964	2,985	62,986
Titanium dioxide, etc.	"		28,016	..	29,067
Total nonmetals			446,922		458,491

TABLE 1 (Cont'd)

	Unit of Measure	1968		1969p	
		Quantity	$000	Quantity	$000
Fuels					
Coal	000 st	10,981	53,936	10,672	52,538
Natural gas	000 mcf	1,692,301	225,269	1,979,309	262,884
Natural gas byproducts	000 bbl	..	126,058	..	135,566
Petroleum crude	"	379,396	937,287	410,814	1,019,546
Total fuels			1,342,550		1,470,534
Structural Materials					
Clay products	$ 000		48,721		50,995
Cement	000 st	8,166	152,004	8,544	171,258
Lime	"	1,440	17,386	1,718	20,108
Sand and gravel	"	205,235	129,500	204,060	130,650
Stone	"	75,940	95,658	70,069	88,195
Total structural materials			443,269		461,206
Total all minerals			4,725,341		4,713,810

Symbols: p Preliminary; .. Not available or not applicable; – Nil.
Notes:
1. There was no production of titanium, grindstone, iron oxide, lithia and mica during 1968 and 1969.
2. The data for indium, mercury, tungsten, helium and nitrogen during 1968 and 1969 was not available.

TABLE 2

Value of Mineral Production of Canada and Per Capita Value
Selected Years
($ million)

	Metallics	Industrial Minerals	Fuels	Total	Per Capita Value
	$ million	$ million	$ million	$ million	$
1944	308	81	97	486	40.67
1945	317	88	94	499	41.32
1946	290	110	103	503	40.91
1947	395	140	110	645	51.38
1948	488	172	160	820	63.97
1949	538	179	184	901	67.01
1950	617	227	201	1,045	76.24
1951	746	266	233	1,245	88.91
1952	728	294	263	1,285	88.90
1953	709	313	314	1,336	90.02
1954	800	335	353	1,488	97.36
1955	1,008	373	414	1,795	114.37
1956	1,146	420	519	2,085	129.65
1957	1,159	466	565	2,190	131.87
1958	1,130	460	511	2,101	123.00
1959	1,371	502	536	2,409	137.79
1960	1,407	520	566	2,493	139.48
1961	1,387	542	653	2,582	141.59
1962	1,496	574	781	2,851	153.42
1963	1,510	632	908	3,050	161.13
1964	1,702	690	999	3,391	175.79
1965	1,908	761	1,076	3,745	190.67
1966	1,985	844	1,151	3,980	198.84
1967	2,285	854	1,259	4,399	215.57
1968	2,493	890	1,342	4,725	227.79
1969[p]	2,324	919	1,471	4,714	223.82

[p]Preliminary.

TABLE 3

Indexes of Physical Volume of Total Industrial Production and Mining Production in Canada, 1955-1969
(1961 = 100)

	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969p
Total industrial production	77.7	85.8	87.2	86.7	94.2	96.2	100.0	109.5	116.5	128.1	139.1	148.9	151.7	159.8	167.9
Total mining (including milling) quarries and oil wells	66.4	77.1	84.6	86.0	97.3	97.4	100.0	104.8	110.6	124.9	131.6	136.5	145.2	152.7	149.9
Metals															
All metals	66.8	72.7	85.5	95.5	110.0	107.3	100.0	101.1	103.9	120.6	124.5	125.0	133.8	142.6	126.9
Placer gold and gold quartz mines	102.7	98.4	100.0	104.1	102.2	104.4	100.0	92.6	88.8	85.3	79.2	71.8	65.4	58.8	52.4
Iron mines	72.7	93.0	97.4	70.7	105.2	103.6	100.0	142.4	173.0	229.5	242.6	261.1	276.1	311.4	267.7
Miscellaneous metal mines, n.e.s.	..	..	..	..	..	..	100.0	95.6	94.8	108.5	112.6	111.5	122.0	129.0	116.3
Fuels															
All fuels	63.0	80.0	83.1	76.5	84.1	87.1	100.0	111.3	119.1	128.3	135.2	145.6	158.0	164.3	180.0
Coal	148.5	149.5	131.1	113.8	103.8	107.0	100.0	97.2	103.7	108.9	108.6	105.9	106.2	96.6	93.3
Crude petroleum and natural gas	..	..	..	..	..	..	100.0	113.7	121.7	131.7	139.8	152.5	166.9	176.1	195.0
Nonmetals															
All nonmetals	84.0	88.6	84.8	80.3	92.0	91.5	100.0	109.3	121.9	138.7	161.8	179.2	192.8	196.1	221.6
Asbestos	86.3	86.4	83.8	79.8	86.4	90.3	100.0	103.4	109.2	118.9	123.4	134.7	130.6	124.9	138.0

p Preliminary; .. Not available.

TABLE 4

Percentage Contributions of Leading Minerals to
Total Value of Mineral Production in Canada, 1960-1969

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969p
Petroleum, crude	17.0	18.9	19.4	20.2	19.9	19.3	19.9	19.7	19.8	21.6
Copper	10.6	9.9	9.9	9.3	9.6	10.2	11.4	13.2	12.9	12.2
Nickel	11.9	13.6	13.5	11.8	11.2	11.5	9.5	10.5	11.2	10.2
Iron ore	7.0	7.3	9.2	10.3	11.9	11.0	10.8	10.7	11.3	9.2
Zinc	4.4	4.1	3.9	4.0	5.7	6.6	7.3	7.3	6.9	7.8
Natural gas	2.1	2.6	3.8	4.9	5.1	5.0	4.5	4.5	4.8	5.6
Asbestos	4.9	5.0	4.6	4.5	4.3	3.9	4.1	3.7	3.9	4.2
Cement	3.7	4.0	4.0	3.9	3.9	3.8	3.9	3.3	3.2	3.6
Sand and gravel	4.6	4.1	4.2	4.1	3.7	3.6	3.8	3.3	2.7	2.8
Gold	6.3	6.1	5.5	5.0	4.3	3.6	3.1	2.5	2.2	2.0
Lead	1.8	1.8	1.5	1.5	1.6	2.4	2.3	2.0	1.9	2.0
Stone	2.4	2.6	2.4	2.6	2.6	2.5	2.8	2.3	2.0	1.9
Silver	1.2	1.1	1.2	1.4	1.2	1.2	1.2	1.4	2.2	1.7
Potash (K_2O)	–	–	0.1	0.7	0.9	1.5	1.6	1.5	1.4	1.6
Sulphur, elemental	0.2	0.3	0.3	0.4	0.5	0.7	1.0	1.6	1.7	1.3
Molybdenum	0.04	0.04	0.04	0.04	0.06	0.4	0.9	0.9	0.8	1.1
Coal	3.0	2.7	2.4	2.4	2.1	2.0	2.0	1.9	1.1	1.1
Clay products	1.5	1.4	1.3	1.3	1.2	1.1	1.1	1.0	1.0	1.1
Uranium (U_3O_8)	10.8	7.6	5.5	4.5	2.5	1.7	1.4	1.2	1.1	1.1
Salt	0.8	0.8	0.8	0.7	0.7	0.6	0.6	0.7	0.7	0.7
Platinum group	1.2	0.9	1.0	0.7	0.7	1.0	0.8	0.8	1.0	0.6
Titanium dioxide	0.5	0.6	0.4	0.5	0.6	0.6	0.5	0.5	0.6	0.6
Lime	0.8	0.7	0.6	0.6	0.6	0.5	0.5	0.4	0.4	0.4
Cadmium	0.1	0.1	0.2	0.2	0.3	0.1	0.2	0.3	0.3	0.3
Gypsum	0.4	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3
Other minerals	2.8	3.5	4.0	4.1	4.6	4.9	4.5	4.5	4.6	5.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

p Preliminary; – Nil.

TABLE 5

Canada, Value of Minerals Production by Main Geological Regions 1969[p]

	Metals		Industrial Minerals		Fuels		Total, all Minerals	
	$ million	% of Total	$ million	% of Total	$ million	% of Total	$ million	% of Total
Canadian Shield	1,848.2	79.6	81.5	8.9	–		1,929.7	40.9
Appalachian Region	168.6	7.3	231.6	25.2	28.0	1.9	428.2	9.1
St. Lawrence Lowlands	2.9	0.1	298.4	32.4	7.6	0.5	308.9	6.6
Interior Plains	31.0	1.3	210.2	22.8	1,375.8	93.6	1,617.0	34.3
Cordilleran Region	272.9	11.7	98.0	10.7	59.1	4.0	430.0	9.1
Total, Canada	2,323.6	100.0	919.7	100.0	1,470.5	100.0	4,713.8	100.0

[p]Preliminary; – Nil.

TABLE 6

Canada, Value of Mineral Production by Provinces and Mineral Classes, 1969[p]

	Metals		Industrial Minerals		Fuels		Total	
	$000	% of Total	$000	% of Total	$000	% of Total	$000	% of Total
Ontario	979,912	42.2	229,151	24.9	7,550	0.5	1,216,613	25.8
Alberta	4	–	100,189	10.9	1,107,971	75.3	1,208,164	25.6
Quebec	407,221	17.5	312,826	34.0	20	–	720,067	15.3
British Columbia	247,704	10.6	73,929	8.0	99,945	6.8	421,578	8.9
Saskatchewan	42,058	1.8	100,858	11.0	210,561	14.3	353,477	7.5
Manitoba	205,766	8.9	24,369	2.7	15,549	1.1	245,684	5.2
Newfoundland	217,791	9.4	21,565	2.3	–	–	239,356	5.1
Northwest Territories	115,447	5.0	–	–	985	0.1	116,432	2.5
New Brunswick	81,334	3.5	11,123	1.2	5,803	0.4	98,260	2.1
Nova Scotia	1,388	0.05	31,936	3.5	22,150	1.5	55,474	1.2
Yukon	24,954	1.1	12,701	1.4	–	–	37,655	0.8
Prince Edward Island	–		11,050	0.1	–	–	1,050	0.02
Total	2,323,579	100.0	919,697	100.0	1,470,534	100.0	4,713,810	100.0

[p] Preliminary; – Nil.

TABLE 7

Canada, Value of Mineral Production by Provinces, 1960-1969
($ million)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969p
Ontario	983	944	913	874	904	993	958	1,195	1,356	1,217
Alberta	396	473	567	669	736	794	847	973	1,092	1,208
Quebec	446	455	519	541	685	716	770	734	729	720
British Columbia	186	188	235	261	269	280	331	380	389	422
Saskatchewan	212	216	240	272	292	328	349	362	357	353
Manitoba	59	101	159	170	174	183	179	185	209	246
Newfoundland	87	92	102	138	182	208	244	266	310	239
Northwest Territories	27	18	18	16	18	77	111	118	116	116
New Brunswick	17	19	22	28	49	82	90	90	88	98
Nova Scotia	66	62	62	66	66	71	86	77	57	55
Yukon	13	13	13	14	15	13	12	15	21	38
Prince Edward Island	1	1	1	0.8	0.8	0.6	3	3	1	1
Total	2,493	2,582	2,851	3,050	3,391	3,745	3,980	4,398	4,725	4,713

p Preliminary.

TABLE 8

Canada, Percentage Contribution of Provinces to Total Value of Mineral Production, 1960-1969

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969p
ntario	39.4	36.6	32.0	28.7	26.7	26.5	24.1	27.2	28.7	25.8
.lberta	15.9	18.3	19.9	21.9	21.7	21.2	21.3	22.1	23.1	25.6
uebec	17.9	17.6	18.2	17.7	20.2	19.1	19.3	16.7	15.4	15.3
ritish Columbia	7.5	7.3	8.2	8.6	7.9	7.5	8.3	8.6	8.2	8.9
askatchewan	8.5	8.4	8.4	8.9	8.6	8.8	8.8	8.2	7.6	7.5
Ianitoba	2.4	3.9	5.6	5.6	5.1	4.9	4.5	4.2	4.4	5.2
'ewfoundland	3.5	3.6	3.6	4.5	5.4	5.5	6.1	6.1	6.6	5.1
orthwest Territories	1.1	0.7	0.6	0.5	0.5	2.1	2.8	2.7	2.4	2.5
ew Brunswick	0.7	0.7	0.8	0.9	1.4	2.2	2.3	2.1	1.9	2.1
ova Scotia	2.6	2.4	2.2	2.2	2.0	1.9	2.1	1.8	1.2	1.2
ukon	0.5	0.5	0.5	0.5	0.5	0.3	0.3	0.3	0.5	0.8
rince Edward Island	0.05	0.02	0.02	0.03	0.02	0.02	0.1	0.05	0.02	0.02
otal, Canada	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Preliminary.

TABLE 9
Canada, Production of Leading Mineral

	Unit of Measure	Nfld.	P.E.I.	N.S.	N.B.	Quebec	Ontario
Petroleum, crude	bbl	–	--	–	9,176	–	1,161,61
	$	–	–	–	12,845	–	3,196,62
Copper	st	19,389	–	82	7,062	157,960	229,69
	$	19,944,133	–	84,046	7,264,127	162,476,885	236,268,56
Nickel	st	–	–	–	–	273	146,83
	$	–	–	–	–	622,440	330,966,93
Iron ore	st	14,733,410	–	–	–	12,875,400	10,466,74
	$	178,992,960	–	–	–	109,405,064	126,081,38
Zinc	st	33,906	–	121	158,201	195,922	349,40
	$	10,327,540	–	37,020	48,188,025	59,678,030	106,429,69
Natural gas	cf	–	–	–	105,976	137,897	11,334,27
	$	–	–	–	90,883	20,684	4,353,04
Asbestos	st	55,500	–	–	–	1,336,000	35,00
	$	10,100,000	–	–	–	154,410,000	4,224,00
Cement	st	. .	–	. .	. .	2,390,206	3,269,28
	$	1,960,000	–	4,164,083	2,169,715	47,377,602	59,337,44
Sand and gravel	st	3,600,000	770,000	8,520,000	3,800,000	43,000,000	85,000,00
	$	3,400,000	900,000	7,700,000	1,650,000	18,000,000	55,500,00
Gold	oz	7,440	–	13	1,567	737,554	1,206,11
	$	280,488	–	490	59,076	27,805,786	45,470,34
Lead	st	21,094	–	2,607	56,140	1,405	12,74
	$	6,387,318	–	789,407	16,999,343	425,222	3,859,32
Stone	st	705,000	150,000	825,300	1,730,000	32,230,000	25,749,00
	$	935,000	150,000	2,348,300	3,505,000	37,825,000	32,565,00
Silver	oz	963,100	–	247,064	4,172,200	4,103,420	22,033,09
	$	1,858,783	–	476,834	8,052,346	7,919,600	42,523,87
Potash (K_2O)	st		–	–	–	–	
	$	–	–	–	–	–	–
Sulphur, elemental	st	–	–	–	–	–	1,45
	$	–	–	–	–	–	39,68
Molybdenum	lb	–	–	–	–	2,954,387	–
	$	–	–	–	–	5,499,316	–
Coal	st	–	–	2,621,330	701,952	–	–
	$	–	–	22,149,740	5,699,679	–	–
Clay products	$	145,000	–	1,568,000	620,000	7,415,098	31,213,40
Uranium (U_3O_8)	lb	–	–	–	–	–	6,150,21
	$	–	–	–	–	–	38,750,50
Salt	st	–	–	500,000	–	–	3,762,00
	$	–	–	5,348,000	–	–	21,068,00
Platinum group	oz	–	–	–	–	–	266,10
	$	–	–	–	–	–	26,449,00
Titanium dioxide	st	–	–	–	–	. .	–
	$	–	–	–	–	29,066,600	–
Lime	st	–	–	–	–	451,571	1,129,51
	$	–	–	–	–	4,759,680	12,787,78
Cadmium	lb	–	–	–	113,400	329,968	2,463,82
	$	–	–	–	394,632	1,076,998	8,453,38
Gypsum	st	490,000	–	5,211,548	82,423	–	630,00
	$	1,176,000	–	9,214,892	237,310	–	1,539,00
Total leading minerals		235,507,222	1,050,000	53,880,812	94,942,981	673,784,005	1,191,076,97
Total all minerals		239,356,953	1,050,000	55,473,812	98,260,353	720,067,431	1,216,611,76
Leading minerals as % of all minerals		98.4	100.0	97.1	96.6	93.6	97.9

by Provinces and Territories, 1969[p]

Manitoba	Sask.	Alberta	B.C.	Y.T.	N.W.T.	Total Canada
6,204,651	87,342,758	289,985,049	25,309,036	–	801,341	410,813,622
15,548,929	196,703,751	745,895,152	57,221,959	–	966,898	1,019,546,159
37,042	18,011	–	81,343	7,860	535	558,983
38,101,218	18,525,789	–	83,670,058	8,084,127	550,920	574,969,868
64,850	–	–	1,364	–	–	213,325
147,713,568	–	–	3,109,920	–	–	482,412,858
–	–	–	1,925,090	–	–	40,000,640
–	–	–	17,450,904	–	–	431,930,310
48,909	28,219	–	148,128	17,075	220,000	1,199,889
14,897,699	8,595,317	–	45,119,758	5,201,045	67,012,000	365,486,126
–	58,998,000	1,606,690,871	301,997,822	–	43,723	1,979,308,563
–	7,573,067	218,432,804	32,394,817	–	18,452	262,883,748
–	–	–	81,950	88,000	–	1,596,450
–	–	–	15,323,600	12,701,400	–	196,759,000
491,101	270,023	856,544	852,500	–	–	8,543,622
11,261,502	7,970,111	19,138,991	17,878,440	–	–	171,257,887
9,500,000	8,500,000	13,700,000	26,670,000	–	–	204,060,000
6,000,000	4,500,000	10,800,000	22,200,000	–	–	130,650,000
29,304	37,839	100	112,821	26,305	343,116	2,502,169
1,104,761	1,426,530	3,770	4,253,352	991,700	12,935,473	94,331,773
592	2,505	–	102,548	15,400	102,500	317,537
179,389	758,510	–	31,051,550	4,663,120	31,037,000	96,150,181
2,212,000	–	25,300	5,442,500	–	–	70,069,100
2,835,000	–	697,200	7,334,000	–	–	88,194,500
489,345	636,906	10	5,431,267	2,990,056	2,026,513	43,092,976
944,436	1,229,229	19	10,482,345	5,770,808	3,911,170	83,169,443
–	3,532,000	–	–	–	–	3,532,000
–	75,344,000	–	–	–	–	75,344,000
6,384	29,446	2,894,200	53,941	–	–	2,984,937
174,015	905,149	60,716,042	1,151,429	–	–	62,986,315
–	–	–	27,337,257	–	–	30,291,644
–	–	–	47,123,801	–	–	52,623,117
–	2,020,105	4,426,060	902,432	–	–	10,671,879
–	3,726,698	13,797,746	7,164,377	–	–	52,538,240
448,719	1,628,893	3,839,766	4,116,475	–	–	50,995,351
–	1,559,332	–	–	–	–	7,709,547
–	10,915,000	–	–	–	–	49,665,506
44,000	92,000	231,000	–	–	–	4,629,000
951,000	1,944,000	3,029,000	–	–	–	32,340,000
. .	–	–	–	–	–	266,100
. .	–	–	–	–	–	26,449,000
–	–	–	–	–	–	. .
–	–	–	–	–	–	29,066,600
51,286	–	85,782	–	–	–	1,718,155
824,620	–	1,736,220	–	–	–	20,108,301
232,957	83,460	–	1,074,800	70,000	–	4,368,405
810,690	290,440	–	3,740,443	243,600	–	15,010,186
180,000	–	–	278,000	–	–	6,871,971
487,500	–	–	778,400	–	–	13,433,102
242,283,046	342,036,484	1,078,086,710	411,565,628	37,655,800	116,431,913	4,478,301,571
245,684,113	353,476,231	1,208,164,106	421,578,150	37,655,800	116,431,913	4,713,810,624
98.6	96.8	89.2	97.6	100.0	100.0	95.0

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

TABLE 10
Canada, World Role as a Producer

	Year		World Production	1
				Canada
Nickel (mine production)	1968	st	553,000	263,848
		% of world total		48
				Canada
Zinc (mine production)	1968	st	5,109,037	1,168,830
		% of world total		23
				Canada
Asbestos	1968	st	. .	1,595,951
		% of world total		. .
				Canada
Silver (mine production)	1968	troy oz	271,899,000	45,013,000
		% of world total		17
				U.S.S.R.
Potash (K_2O equivalent)	1968	000 st	17,167	3,472[e]
		% of world total		20
				U.S.A.
Molybdenum (excludes communist countries)	1968	st	64,065	46,739
		% of world total		73
				U.S.A.
Titanium concentrate (Ilmenite)	1968	st	3,216,063	978,509
		% of world total		30
				U.S.A.
Cadmium (smelter production)	1968	000 lb	33,953	10,651
		% of world total		31
				U.S.A.
Gypsum	1968	000 st	. .	10,018
		% of world total		. .
				Congo
Cobalt (mine production)	1968	st	21,789	11,000
		% of world total		51
				U.S.S.R.
Lead (mine production)	1968	st	3,308,994	529,000
		% of world total		16
				U.S.A.
Aluminum (primary metal)	1968	st	9,042,120	3,255,041
		% of world total		36
				U.S.A.
Uranium (U_3O_8 concentrates) (excludes communist countries)	1968	st	22,345	12,338
		% of world total		55
				U.S.S.R.
Platinum group metals (mine production)	1968	troy oz	3,436,816	2,000,000
		% of world total		58
				Rep. of S. Africa
Gold (mine production)	1968[p]	troy oz	46,243,322	31,094,466
		% of world total		67
				U.S.S.R.
Iron ore	1968	000 l.t.	658,328	174,205
		% of world total		27
				U.S.A.
Magnesium	1968	st	207,089	98,375
		% of world total		48
				U.S.A.
Copper (mine production)	1968	st	5,994,862	1,203,000
		% of world total		20

[e] Estimated; [p] Preliminary; . . Not available.

Rank of Six Leading Countries with % of World Total				
2	3	4	5	6
U.S.S.R. 114,000 21	New Caledonia 88,100 16	Cuba 40,000 7	U.S.A. 15,154 3	Rep. of S. Africa 6,500 1
U.S.S.R. 565,000 11	U.S.A. 526,428 10	Australia 357,576 7	Peru 340,720 7	Japan 291,300 6
U.S.S.R. 881,848 . .	Rep. of S. Africa 260,530 . .	China 165,000[e] . .	U.S.A. 120,690 . .	Italy 116,845[e] . .
Mexico 40,031,000 15	Peru 36,020,000 13	U.S.S.R. 35,000,000 13	U.S.A. 32,729,000 12	Australia 21,618,000 8
Canada 2,918 17	U.S.A. 2,722 16	West Germany 2,447 14	East Germany 2,425 14	France 1,895 11
Canada 11,232 18	Chile 4,261 7	Peru 875 1	Norway 300[e] 0.5	Japan 250[e] 0.4
Canada 672,866 21	Australia 616,131 19	Norway 441,000[e] 14	Finland 154,000 5	Malaysia 138,698 4
Canada 5,015 15	U.S.S.R. 4,850 14	Japan 4,500 13	Belgium 1,898 6	France 1,246 4
Canada 5,927 . .	France 5,512[e] . .	U.S.S.R. 5,346 . .	U.K. 5,126[e] . .	Spain 3,693[e] . .
Canada 2,015 9	Finland 1,875 9	Morocco 1,840 8	U.S.S.R. 1,500 7	Zambia 1,319 6
Australia 415,227 13	**Canada** 361,128 11	U.S.A. 354,166 11	Mexico 185,708 6	Peru 184,958 6
U.S.S.R. 1,350,000 15	**Canada** 979,171 11	Japan 531,200 6	Norway 518,169 6	France 403,159 5
Rep. of S. Africa 3,865 17	**Canada** 3,701 16	France 1,445 7	Gabon 528[e] 2	Australia 330 1
Rep. of S. Africa 914,000[e] 27	**Canada** 485,891 14	Columbia 15,076 0.4	U.S.A. 14,793 0.4	Japan 6,806 0.2
U.S.S.R. 6,040,000 13	**Canada** 2,743,021 6	U.S.A. 1,478,292 3	Australia 796,635 2	Ghana 727,122 1
U.S.A. 85,860 13	France 54,902 8	**Canada** 44,083 7	Sweden 31,882 5	China 31,494 5
U.S.S.R. 45,000 22	Norway 34,500 17	**Canada** 9,878 5	Italy 7,267 4	Japan 6,236 3
U.S.S.R. 905,000 15	Zambia 804,134 13	Chile 725,559 12	**Canada** 620,076 10	Rep. of Congo 357,700 6

TABLE 11

Canada – Census Values Added, Commodity Producing Industries, 1962-1967
($ million)

	1962	1963	1964	1965	1966	1967
Primary Industries						
Agriculture	2,353	2,592	2,394	2,614	3,271	2,729
Forestry	702	492	557	603	673	688
Fishing	131	130	149	160	176	164
Trapping	10	12	13	12	14	10
Mining*	1,868	2,023	2,291	2,476	2,610	2,910
Electric Power	876	912	970	1,036	1,132	1,234
Total	5,940	6,161	6,374	6,901	7,876	7,735
Secondary Industries						
Manufacturing	11,430	12,273	13,536	14,928	16,352	17,005
Construction	2,900	3,065	3,391	3,987	4,844	5,148
Total	14,330	15,338	16,927	18,915	21,196	22,153
Grand total	20,270	21,499	23,301	25,816	29,072	29,888

Note: Data revised to conform 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 table are included under Manufacturing.

TABLE 12

Canada, Exports of Crude Minerals and Fabricated Mineral Products
by Main Groups, 1968 and 1969
($ million)

	1968	1969	Increase or decrease	
			$ million	%
Ferrous				
Crude material	458.3	363.5	− 94.8	−20.7
Fabricated material	384.9	352.9	− 32.0	− 8.3
Total	843.2	716.4	−126.8	−15.0
Nonferrous				
Crude material	803.9	775.2	− 28.7	− 3.6
Fabricated material*	1,338.5	1,286.2	− 52.3	− 3.9
Total	2,142.4	2,061.4	− 81.0	− 3.8
Nonmetals				
Crude material	320.7	336.7	+ 16.0	+ 5.0
Fabricated material	166.2	178.4	+ 12.2	+ 7.3
Total	486.9	515.1	+ 28.2	+ 5.8
Mineral fuels				
Crude material	621.2	711.7	+ 90.5	+14.6
Fabricated material	50.4	58.9	+ 8.5	+16.9
Total	671.6	770.6	+ 99.0	+14.7
Total mineral and products				
Crude material	2,204.1	2,187.1	− 17.0	− 0.8
Fabricated material	1,940.0	1,876.4	− 63.6	− 3.3
Total	4,144.1	4,063.5	− 80.6	− 1.9

*Includes gold, refined and unrefined.

TABLE 13

Canada, Imports of Crude Minerals and Fabricated Mineral Products, by Main Groups, 1968 and 1969
($ million)

	1968	1969	Increase or decrease $ million	Increase or decrease %
Ferrous				
Crude material	48.7	47.5	- 1.2	- 2.5
Fabricated material	537.1	723.6	+186.5	+34.7
Total	585.8	771.1	+185.3	+31.6
Nonferrous*				
Crude material	172.5	145.7	- 26.8	-15.5
Fabricated material	298.2	328.2	+ 30.0	+10.1
Total	470.7	473.9	+ 3.2	+ 0.7
Nonmetals				
Crude material	63.6	63.8	+ 0.2	+ 0.3
Fabricated material	141.2	165.6	+ 24.4	+17.3
Total	204.8	229.4	+ 24.6	+12.0
Mineral fuels				
Crude material	568.8	493.6	- 75.2	-13.2
Fabricated material	216.0	223.5	+ 7.5	+ 3.5
Total	784.8	717.1	- 67.7	- 8.6
Total minerals and products				
Crude material	853.6	750.6	-103.0	-12.1
Fabricated material	1,192.5	1,440.9	+248.4	+20.8
Total	2,046.1	2,191.5	+145.4	+ 7.1

*Includes gold, refined and unrefined.

TABLE 14

Canada, Value of Exports of Crude Minerals and Fabricated Mineral Products in Relation to Total Export Trade 1968 and 1969

	1968 $ million	1968 % of Total	1969 $ million	1969 % of Total
Crude material	2,204.1	16.6	2,187.1	15.1
Fabricated material*	1,940.0	14.6	1,876.4	13.0
Total	4,144.1	31.2	4,063.5	28.1
Total exports* all products	13,250.9[r]	100.0	14,441.6	100.0

* Includes gold refined and unrefined, which are considered non-trade items and not included in domestic exports.
[r] Revised from previously published figure.

TABLE 15

Canada, Value of Imports of Crude Minerals and Fabricated Mineral Products in Relation to Total Import Trade 1968 and 1969

	1968		1969	
	$ million	% of Total	$ million	% of Total
Crude material	853.5	6.9	750.6	5.3
Fabricated material*	1,192.6	9.7	1,440.9	10.1
Total	2,046.1	16.6	2,191.5	15.4
Total imports* all products	12,357.9[r]	100.0	14,201.6	100.0

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

TABLE 16

Canada, Value of Exports of Crude Minerals and Fabricated Mineral Products by Main Groups and Destination, 1969
($ million)

	Britain	United States	Other Countries	Total
Ferrous materials and products	44.3	516.1	156.0	716.4
Nonferrous* materials and products	392.0	901.0	768.4	2,061.4
Nonmetallic mineral materials and products	23.6	268.1	223.5	515.2
Mineral fuels, materials and products	0.3	751.9	18.4	770.6
Total	460.2	2,437.1	1,166.3	4,063.6
Percentage	11.3	60.0	28.7	100.0

*Includes gold, refined and unrefined.

TABLE 17

Canada, Value of Imports of Crude Minerals and Fabricated Mineral Products by Main Groups and Source, 1969
($ million)

	Britain	United States	Other Countries	Total
Ferrous materials and products	52.5	536.4	182.2	771.1
Nonferrous* materials and products	23.5	277.4	173.0	473.9
Nonmetallic mineral materials and products	16.9	153.9	58.6	229.4
Mineral fuels, materials and products	2.3	176.9	537.9	717.1
Total	95.2	1,144.6	951.7	2,191.5
Percentage	4.4	52.2	43.4	100.0

*Includes gold, refined and unrefined.

TABLE 18

Canada, Value of Exports of Crude Minerals and Fabricated Mineral Products by Commodity and Destination, 1969
($ 000)

		E.F.T.A.					
	U.S.A.	Britain	Other[1]	E.E.C. Countries[2]	Japan	Other Countries	Total
Iron ore	231,144	29,867	–	49,468	21,956	695	333,130
Primary ferrous metals	63,785	6,043	1,868	16,313	8,844	8,120	104,973
Aluminum	226,107	74,486	3,299	39,374	61,385	89,736	494,387
Copper	149,712	97,641	33,002	76,967	138,034	39,274	534,630
Lead	25,533	11,703	583	8,071	7,458	1,224	54,572
Nickel	229,775	110,540	65,990	21,354	12,936	10,795	451,390
Zinc	87,547	22,504	1,894	47,906	9,911	9,698	179,460
Molybdenum	–	13,733	3,236	22,720	8,063	1,540	49,292
Uranium	478	14,996	–	5,469	3,564	–	24,507
Asbestos	75,117	16,586	8,147	44,429	18,292	57,765	220,336
Fuels	751,877	335	19	2,831	14,196	1,320	770,578
All other minerals[3]	596,002	61,795	7,251	51,425	22,887	106,941	846,301
Total	2,437,077	460,229	125,289	386,327	327,526	327,108	4,063,556

[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 19

Canada, Reported Consumption of Minerals, and its Relation to Production, 1968

Mineral	Unit of Measure	Consumption[1]	Production[2]	Consumption as % of Production
Metals				
Aluminum	st	239,636	979,171	24.5
Antimony	lb	1,169,631	1,159,960	100.8
Bismuth	lb	59,346	648,232	9.2
Cadmium	lb	125,564	5,014,965	2.5
Chromium (chromite)	st	77,075	–	
Cobalt	lb	358,098	4,029,549	8.9
Copper	st	253,200[3]	633,312	40.0
Lead	st	94,660	340,176	27.8
Magnesium	st	5,654	9,929	56.9
Manganese ore	st	124,904		
Mercury	lb	327,939	..	..
Molybdenum (Mo content)	lb	1,543,432	22,464,273	6.9
Nickel	st	11,239	264,358	4.3
Selenium	lb	21,440	635,510	33.7
Silver	oz	13,598,358	45,012,797	30.2
Tellurium	lb	4,605	70,991	6.5
Tin	lt	4,251	160	2,656.8
Tungsten (W content)	lb	1,181,541	..	
Zinc	st	118,581	1,159,392	10.2
Nonmetals				
Barite	st	21,403	138,059	15.5
Feldspar	st	7,343r	10,620	69.1
Fluorspar	st	178,901r	..	
Mica	lb	3,932,000r	–	
Nepheline Syenite	st	77,793	426,595	18.2
Phosphate rock	st	2,234,259	–	
Potash (K_2O)	st	183,100[5]	2,917,611	6.3
Sodium sulphate	st	371,523	459,669	80.8
Sulphur elemental	st	830,147	2,580,746	32.2
Talc, etc.	st	33,001	80,589	40.9
Fuels				
Coal	st	27,317,782r	10,980,850	248.8
Natural gas	mcf	765,786,814[4]	1,692,300,787	45.3
Petroleum	bbl	413,471,510[6]	379,396,276	109.0

[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 it 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.

TABLE 20

Canada, Reported Consumption of Minerals, and its Relation to Production, 1969

Mineral	Unit of Measure	Consumption[1]	Production[2]	Consumption as % of Production
Metals				
Aluminum	st	217,215[3]	1,098,080	19.8
Antimony	lb	1,305,742	845,000	154.5
Bismuth	lb	33,800	720,698	4.7
Cadmium	lb	132,136	4,368,405	3.0
Chromium (chromite)	st	68,484	–	
Cobalt	lb	393,658	3,203,947	12.3
Copper	st	240,256[3]	558,983	43.0
Lead	st	107,270	317,537	33.8
Magnesium	st	5,672	10,484	54.1
Manganese ore	st	168,485	–	
Mercury	lb	308,814	. .	
Molybdenum (Mo content)	lb	1,806,682	30,291,644	6.0
Nickel	st	12,094	213,325	5.7
Selenium	lb	15,572	710,618	2.2
Silver	oz	5,747,068	43,092,976	13.3
Tellurium	lb	3,532	103,777	3.4
Tin	lt	4,280	120	3,566.7
Tungsten (W content)	st	1,050,824	. .	
Zinc	st	121,417	1,199,889	10.1
Nonmetals				
Barite	st	. .	141,392	
Feldspar	st	. .	11,743	
Fluorspar	st	. .	. .	
Mica	lb	. .	–	
Nepheline syenite	st	. .	502,893	
Phosphate rock	st	. .	–	
Potash (K_2O)	st	200,531[5]	3,532,000	5.7
Sodium sulphate	st	. .	508,484	
Sulphur, elemental	st	. .	2,984,937	
Talc, etc.	st	. .	81,427	
Fuels				
Coal	st	26,641,411	10,671,879	249.6
Natural gas	mcf	843,164,967[4]	1,979,308,563	42.6
Petroleum, crude	bbl	432,450,839[6]	410,813,622	105.3

[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 it 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.

TABLE 21

Canada, Apparent Consumption of Some Minerals
and Relation to Production, 1968

Mineral	Unit of Measure	Apparent* Consumption	Production**	Consumption as % of Production
Asbestos	st	142,898	1,595,951	9.0
Cement	st	7,864,571	8,165,805	96.3
Gypsum	st	1,540,862	5,926,940	26.0
Iron ore	lt	9,097,894	42,360,092	21.5
Lime	st	1,379,474	1,439,967	95.8
Quartz (silica)	st	3,597,595	2,554,565	140.8
Salt	st	4,000,000[e]	4,864,092	82.5

*Production plus imports less exports. **Producers' shipments.
[e]Estimated.

TABLE 22

Canada, Apparent Consumption of Some Minerals
and Relation to Production, 1969

Mineral	Unit of Measure	Apparent* Consumption	Production**	Consumption as % of Production
Asbestos	st	39,750	1,596,450	2.5
Cement	st	7,978,345	8,543,622	93.4
Gypsum	st	2,094,927	6,871,971	30.5
Iron ore	lt	10,069,104	35,714,857	28.2
Lime	st	1,564,221	1,718,155	91.0
Quartz (silica)	st	3,467,369	2,263,594	153.2
Salt	st	4,100,000[e]	4,629,000	88.5

*Production plus imports less exports. **Producers' shipments.
[e]Estimated.

TABLE 23

Canada, Domestic Consumption of Principal Refined Metals in Relation to Production* 1960-1969

	Unit of Measure or Percentage	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Copper											
Domestic consumption**	st	117,637	141,808	151,525	169,750	202,225	224,684	262,557	224,398	253,198	240,256
Production	st	417,029	406,359	382,862	380,075	407,942	434,133	433,921	500,020	524,956	450,654
Consumption of production	%	28.2	34.9	39.6	44.7	49.6	51.8	60.5	44.9	48.2	53.3
Zinc											
Domestic consumption†	st	59,143	63,753	68,074	75,591	91,052	97,345	110,481	110,487	118,581	121,417
Production	st	260,968	268,007	280,158	284,021	337,728	358,498	382,612	405,098	426,933	466,351
Consumption of production	%	22.7	23.8	24.3	26.6	27.0	27.2	28.9	27.3	27.8	26.0
Lead											
Domestic consumption†	st	72,087	73,418	77,286	77,958	82,736	90,168	96,683	93,954	94,660	107,270
Production	st	158,510	171,833	152,217	155,000	151,372	186,484	184,871	194,814	202,100	187,143
Consumption of production	%	45.5	42.7	50.8	50.3	54.7	48.4	52.3	48.2	46.8	57.3
Aluminum											
Domestic consumption†	st	120,831	135,575	151,893	166,833	172,443	213,094	243,065	217,494	239,637	217,215**
Production	st	762,012	663,173	690,297	719,390	842,640	830,505	889,915	975,439	994,457	1,098,080
Consumption of production	%	15.9	20.4	22.0	23.2	20.5	25.7	27.3	22.3	24.1	19.8

*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.

TABLE 24

Annual Averages of Prices of Main Minerals*, 1968 and 1969

	Unit of Measure	Average 1968	Average 1969	Increase or decrease Cents or Dollars	Increase or decrease %
Aluminum ingot 99.5%	cents/lb	25.500	27.176	+ 1.676	+ 6.6
Antimony, R.M.M. f.o.b. Laredo, Texas	cents/lb	44.000	55.700	+11.700	+26.6
Bismuth, ton lots delivered	$/lb	4.000	4.625	+ 0.625	+15.6
Cadmium	cents/lb	270.000	327.000	+57.000	+21.1
Calcium, ton lots, crowns	$/lb	0.95	0.95	–	–
Chromium metal, 98.5%, 0.5% C	$/lb	0.96	0.97	+ 0.01	+ 1.0
Cobalt metal, 500 lb lots	$/lb	1.850	1.910	+ 0.06	+ 3.2
Copper, U.S. domestic, f.o.b. refinery	cents/lb	41.847**	47.484	+ 5.637	+13.5
Gold, Canadian dollars	$/troy oz	37.71	37.70	- 0.01	- 0.02
Iron ore, 51.5% Fe, lower lake ports					
Mesabi	$/lt	10.70	10.69	- 0.01	- 0.09
Old Range	$/lt	10.95	10.95	–	–
Mesabi	$/lt	10.55	10.55	–	–
Old Range	$/lt	10.80	10.80	–	–
Lead, common, New York	cents/lb	13.212	14.895	+ 1.683	+12.7
Magnesium, ingot	cents/lb	35.250	35.250	–	–
Mercury	$flask(76 lb)	535.555	505.043	-30.512	- 5.7
Molybdenum metal	$/lb	3.69	3.82	+ 0.13	+ 3.5
Molybdenite, 95% MoS_2 contained Mo	$/lb	1.62	1.68	+ 0.06	+ 3.7
Nickel, f.o.b. Port Colborne (duty incl.)	cents/lb	94.071	105.000	+10.929	+11.6
Platinum	$/troy oz	114.500	121.660	+ 0.716	+ 6.3
Selenium	$/lb	4.50	5.31	+ 0.81	+18.0
Silver, New York	cents/troy oz	214.460	178.975	-35.485	-16.5
Tin, straits, New York	cents/lb	148.151	164.498	+16.347	-11.0
Titanium metal, 500 lb lots 99.3%	$/lb	1.32	1.32	–	–
Titanium ore (ilmenite) 54% TiO_2	$/st	20.50	20.50	–	–
Tungsten metal	$/st	2.75	2.75	–	–
Zinc, prime western, East St. Louis	cents/lb	13.500	14.600	+ 1.100	+ 8.1

*These prices, except for gold are in United States currency and are from *Metal Week*. **Average last nine months because price quotes are suspended from January through March.
–Nil.

TABLE 25

Canada, Wholesale Price Indexes of Minerals and Mineral Products.
1959 and 1967-1969
Base Year – Av. (1935-1939 = 100)

	1959	1967	1968	1969
Iron and products	255.7	274.4	276.8	285.8
Pig iron	295.3	289.9	285.1	285.8
Rolling mill products	249.2	264.0	263.0	275.8
Pipe and tubing	265.0	291.4	302.3	304.4
Wire	293.7	300.5	300.2[r]	314.2
Scrap iron and steel	307.4	263.5	252.7	250.0
Tinplate and galvanized sheet	240.7	256.7	257.2	258.8
Nonferrous metal and products				
Total (including gold)	174.6	240.2	250.8	264.0
Total (excluding gold)	238.0	346.6	365.8	389.6
Antimony	163.9	..	398.2	507.5
Copper and products	285.0	446.9	455.0	493.1
Lead and products	222.6	293.2	281.2	318.4
Silver	225.8	425.8	602.8	497.5
Tin	196.0	317.3	305.8	338.0
Zinc and products	266.0	315.9	307.7	333.8
Solder	199.3	304.0	304.8	328.0
Nonmetallic minerals and products	186.5	199.2	206.0	210.0
Clay and clay products	253.2	251.7	259.5	265.8
Pottery	185.8	258.2	261.7	280.8
Coal	193.0	204.7	208.8	210.3
Coal tar	242.8	248.0	270.0	282.7
Coke	241.3	278.0	284.8[r]	288.4
Window glass	272.1	350.3	350.3	375.4
Plate glass	218.4	292.1	292.1	307.3
Petroleum products	164.2	162.3	164.1	165.5
Crude oil	..	191.7	191.6	191.0
Gasoline	138.0	..	127.4	129.9
Coal oil	134.4	134.2	136.5	137.9
Asphalt	203.7	197.7	197.7	197.7
Asphalt shingles	127.2	101.9	115.4	123.7
Sulphur	199.6	342.6	435.3	290.4
Plaster	137.5	163.0	171.7	181.3
Lime	211.2	246.3	259.7	273.7
Cement	160.6	186.4	193.1	201.2
Sand and gravel	145.4	148.6	168.8	185.2
Crushed stone	171.4	162.1	165.3	171.9
Building stone	208.8	232.4	256.3	257.7
Asbestos	304.3	339.0	348.8	366.3
General wholesale price index (all products)	230.6	264.1	269.9	282.4

[r] Revised; .. Not available.

TABLE 26

Canada, General Wholesale Price Index and Wholesale Price Indexes of Mineral and Non-Mineral Products Industries, 1945-1969
Base Year – Av. (1935-1939 = 100)

	Mineral Products Industries			Non-mineral Products Industries					
	Ferrous Metal Products	Nonferrous Metal Products	Mineral Products	Vegetable Products	Animal Products	Textile Products	Wood Products	Chemical Products	General Wholesale Price Index
1945	117.9	107.6	113.5	131.6	150.0	130.8	154.9	124.0	132.1
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

TABLE 27

Canada, Mineral Industry and Mineral Products Industries, Selling Price Indexes, 1966-1969
Base Year, 1961 = 100

	1966	1967	1968	1969
Iron and steel products industries				
Agricultural implements industry	108.2	110.2	114.3	118.5
Hardware, tool and cutlery manufacturers	106.3	110.4	115.7	121.0
Heating equipment manufacturers	98.6	100.9	104.5	107.6
Primary metal industries	115.3	118.9	120.5	129.0
Iron and steel mills	101.7	103.4	103.0	106.7
Steel pipe and tube mills	103.2	98.7	95.3	95.5
Iron foundries	110.9	115.3	119.0	122.0
Wire and wire products manufacturers	104.9	106.0	106.1	110.1
Nonferrous metal products industries				
Aluminum rolling, casting and extruding	105.2	106.2	104.3	107.2
Copper and alloy, rolling, casting and extruding	142.5	148.8	150.9	164.7
Jewellery and silverware manufacturers	120.6	128.8	142.3	144.0
Metal rolling, casting and extruding n.e.s.	146.0	140.1	141.7	158.1
Nonmetallic mineral products industries				
Abrasive manufacturers	105.1	108.3	108.9	110.3
Cement manufacturers	106.8	111.8	116.3	121.1
Clay products manufacturers from imported clay	105.4	109.9	112.3	115.5
Glass manufacturers	109.0	111.6	114.2	119.3
Lime manufacturers	110.8	114.0	119.6	124.4
Gypsum products manufacturers	103.5	108.3	112.0	117.0
Concrete products manufacturers	107.6	113.6	116.7	120.5
Clay products from domestic clay	106.4	109.0	112.6	118.3
Petroleum and coal products industries	95.1	96.0	98.1	100.1
Petroleum refining	95.0	95.8	97.8	99.7
Lubricating oils and greases	106.9	110.4	117.0	121.4
Manufacturers of mixed fertilizers	110.2	111.6	116.6	110.0

Note: Industry selling price indexes are considered as wholesale price indexes.

TABLE 28

Canada – Principal Statistics of the Mineral Industry by Sectors, 1967

	Mineral Activity								Total Activity		
		Production and Related Workers							Employees		
	Establishments Number	Number	Man hours paid thousand	Wages $000	Cost of Fuel and Electricity $000	Cost of Materials & Supplies $000	Value of Production $000	Value Added $000	Number	Salaries & Wages $000	Value Added $000
Metallic											
Placer gold	22	15	27	76	24	79	360	257	16	79	260
Gold quartz	45	8,683	18,154	43,674	5,954	28,890	120,196	85,352	10,319	54,412	86,075
Copper-gold-silver	45	10,776	22,515	65,660	12,462	173,963	543,914	357,487	13,270	84,118	360,817
Silver-cobalt	8	438	880	2,141	264	1,715	8,850	6,870	519	2,684	6,843
Silver-lead-zinc	22	4,441	9,429	27,536	6,080	98,311	243,303	138,912	5,511	35,835	138,454
Nickel-copper	10	13,699	28,868	98,137	5,345	258,972	641,803	377,487	16,018	119,615	386,870
Iron	18	7,001	16,903	58,312	29,944	94,782	414,320	289,595	10,899	92,267	292,314
Misc. metal mines	15	3,209	7,024	22,442	4,410	23,599	106,445	78,437	4,122	28,999	79,532
Sales and Head offices	–	–	–	–	–	–	–	–	1,054	11,374	1,260
Total	185	48,262	103,800	317,978	64,483	680,311	2,079,191	1,334,397	61,728	429,383	1,352,425

TABLE 28 (Cont'd)

	Mineral Activity								Total Activity		
		Production and Related Workers							Employees		
	Establishments Number	Number	Man hours paid thousand	Wages $000	Cost of Fuel and Electricity $000	Cost of Materials &Supplies $000	Value of Production $000	Value Added $000	Number	Salaries & Wages $000	Value Added $000
Industrial Minerals											
Asbestos	11	5,651	13,003	35,864	9,538	27,912	174,368	136,918	6,931	46,214	136,905
Cement	24	2,654	5,860	17,456	21,889	21,038	139,772	100,496	3,972	27,389	100,294
Clay and clay products	78	2,723	5,959	13,276	5,737	7,547	44,138	30,906	3,300	17,352	31,074
Feldspar, quartz and nepheline syenite	11	283	647	1,492	485	1,460	8,729	6,784	373	2,052	6,956
Gypsum	9	406	881	1,934	381	1,443	9,793	7,968	505	2,610	7,981
Lime	13	577	1,273	3,119	2,612	2,294	12,606	7,769	724	4,043	7,973
Peat	60	1,148	2,271	3,696	412	3,221	11,531	7,898	1,261	4,421	7,924
Salt	10	871	1,930	4,828	1,369	5,058	27,514	21,087	1,413	8,633	21,419
Sand and gravel	207	1,854	4,239	10,440	3,334	9,713	50,230	37,182	2,398	14,428	37,549
Stone	160	2,779	6,478	14,271	4,239	15,651	63,319	43,428	3,381	18,251	43,522
Talc and soapstone	4	78	175	309	57	291	988	640	99	426	634
Misc. nonmetals	15	1,979	4,095	11,922	6,449	14,368	85,085	64,268	2,620	16,976	64,573
Total	602	21,003	46,811	118,607	56,502	109,996	628,073	465,344	26,977	162,795	466,804
Fuels											
Coal	63	7,368	14,193	36,807	3,363	14,733	82,925	64,829	8,981	46,288	65,018
Petroleum and natural gas	745	3,551	7,472	25,949	13,453	30,896	1,229,686	1,183,814	13,113	111,855	1,189,495
Total	808	10,919	21,665	62,756	16,816	45,629	1,312,611	1,248,643	22,094	158,143	1,254,513
Total Mining Industry	1,595	80,184	172,276	499,341	137,801	835,936	4,019,875	3,048,384	110,799	750,321	3,073,742
Nonferrous Smelting and Refining	24	26,122	55,594	169,772	65,137	348,753	862,014	448,124	34,764	236,340	463,321
Total Mineral Industry	1,619	106,306	227,870	669,113	202,938	1,184,689	4,881,889	3,496,508	145,563	986,661	3,537,063

– Nil.

TABLE 29

Canada – Principal Statistics of the Mining Industry* 1962-1967

		Mining Activity							Total Activity**		
		Production and Related Workers							Employees		
	Establish-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	$000	$000	$000	$000	$000	Number	$000	$000
1962	1,574	79,726	168,136	376,066	92,261	492,559	2,573,389	1,988,569	104,615	537,800	2,012,568
1963	1,552	78,016	168,236	377,669	101,160	520,865	2,770,675	2,148,649	103,502	547,751	2,181,370
1964	1,548	78,381	170,622	393,272	109,803	583,143	3,118,200	2,425,253	104,441	571,948	2,459,723
1965	1,586	81,238	176,473	428,500	127,658	678,773	3,428,308	2,621,877	108,979	626,688	2,660,445
1966	1,542	80,575	172,418	454,149	132,399	728,386	3,634,035	2,763,248	110,576	678,002	2,787,022
1967	1,595	80,184	172,276	499,341	137,801	835,936	4,019,875	3,048,384	110,799	750,321	3,073,742

*Includes cement manufacturing, lime manufacturers, clay and clay products (domestic clays). **Total Activity includes sales and head offices employees.

TABLE 30

Canada – Principal Statistics of the Nonferrous Smelting and Refining Industries, 1962-1967

		Mining Activity							Total Activity*		
		Production and Related Workers							Employees		
	Establish-ments		Man-hours paid	Wages	Cost of Fuel and Electricity	Cost of Materials and Supplies	Value of Production	Value Added		Salaries and Wages	Valued Added
	Number	Number	$000	$000	$000	$000	$000	$000	Number	$000	$000
1962	22	22,621	46,320	116,049	46,697	291,166	649,792	311,929	29,093	158,163	320,373
1963	23	21,553	45,176	112,191	47,055	295,825	639,659	296,779	28,516	159,151	307,247
1964	23	23,239	48,900	126,109	52,988	314,567	718,254	350,699	30,153	174,450	364,749
1965	23	24,382	52,190	139,120	57,950	305,468	770,690	407,272	31,835	192,668	427,651
1966	23	24,593	50,896	145,402	62,829	347,280	826,167	416,058	33,237	209,528	433,858
1967	24	26,122	55,594	169,772	65,137	348,753	862,014	448,124	34,764	236,340	463,321

*Total Activity includes sales and head offices employees.

TABLE 31

Canada – Consumption of Fuel and Electricity in the Mineral Industry, 1967

	Unit	Metal Mining	Nonferrous Smelting and Refining	Total	Production of Industrial Minerals*	Production of Crude Mineral Fuels	Total Mineral Industry
Coal and coke	st	62,233	1,155,865	1,218,098	911,348	168	2,129,614
	$000	942	19,021	19,963	10,035	4	30,002
Gasoline	gal	4,157,711	1,253,683	5,411,394	9,674,900	914,017	16,000,311
	$000	1,512	351	1,863	3,426	290	5,579
Fuel oil, kerosene, coal oil	gal	161,016,007	108,082,693	269,098,700	121,085,168	2,003,485	392,187,353
	$000	20,345	8,802	29,147	14,153	334	43,634
Liquefied petroleum gas	gal	1,340,345	4,283,779	5,624,124	503,409	50,907	6,178,440
	$000	242	486	728	142	6	876
Natural gas	Mcf	5,996,466	18,410,455	24,406,921	34,798,844	–	59,205,765
	$000	2,730	6,829	9,559	10,714	–	20,273
Other fuels	$000	370	16	386	694	56	1,136
Total fuels	$000	26,141	35,505	61,646	39,164	690	101,500
Electricity purchased	million kwh	6,300	8,142	14,442	2,254	989	17,685
	$000	38,342	29,632	67,974	17,339	16,126	101,439
Total value, fuels and electricity purchased	$000	64,483	65,137	129,620	56,503	16,816	202,939
Electricity generated by industry for own use	million Kwh	420	15,974	16,394	151	–	16,545

–Nil.
*Includes cement, lime and clay and clay products (from domestic clays) industries.
Note: Statistics are based on the revised Canadian Standard Industrial Classification.

TABLE 32

Canada – Cost of Fuel and Electricity Used in the Mining Industry 1961-1967

		1961	1962	1963	1964	1965	1966	1967
Fuel	$million	37.8	41.8	46.8	51.0	60.1	64.2	66.0
Electricity purchased	million kwh	5,350	5,658	6,355	7,032	8,443	8,605	9,543
	$million	47.3	50.5	54.4	58.8	67.6	68.1	71.9
Total cost of fuel and electricity	$million	85.1	92.3	101.2	109.8	127.7	132.3	137.9
Electricity generated for own use and for sale	million kwh	586.3	654.6	541.6	486.8	524.5	613.2	661.2

Note: Statistics are based on the revised Canadian Standard Industrial Classification.

TABLE 33

Canada – Cost of Fuel and Electricity Used in the Nonferrous Smelting and Refining Industry, 1961-1967

		1961	1962	1963	1964	1965	1966	1967
Fuel	$ million	28.1	25.8	24.3	28.4	32.9	35.5	35.5
Electricity purchased	million kwh	5,389	5,046	6,330	7,189	7,261	7,680	8,142
	$ million	21.8	20.9	22.8	24.6	25.1	27.3	29.6
Total cost of fuel and electricity	$million	49.9	46.7	47.1	53.0	58.0	62.8	65.1

Note: Statistics are based on the revised Canadian Standard Industrial Classification.

TABLE 34

Canada – Employment, Salaries and Wages in the Mineral Industry 1947, 1952, 1957, 1962, 1966, 1967

	1947		1952		1957		1962		1966		1967	
	Em-ployees	$ 000	Em-ployees	$ 000	Em-ployees	$ 000	Em-ployees	$ 000	Em-ployees	$ 000	Em-ployees	$ 000
Metal mining	39,334	96,768	55,338	197,683	62,554	278,533	58,243	306,004	61,698	385,142	61,728	429,383
Nonferrous smelting and refining	17,449	40,768	24,608	87,964	29,613	134,775	29,093	158,163	33,237	209,528	34,764	236,340
Industrial minerals*	22,429	39,600	26,141	79,394	31,312	114,340	25,243	116,774	27,082	152,464	26,977	162,793
Fuels	25,307	52,425	28,029	87,935	21,985	81,954	21,129	115,023	21,796	140,396	22,094	158,143
Total	104,519	229,561	134,116	452,976	145,464	609,602	133,708	695,964	143,813	887,530	145,563	986,659
Annual average of salaries and wages		$ 2,196		$ 3,377		$ 4,191		$ 5,205		$ 6,171		$ 6,778

*Includes cement, lime and clay and clay products (from domestic clays) manufacture.

TABLE 35

Canada – Number of Wage Earners, Surface, Underground and Mill, Mining Industry, by Sectors, 1961-1967

	1961	1962	1963	1964	1965	1966	1967
Metallics							
Surface	13,076	13,689	13,220	13,703	14,639	14,198	13,864
Underground	28,815	27,424	25,838	25,669	26,055	26,009	25,482
Mill	6,377	6,601	7,192	7,355	8,356	8,097	8,916
Total	48,268	47,714	46,250	46,727	49,050	48,304	48,262
Industrial Minerals*							
Surface	9,333	8,770	8,892	8,692	8,885	9,237	8,851
Underground	978	968	865	920	1,045	1,117	1,382
Mill	9,567	10,729	10,555	10,643	10,950	10,914	10,770
Total	19,878	20,467	20,312	20,255	20,880	21,268	21,003
Fuels							
Surface	5,321	5,366	5,246	5,255	5,256	5,248	5,380
Underground	6,338	6,179	6,208	6,144	6,052	5,755	5,539
Total	11,659	11,545	11,454	11,399	11,308	11,003	10,919
Total Mining Industry							
Surface	27,730	27,825	27,358	27,650	28,780	28,683	28,095
Underground	36,131	34,571	32,911	32,733	33,152	32,881	32,403
Mill	15,944	17,330	17,747	17,998	19,306	19,011	19,686
Total	79,805	79,726	78,016	78,381	81,238	80,575	80,184

*Includes cement, lime, clay and clay products (from domestic clays) manufacture.

TABLE 36

Canada – Labour Costs in Relation to Tons Mined – Metal Mines, 1947, 1957, 1966, 1967

Type of Metal Mines	Number of Wage Earners	Total Wages $000	Average Annual Wage $	Tons Mined 000 s t	Average Annual tons mined per Wage Earner s t	Wage Cost per ton mined $
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	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	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
1957						
Auriferous quartz	16,911	63,709	3,767	14,473	856	4.40
Copper-gold-silver	10,359	46,694	4,508	10,571	1,020	4.42
Nickel-copper	12,124	59,808	4,933	19,290	1,591	3.10
Silver-cobalt	598	2,210	3,696	186	311	11.88
Silver-lead-zinc	5,844	26,257	4,493	6,715	1,149	3.91
Iron ore	7,770	36,289	4,670	26,418	3,400	1.37
Miscellaneous	8,705	42,386	4,869	6,689	768	6.34
Total	62,311	277,353	4,451	84,342	1,354	3.29
1947						
Auriferous quartz	22,906	54,612	2,384	11,633	508	4.69
Copper-gold-silver	5,220	13,149	2,519	5,462	1,046	2.41
Nickel-copper	6,144	15,686	2,553	11,138	1,813	1.41
Silver-cobalt	183	360	1,967	11	60	32.72
Silver-lead-zinc	3,240	8,305	2,563	2,857	882	2.91
Iron ore	–	–	–	–	–	–
Miscellaneous	1,183	2,971	2,511	133	112	22.32
Total	38,876	95,083	2,446	31,234	803	3.04

– Nil.

TABLE 37

Canada – Man-hours Worked, Production and Related Workers, Tons of Ore Mined and Rock Quarried, Metal Mines and Industrial Mineral Operations 1961-1967

	Unit	1961	1962	1963	1964	1965	1966	1967
Metal mines*								
Ore mined	million st	99.4	114.3	124.3	141.1	166.5	162.8	186.5
Man-hours paid**	million	101.2	99.4	99.7	100.7	106.4	101.4	103.8
Man-hours paid per ton mined	number	1.02	0.87	0.80	0.71	0.64	0.62	0.56
Industrial mineral operations†								
Ore mined and rock quarried	million st	94.6	100.9	119.0	132.9	144.0	160.3	174.6
Man-hours paid**	million	21.9	22.8	23.1	24.0	23.2	24.7	23.1
Man-hours paid per ton mined	number	0.23	0.22	0.19	0.18	0.16	0.15	0.13

*Excludes placer mining. **Man-hours paid for production and related workers only. †Excludes salt, cement, clay products, stone for cement and lime manufacture and peat.

TABLE 38

Basic Wage Rates per Hour in Canadian Metal Mining Industry on October 1, 1968 and 1969

	Gold Mining		Iron Mining		Other Metal Mining	
	1968	1969P	1968	1969P	1968	1969P
	$	$	$	$	$	$
Underground workers						
Cage and skiptenders	2.22	2.31	. .	. .	2.89	2.97
Chute blaster	2.18	2.26	. .	. .	2.96	3.05
Deckman	2.06	2.17	. .	. .	2.58	2.76
Hoistman	2.37	2.46	. .	. .	3.09	3.21
Labourer	2.09	2.19	. .	. .	2.59	2.72
Miner	2.20	2.32	. .	. .	2.92	3.02
Miner's helper	2.02	2.20	. .	. .	2.53	2.66
Motorman	2.05	2.17	. .	. .	2.88	–
Mucking machine operator	2.07	2.14	. .	. .	2.80	–
Mucker and trammer	2.06	2.12	. .	. .	2.82	2.90
Timberman	2.21	2.33	. .	. .	2.94	3.04
Trackman	2.12	2.27	. .	. .	2.84	2.96
Open-pit workers						
Blaster	. .	. .	3.05	3.30	. .	. .
Bulldozer operator	. .	. .	3.04	3.36	. .	. .
Driller machine	. .	. .	3.17	3.42	. .	. .
Dumptruck driver	. .	. .	3.15	3.47	. .	. .
Oiler	. .	. .	2.81	3.16	. .	. .
Shovel operator (power)	. .	. .	3.57	3.95	. .	. .
Surface and mill workers						
Blacksmith	. .	. .	. .	. .	3.05	3.18
Carpenter, maintenance	2.35	2.43	3.42	3.79	3.04	3.26
Crusher operator	2.17	2.27	2.99	3.21	2.79	2.92
Electrician	2.43	2.56	3.51	3.90	3.29	3.48
Filter operator	. .	. .	. .	. .	2.73	2.83
Flotation operator	. .	. .	. .	. .	2.84	3.04
Grinding-mill operator	. .	. .	3.08	3.42	2.79	2.98
Hoistman	. .	. .	. .	. .	. .	. .
Labourer	2.00	2.10	2.60	2.89	2.51	2.66
Machinist, maintenance	2.40	2.70	3.55	3.95	3.38	3.55
Mechanic, diesel	. .	. .	3.52	3.83	3.25	3.49
Mechanic, maintenance	2.37	2.40	3.45	3.85	3.19	3.33
Millman*	2.22	2.31	. .	. .	. .	. .
Pipefitter, maintenance	2.26	2.34	3.36	. .	2.97	3.14
Solution man	. .	. .	. .	. .	2.74	3.06
Steel sharpener	2.27	2.35	. .	. .	2.78	2.95
Trademan's helper	2.08	2.13	2.87	3.09	2.67	2.76
Truck driver, light and heavy	2.12	2.21	3.03	3.30	2.83	3.01
Welder, maintenance	2.42	2.50	3.40	3.77	3.16	3.39
Millwright	. .	. .	3.36	3.73	. .	. .

*Includes filter operator, grinding mill operator (ball-mill operator, rod-mill operator, tubeman) and solution man.
P Preliminary; . . Not available or not applicable.

TABLE 39

Canada, Index Numbers of Average Wage Rates* by Industries
1964-1969
Base Year, 1961 = 100

	1964	1965	1966	1967	1968	1969
Logging	117.5	126.4	140.2	156.0	162.5	179.8
Metal mining	109.6	113.3	122.7	130.2	138.9	146.2
Gold-quartz	115.7	121.6	134.6	142.7	154.5	161.6
Iron	112.1	112.2	121.0	129.0	133.2	147.1
Other metal	106.6	110.3	118.4	125.6	134.1	140.0
Manufacturing	109.7	115.0	121.6	130.5	140.6	151.2
Non-durable	110.5	115.5	121.9	131.0	141.4	152.5
Petroleum refineries	109.8	112.6	123.1	131.4	139.3	146.2
Durable	108.9	114.4	121.2	130.0	139.7	149.7
Primary metal industries	109.3	114.8	116.5	123.1	128.5	135.1
Metal fabricating industries	109.3	115.7	125.0	131.2	140.4	151.9
Machinery industries	109.5	114.9	122.7	131.0	140.5	151.8
Transportation equipment industries	109.6	115.4	122.5	131.7	142.1	152.8
Electrical products industries	102.7	105.9	112.3	123.4	133.8	141.7
Construction	113.9	119.8	129.8	142.0	154.9	167.0
Transportation, communication and other utilities	109.8	114.3	122.3	132.8	143.4	154.9
Trade	111.0	116.9	123.9	132.5	144.5	155.2
Service	111.7	118.4	125.5	133.9	141.8	154.0
Local government (Municipal government only)	111.5	118.1	124.6	136.9	146.7	163.4
General Index – All Industries	110.9	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 40

Average Weekly Wages and Hours of Hourly-Rated Employees in Canadian Mining, Manufacturing and Construction Industries, 1963-1969

	1963	1964	1965	1966	1967	1968	1969p
Mining							
Average hours per week	42.0	42.2	42.5	42.3	41.9	41.8	41.4
Average weekly wage	93.87	97.43	103.30	110.29	119.09	128.28	135.94
Metals							
Average hours per week	41.5	41.7	41.9	41.6	41.3	41.2	40.7
Average weekly wage	96.22	99.48	105.76	112.99	122.79	131.55	137.50
Fuels							
Average hours per week	42.5	42.1	41.3	42.3	42.5	41.9	41.9
Average weekly wage	85.10	86.98	89.07	95.68	101.24	109.96	123.08
Nonmetals							
Average hours per week	41.1	41.7	42.7	42.1	42.3	42.4	42.0
Average weekly wage	89.66	94.42	99.49	104.00	112.35	121.24	129.01
Manufacturing							
Average hours per week	40.8	41.0	41.0	40.8	40.3	40.3	40.0
Average weekly wage	79.51	82.96	86.89	91.65	96.84	104.00	111.69
Construction							
Average hours per week	41.2	41.4	41.3	42.2	41.3	40.5	39.6
Average weekly wage	92.20	97.39	104.45	118.23	128.76	134.84	146.90

p Preliminary.

TABLE 41

Average Weekly Wages of Hourly-Rated Employees in Canadian Mining Industry in Current and 1949 Dollars, 1963-1969

	1963	1964	1965	1966	1967	1968	1969
Current Dollars							
All mining	93.87	97.43	103.30	110.29	119.09	128.28	135.94
Metals	96.22	99.48	105.76	112.99	122.79	131.55	137.50
Gold	77.38	80.27	84.71	91.12	95.72	101.26	107.29
Fuels	85.10	86.98	89.07	95.68	101.24	109.96	123.08
Coal	79.25	80.84	80.68	85.53	90.63	97.41	108.69
Nonmetallics	89.66	94.42	99.49	104.00	112.35	121.24	129.01
1949 Dollars							
All mining	70.58	71.96	74.48	76.64	79.92	82.65	83.86
Metals	72.35	73.47	76.25	78.52	82.40	84.76	84.82
Gold	58.18	59.28	61.07	63.32	64.24	65.24	66.19
Fuels	63.98	64.24	64.22	66.49	67.94	70.85	75.93
Coal	59.59	59.70	58.17	59.44	60.83	62.76	67.05
Nonmetallics	67.41	69.73	71.73	72.27	75.40	78.12	79.59

TABLE 42

Canada, Industrial Fatalities per Thousand Paid Workers
in Main Industry Groups* 1959-1969

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969p
Agriculture	0.92	0.62	0.61	0.56	0.48	0.72	0.48	0.54	0.30	0.27	0.31
Forestry	1.70	1.50	1.32	2.04	1.79	2.21	1.64	1.53	1.49	1.46	1.18
Fishing and Trapping	7.20	2.70	4.00	1.20	3.40	3.70	4.00	3.60	3.30	2.11	2.57
Mining*	2.00	1.92	1.73	1.89	2.33	1.87	1.24	1.13	1.62	1.14	1.32
Manufacturing	0.13	0.19	0.12	0.15	0.15	0.14	0.14	0.14	0.10	0.10	0.11
Construction	0.79	0.56	0.77	0.63	0.70	0.75	0.72	0.66	0.56	0.55	0.55
Transportation, Communication and other Utilities	0.44	0.37	0.36	0.38	0.42	0.43	0.49	0.41	0.37	0.28	0.31
Trade	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.05	0.06	0.05	0.05
Finance, Insurance and Real Estate	0.01	0.09	0.05	0.08	0.04	0.08	0.01	0.04	0.01	–	0.01
Service†	0.06	0.07	0.06	0.06	0.09	0.07	0.05	0.04	0.04	0.05	0.04
Total	0.28	0.21	0.22	0.22	0.23	0.24	0.23	0.19	0.18	0.16	0.16

*Includes quarrying and oil-well drilling. Cement, lime and clay products manufacture are included under manufacturing.

† Includes Public Administration.

p Preliminary; – Nil.

TABLE 43

Canada, Strikes and Lockouts in Existence, 1968 and 1969

	1968			1969		
	Strikes and Lockouts	Workers Involved	Duration in Man-Days	Strikes and Lockouts	Workers Involved	Duration in Man-Days
Agriculture	2	80	150	–	–	–
Forestry	6	896	9,740	12	2,798	8,100
Mines	21	4,882	100,800	27	31,511	2,087,490
Manufacturing	342	155,653	3,746,190	284	88,303	2,688,260
Construction	103	18,628	275,510	118	79,748	1,981,300
Transportation and Utilities	40	31,040	490,090	46	30,312	559,460
Trade	31	5,252	366,712	44	7,052	270,930
Service	21	1,735	26,000	51	58,147	141,250
Public Administration	16	5,396	67,540	13	8,928	13,090
All Industries	582	223,562	5,082,732	595	306,799	7,749,880

– Nil.

TABLE 44

Canada, Ore Mined and Rock Quarried Mining Industry,
1965-1967
(short tons)

	1965	1966	1967
Metallic ores			
Gold-quartz	12,042,354	11,187,827	10,289,826
Copper-gold-silver	20,016,849	23,085,616	31,279,288
Silver-cobalt	279,091	270,492	225,898
Silver-lead-zinc	10,139,481	11,755,330	11,662,803
Nickel-copper	24,249,575	21,792,636	24,795,565
Iron	89,154,543	79,818,862	90,165,071
Miscellaneous metals	10,654,616	14,883,076	18,118,195
Total	166,536,509	162,793,839	186,536,646
Nonmetallics			
Asbestos	53,399,988	60,239,777	77,502,293
Feldspar, nepheline syenite	448,777	557,003	588,330
Quartz (exclusive of sand)	1,471,830	1,509,603	1,264,397
Gypsum	6,112,078	5,857,796	5,302,119
Talc, soapstone	57,169	69,817	62,949
Rock salt	3,363,611	3,077,027	3,625,115
Other nonmetallics	5,732,636	7,223,902	9,221,764
Total	70,586,089	78,534,925	97,566,967
Structural materials			
Stone, all kinds quarried	76,758,105	84,874,387	80,636,102
Stone used to make cement	11,236,634	12,104,057	11,058,249
Stone used to make lime	2,927,691	2,972,618	3,269,092
Total	90,922,430	99,951,062	94,963,443
Total ore mined and rock quarried	328,045,028	341,279,826	379,067,056

TABLE 45

Canada, Ore Mined and Rock Quarried, Mining Industry,
1934-1967
(million short tons)

	Metal Mines	Industrial Minerals Operations	Total
1934	18.8	8.8	27.6
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	178.5	341.3
1967	186.5	192.5	379.0

TABLE 46

Exploration and Development Expenditures* Metal and Nonmetal Mines in Canada, by Province or Territory, 1967 and 1968
($000)

Province or Territory	1967			1968		
	Exploration	Development	Total	Exploration	Development	Total
Newfoundland	1,607	2,482	4,089	2,060	2,617	4,677
Prince Edward Island	–	–	–	–	–	–
Nova Scotia	1,212	802	2,014	683	845	1,528
New Brunswick	1,670	3,630	5,300	2,673	4,665	7,338
Quebec	12,154	10,434	22,588	17,479	15,653	33,132
Ontario	17,236	34,300	51,536	25,495	44,751	70,246
Manitoba	6,337	15,418	21,755	8,479	21,308	29,787
Saskatchewan	4,451	30,765	35,216	7,644	31,401	39,045
Alberta	568	1,102	1,670	2,360	2,256	4,616
British Columbia	25,727	30,192	55,919	27,421	23,272	50,693
Yukon Territory	1,214	671	1,885	6,279	2,444	8,723
Northwest Territories	1,745	2,321	4,066	4,975	1,245	6,220
Canada	73,921	132,117	206,038	105,548	150,457	256,005

*These expenditures on exploration and development are the results of a survey on mining exploration and development expenditures instituted by the Dominion Bureau of Statistics in 1967. All mining companies, both producers and nonproducers, in the metallic and nonmetallic mining sectors were covered. Mining companies classified in the fuels area (coal, petroleum, natural gas) were not covered in this survey.
–Nil.

TABLE 47

Canada – Diamond Drilling on Metal Deposits by Mining Companies with Own Equipment and by Drilling Contractors
1954-1967
(footage)

	Gold-Quartz Deposits	Copper-Gold-Silver and Nickel-Copper Deposits	Silver-Lead Zinc Deposits	Other Metal Bearing Deposits*	Total Metal Deposits
1954	2,418,853	2,710,920	891,972	653,206	6,674,951
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	2,317,170	3,603,971	1,062,020	942,794	7,925,955
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	2,960,263	3,363,019	1,148,886	1,176,768	8,648,936
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

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

TABLE 48

Canada, Exploration, Diamond Drilling, Metal Deposits, 1954-1967 (footage)

	By Mining Companies with Own Personnel and Equipment	By Diamond Drill Contractors	Total
1954	969,858	3,041,220	4,611,078
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

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

TABLE 49

Canada, Contract Diamond Drilling Operations, 1957-1967

	Footage Drilled feet	Income from Drilling $ million	Average No. of Employees number	Total Salaries and Wages $ 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

TABLE 50

Canada, Contract Drilling for Oil and Gas 1958-1967

	Footage Drilled				Gross Income from Drilling	Average No. of Employees	Total Salaries and Wages
	Rotary	Cable feet	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

TABLE 51

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

– Nil.

* Domestic and imported.

TABLE 52

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 53

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 54

Crude and Fabricated Minerals* Transported Through Canadian Canals† 1967 and 1968
(thousand short tons)

	1967	1968
Crude minerals		
Alumina and bauxite ores	186	343
Copper ore, concentrates, matte, precipitate	2	2
Iron ore, crude, concentrated, calcined	32,797	36,373
Manganese ore	394	271
Nickel-copper ore, matte, concentrates	4	6
Ores, concentrates, precipitates, n.e.s.	48	69
Iron and steel scrap	930	846
Nonferrous and precious metal scrap	70	46
Slag, dross and byproducts	25	44
Coal, bituminous, subbituminous and lignite	9,830	11,020
Coal, n.e.s.	1	–
Crude petroleum and natural gasoline	239	196
Natural gas and other crude bituminous substances	8	7
Asbestos, unmanufactured	6	5
Bentonite	230	374
China clay	60	70
Dolomite	1,134	1,387
Clay and other crude refractory materials, n.e.s.	101	27
Sand and gravel	216	228
Limestone	10	9
Crushed stone, including stone refuse, excluding limestone	1	16
Stone, crude, n.e.s.	60	52
Fluorspar	320	366
Gypsum	59	38
Phosphate rock	133	3
Salt	1,320	1,658
Sulphur in ores, crude and refined	51	12
Crude nonmetallic minerals, n.e.s.	52	10
Total crude minerals	48,287	53,478
Fabricated		
Gasoline	828	829
Fuel oil	3,586	4,222
Lubricating oils and greases	346	293
Coke of petroleum and coal	490	598
Asphalt and road oils	45	17
Coal tar and coal pitch	113	139
Petroleum and coal products, n.e.s.	291	352
Ferroalloys	140	155
Pig iron	476	521
Primary iron and steel, n.e.s.	59	99
Castings and forgings (except pipes and fittings)	42	112
Bars and rods, steel	670	978
Plate, sheet, strip, steel	4,422	7,632
Structural shapes and sheet piling	1,218	1,640
Rails and railway track material	4	8
Pipes and tubes, iron and steel	96	109
Wire and wire rope	189	223
Aluminum, including alloys	46	55
Copper and alloys	20	22

TABLE 54 (Cont'd)

	1967	1968
Fabricated (Cont'd)		
Lead and alloys	28	8
Nickel and alloys	16	10
Zinc and alloys	61	72
Nonferrous metals, n.e.s.	13	17
Metal fabricated, basic products, n.e.s.	212	193
Building brick, clay	–	–
Bricks, tiles, n.e.s.	22	55
Glass basic products	118	144
Asbestos and asbestos cement basic products	1	2
Cement	244	170
Cement basic products	1	2
Nonmetallic mineral, basic products, n.e.s.	50	58
Total fabricated minerals	13,847	18,735
Total, crude and fabricated minerals	62,134	72,213
Total all freight transported	98,774	108,274
Per cent crude and fabricated minerals of total freight	62.9	66.7

*Domestic and imported. † Canals and inland waterways include: St. Lawrence, Welland, Sault Ste. Marie, St. Peter's, Canso, Richelieu River, Ottawa River, Rideau, Murray, Trent and St. Andrews.
n.e.s. – not elsewhere specified.

TABLE 55

Canada – Taxes* Paid to Federal, Provincial and Municipal Governments
by Important Divisions of the Mining Industry
1966 and 1967
($ 000)

	1966				1967			
	Federal Income Tax	Provincial Tax	Municipal Tax	Total	Federal Income Tax	Provincial Tax	Municipal Tax	Total
Auriferous-quartz mining	2,633	1,577	961	5,171	2,376	1,570	925	4,871
Copper-gold-silver mining, smelting and refining	18,866	12,690	2,775	34,331	25,827	22,937	3,292	52,056
Silver-lead-zinc mining, smelting and refining	11,078	9,442	2,383	22,903	8,440	7,503	2,739	18,682
Nickel-copper, mining, smelting and refining	43,976	23,989	2,780	70,745	26,067	15,914	2,942	44,923
Iron mining	1,913	8,761	4,307	14,981	1,482	7,647	3,891	13,020
Miscellaneous metal mining	22	1,346	585	1,953	88	1,883	820	2,791
Asbestos mining	14,479	9,798	2,069	26,346	14,325	10,250	1,629	26,204
Feldspar, quartz, nepheline syenite mining	26	85	26	137	34	71	41	146
Gypsum mining	897	306	284	1,487	694	234	278	1,206
Peat mining	23	64	75	162	34	73	91	198
Salt mining	–	559	303	862	–	1,020	314	1,334
Talc and soapstone, mining	2	15	7	24	1	16	6	23
Stone quarries	1,378	666	372	2,416	1,179	713	449	2,341
Sand and gravel pits	499	636	296	1,431	729	534	303	1,566
Miscellaneous nonmetal mining	2,644	2,547	736	5,927	1,751	2,321	990	5,062
Total of sectors covered	98,436	72,481	17,959	188,876	83,027	72,686	18,710	174,423

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

TABLE 56

Canada – Taxes* Paid by Six Important Divisions of the Mineral Industry, 1961-1967
($ million)

	1961	1962	1963	1964	1965	1966	1967
Auriferous quartz mining	7.0	6.1	6.5	5.2	4.4	5.2	4.9
Copper-gold-silver mining	20.1	15.2	20.3	26.0	34.9	34.3	52.1
Silver-lead-zinc mining, smelting and refining	15.7	17.7	20.5	26.5	27.9	22.9	18.7
Nickel-copper-mining, smelting and refining	38.2	51.6	35.9	47.8	77.7	70.7	44.9
Iron mining	5.6	7.5	11.0	6.1	11.6	15.0	13.0
Asbestos mining	16.8	18.4	18.6	20.3	22.5	26.3	26.2
Total	103.4	116.5	112.8	131.9	179.0	174.4	159.8

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

TABLE 57

Canada – Federal Income Taxes of Reporting Companies in the Mining and Mineral Fabricating Industries, 1966 and 1967
($ million)

	1966	1967
Mining		
Metals		
Gold	2.4	1.7
Iron	2.8	1.1
Other metal mines	20.5	29.0
Total	25.7	31.8
Mineral fuels		
Coal	0.2	0.1
Oil and gas	14.1	46.4
Total	14.3	46.5
Other mining		
Nonmetal mines	16.9	11.4
Quarries	3.4	2.6
Mining service	2.5	2.4
Total	22.8	16.4
Total mining industry	62.8	94.7
Mineral fabricating industries		
Primary metals		
Iron and steel mills	13.9	8.6
Iron foundries	3.9	4.4
Smelting and refining	5.9	46.6
Total	23.7	59.6
Nonmetallic mineral products		
Cement	7.9	0.3
Concrete	1.7	4.0
Ready-mix concrete	2.7	3.7
Clay products	1.1	1.8
Glass and glass products	3.3	2.0
Other nonmetallic products	9.5	9.0
Total	26.2	20.8
Petroleum and coal products		
Petroleum refineries	44.1	21.4
Other petroleum and coal products	0.5	0.5
Total	44.6	21.9
Total mineral manufacturing	94.5	102.3

TABLE 58

Canada – Provincial Income Taxes of Reporting Companies in the Mining and Mineral Fabricating Industries, 1966 and 1967

($ million)

	1966	1967
Mining		
Metals		
Gold	0.5	0.4
Iron	0.8	0.3
Other metal mines	5.7	8.2
Total	7.0	8.9
Mineral fuels		
Coal	0.1	–
Oil and gas	3.1	12.2
Total	3.2	12.2
Other mining		
Nonmetal mines	4.6	3.4
Quarries	1.2	1.1
Mining services	0.8	0.8
Total	6.6	5.3
Total mining industry	16.8	26.4
Mineral fabricating industries		
Primary metals		
Iron and steel mills	3.7	2.6
Iron foundries	1.1	1.1
Smelting and refining	16.0	13.7
Total	20.8	17.4
Nonmetallic mineral products		
Cement	2.1	0.1
Concrete	0.7	1.3
Ready-mix concrete	0.9	1.2
Clay products	0.4	0.6
Glass and glass products	0.9	0.7
Other nonmetallic products	2.8	2.9
Total	7.8	6.8
Petroleum and coal products		
Petroleum refineries	11.0	5.9
Other petroleum and coal products	0.2	0.2
Total	11.2	6.1
Total mineral fabricating industries	39.8	30.3

TABLE 59

Canada – Capital and Repair Expenditure in the Mineral Industry, 1968, 1969, 1970
($ million)

	1968			1969p			1970f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
Mining Industry									
Metal mines									
Gold	14.9	6.8	21.7	12.9	7.2	20.1	15.0	6.7	21.7
Silver, lead, zinc	41.1	9.0	50.1	43.4	9.9	53.3	15.6	10.7	26.3
Iron	46.2	86.3	132.5	28.4	11.5	39.9	23.1	49.1	72.2
Other metal mines	267.8	98.0	365.8	279.0	159.2	438.2	326.5	156.3	482.8
Total metal mines	370.0	200.1	570.1	363.7	187.8	551.5	380.2	222.8	603.0
Nonmetal mines*									
Quarries and sand pits	10.3	13.9	24.2	10.4	13.4	23.8	10.8	13.8	24.6
Other nonmetal mines	228.3	47.9	276.2	167.5	54.2	221.7	156.2	57.4	213.6
Total nonmetal mines	238.6	61.8	300.4	177.9	67.6	245.5	167.0	71.2	238.2
Mineral Fuels									
Petroleum and gas	465.4	75.5	540.9	553.9	98.0	651.9	620.1	100.9	721.0
Total mining industry	1,074.0	337.4	1,411.4	1,095.5	353.4	1,448.9	1,167.3	394.9	1,562.2
Mineral Manufacturing									
Primary Metal Industries									
Iron and steel mills	65.3	153.6	218.9	102.4	138.1	240.5	204.4	164.5	368.9
Steel pipe and tube mills	10.0	10.0	20.0	9.1	9.9	19.0	8.6	9.6	18.2
Iron foundries	5.5	9.0	14.5	9.5	9.6	19.1	11.7	9.6	21.3
Smelting and refining	128.3	122.1	250.4	163.8	111.9	275.7	192.9	133.4	326.3
Aluminum rolling, casting and extruding	13.1	7.1	20.2	11.4	5.6	17.0	20.9	5.6	26.5
Copper and alloy rolling casting and extruding	6.4	5.1	11.5	2.5	4.7	7.2	2.4	4.5	6.9
Other primary metal industries	6.8	2.2	9.0	3.6	2.5	6.1	4.9	2.2	7.1
Total primary metal industries	235.4	309.1	544.5	302.3	282.3	584.6	445.8	329.4	775.2

TABLE 59 (Cont'd)

	1968			1969p			1970f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
Nonmetallic mineral products									
Cement	19.1	12.4	31.5	15.8	12.2	28.0	14.7	13.1	27.8
Lime	0.3	1.1	1.4	0.9	1.0	1.9	11.9	1.0	12.9
Gypsum products	1.6	1.1	2.7	4.8	1.3	6.1	4.7	1.1	5.8
Concrete products and ready mix	27.9	35.8	63.7	42.0	39.0	81.0	31.9	38.2	70.1
Clay products	4.5	5.0	9.5	8.4	4.3	12.7	6.8	4.5	11.3
Refractories	1.6	1.4	3.0	1.0	1.2	2.2	2.1	1.3	3.4
Asbestos †	..	..	..	.6	1.9	2.5	.8	1.7	2.5
Glass and glass products	21.5	13.7	35.2	46.7	14.3	61.0	61.9	13.8	75.7
Abrasives	2.8	4.5	7.3	2.0	5.1	7.1	4.0	5.3	9.3
Other nonmetallic mineral products	6.8	6.0	12.8	5.2	4.2	9.4	3.7	4.6	8.3
Total nonmetallic mineral products	86.1	81.0	167.1	127.4	84.5	211.9	142.5	84.6	227.1
Petroleum and coal products	127.8	55.2	183.0	134.5	61.1	195.6	203.5	61.7	265.2
Total mineral manufacturing industries	449.3	445.3	894.6	564.2	427.9	992.1	791.8	475.7	1,267.5

*** Includes coal mines, asbestos, gypsum, salt, miscellaneous nonmetal mines and quarrying. † Detail not available for 1968 included under other nonmetallic mineral products.**

p Preliminary estimates of intentions; f Forecast intentions; .. Not available.

TABLE 60

Canada – Capital and Repair Expenditure in the Mining Industry*, 1960-1970
($ million)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969p	1970f
Metal Mines											
Capital											
Construction	88.8	107.6	137.8	118.3	146.8	121.4	209.8	238.1	264.8	257.1	249.8
Machinery	46.6	42.5	71.2	71.6	92.7	79.2	138.6	131.3	105.2	106.6	130.4
Total	135.4	150.1	209.0	189.9	239.5	200.6	348.4	369.4	370.0	363.7	380.2
Repair											
Construction	14.6	12.8	14.0	15.8	17.8	21.9	25.2	33.4	47.9	42.1	52.3
Machinery	47.8	55.7	64.5	76.3	84.5	100.5	115.9	116.6	152.2	145.7	170.5
Total	62.4	68.5	78.5	92.1	102.3	122.4	141.1	150.0	200.1	187.8	222.8
Total capital and repair	197.8	218.6	287.5	282.0	341.8	323.0	489.5	519.4	570.1	551.5	603.0
Nonmetal mines†											
Capital											
Construction	12.4	15.9	24.7	18.7	36.7	58.1	106.7	121.1	110.2	66.4	68.9
Machinery	18.7	20.8	35.5	40.8	44.9	34.8	68.8	85.4	128.4	111.5	98.1
Total	31.1	36.7	60.2	59.5	81.6	92.9	175.5	206.5	238.6	177.9	167.0
Repair											
Construction	2.7	3.1	3.3	3.6	3.2	3.7	3.5	4.5	4.3	5.3	6.5
Machinery	26.9	28.6	27.6	31.5	37.9	47.2	49.5	57.0	57.5	62.3	64.7
Total	29.6	31.7	30.9	35.1	41.1	50.9	53.0	61.5	61.8	67.6	71.2
Total capital and repair	60.7	68.4	91.1	94.6	122.7	143.8	228.5	268.0	300.4	245.5	238.2
Mineral fuels											
Capital											
Construction	202.2	238.4	176.8	234.3	270.6	419.2	450.0	403.0	407.4	462.2	539.1
Machinery	31.5	23.6	33.7	37.9	40.4	22.1	55.7	71.8	58.0	91.7	81.0
Total	233.7	262.0	210.5	272.2	311.0	441.3	505.7	474.8	465.4	553.9	620.1
Repair											
Construction	9.4	10.2	13.6	15.7	23.6	25.4	28.6	34.2	56.3	78.6	79.4
Machinery	11.0	11.4	12.3	13.9	10.8	24.0	21.3	14.7	19.2	19.4	21.5
Total	20.4	21.6	25.9	29.6	34.4	49.4	49.9	48.9	75.5	98.0	100.9
Total capital and repair	254.1	283.6	236.4	301.8	345.4	490.7	555.6	523.7	540.9	651.9	721.0

TABLE 60 (Cont'd)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969p	1970f
Total mining											
Capital											
Construction	303.4	361.9	339.3	371.3	454.1	598.7	766.5	762.2	782.4	785.7	857.8
Machinery	96.8	86.9	140.4	150.3	178.0	136.1	263.1	288.5	291.6	309.8	309.5
Total	400.2	448.8	479.7	521.6	632.1	734.8	1,029.6	1,050.7	1,074.0	1,095.5	1,167.3
Repair											
Construction	26.7	26.1	30.9	35.1	44.6	51.0	57.3	72.1	108.5	126.0	138.2
Machinery	85.7	95.7	104.4	121.7	133.2	171.7	186.7	188.3	228.9	227.4	256.7
Total	112.4	121.8	135.3	156.8	177.8	222.7	244.0	260.4	337.4	353.4	394.9
Total capital and repair	512.6	570.6	615.0	678.4	809.9	957.5	1,273.6	1,311.1	1,411.4	1,448.9	1,562.2

*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; fForecast intentions.

TABLE 61

Canada, Capital and Repair Expenditures in the Mineral Manufacturing Industries, 1960-1970
($ million)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969p	1970f
Primary metal industries*											
Capital											
Construction	51.3	32.9	58.4	44.4	58.4	61.6	85.2	82.0	77.5	88.0	104.9
Machinery	142.9	93.7	159.1	136.8	214.4	202.9	300.7	202.8	157.9	214.3	340.9
Total	194.2	126.6	217.5	181.2	272.8	264.5	385.9	284.8	235.4	302.3	445.8
Repair											
Construction	20.0	19.0	18.5	16.6	18.0	18.5	21.8	24.9	27.7	23.8	27.6
Machinery	145.0	134.9	151.9	166.1	194.4	215.0	253.4	258.1	281.4	258.5	301.8
Total	165.0	153.9	170.4	182.7	212.4	233.5	275.2	283.0	309.1	282.3	329.4
Total capital and repair	359.2	280.5	387.9	363.9	485.2	498.0	661.1	567.8	544.5	584.6	775.2
Nonmetallic mineral products†											
Capital											
Construction	15.7	11.8	13.7	13.8	20.1	30.0	50.9	39.5	19.6	34.1	18.4
Machinery	33.3	32.8	38.4	38.9	61.9	78.3	108.6	80.3	66.5	93.3	124.1
Total	49.0	44.6	52.1	52.7	82.0	108.3	159.5	119.8	86.1	127.4	142.5
Repair											
Construction	4.2	4.3	5.2	5.5	5.4	6.4	7.2	9.3	7.2	6.8	6.5
Machinery	38.3	41.9	51.3	52.8	58.3	66.1	72.1	63.9	73.8	77.7	78.1
Total	42.5	46.2	56.5	58.3	63.7	72.5	79.3	73.2	81.0	84.5	84.6
Total capital and repair	91.5	90.8	108.6	111.0	145.7	180.8	238.8	193.0	167.1	211.9	227.1
Petroleum and coal products											
Capital											
Construction	52.0	27.7	56.7	38.0	20.4	30.3	55.5	78.8	99.0	119.6	189.7
Machinery	7.8	4.0	8.9	8.6	4.3	10.3	9.6	21.4	28.8	14.9	13.8
Total	59.8	31.7	65.6	46.6	24.7	40.6	65.1	100.2	127.8	134.5	203.5
Repair											
Construction	26.0	26.1	28.1	30.0	32.3	29.5	32.6	36.0	46.6	49.5	51.8
Machinery	4.2	4.4	4.9	5.2	5.9	7.0	9.1	10.2	8.6	11.6	9.9
Total	30.2	30.5	33.0	35.2	38.2	36.5	41.7	46.2	55.2	61.1	61.7
Total capital and repair	90.0	62.2	98.6	81.8	62.9	77.1	106.8	146.4	183.0	195.6	265.2

TABLE 61 (Cont'd)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969P	1970f
Total mineral manufacturing industries											
Capital											
Construction	119.0	72.4	128.8	96.2	98.9	121.9	191.6	200.3	196.1	241.7	313.0
Machinery	184.0	130.5	206.4	184.3	280.6	291.5	418.9	304.5	253.2	322.5	478.8
Total	303.0	202.9	335.2	280.5	379.5	413.4	610.5	504.8	449.3	564.2	791.8
Repair											
Construction	50.2	49.4	51.8	52.1	55.7	54.4	61.6	70.2	81.5	80.1	85.9
Machinery	187.5	181.2	208.1	224.1	258.6	288.1	334.6	332.2	363.8	347.8	389.8
Total	237.7	230.6	259.9	276.2	314.3	342.5	396.2	402.4	445.3	427.9	475.7
Total capital and repair	540.7	433.5	595.1	556.7	693.8	755.9	1,006.7	907.2	894.6	992.1	1,267.5

* Includes smelting and refining. †Includes cement, lime, and clay products manufacturing.
P Preliminary estimates of intentions; f Forecast intentions.

TABLE 62

Canada – Capital Investment in the Petroleum and Natural Gas Industries, 1961–1970
($ million)

	Development and Production	Oil and Gas Pipelines	Gas Processing	Petroleum Refining	Marketing		Total Capital Investment	
					Oil	Gas	Petroleum and Natural Gas Ind.	All Industries
1961	272.0	164.8	76.5	31.2	56.0	59.3	659.8	8,172.0
1962	268.9	72.2	21.9	64.8	47.7	69.3	544.8	8,715.0
1963	297.1	107.9	38.6	44.2	53.0	84.1	624.9	9,393.0
1964	336.7	164.1	40.6	23.9	48.3	68.3	681.9	10,944.0
1965	381.0	112.1	41.5	39.8	55.2	72.5	702.1	12,865.0
1966	453.5	153.9	50.1	64.8	64.0	92.3	878.6	15,090.0
1967	385.1	204.9	89.7	99.6	86.8	76.4	942.5	15,322.0
1968	374.3	248.0	91.1	127.6	87.6	117.4	1,046.0	15,455.0
1969	426.9	213.6	127.0	134.0	106.3	118.0	1,125.8	16,612.0
1970	445.9	268.4	174.2	202.9	115.7	102.2	1,309.3	17,865.0

Notes: 1. The petroleum and natural gas industries in this table include all companies engaged, in whole or in part, in oil and gas activities.

2. Expenditures on geological and geophysical operations are not included in Development and Production.

3. Figures for Development and Production and Gas Processing have been revised back to 1961, based on changes in concepts used in a special survey questionnaire for the industry beginning in 1965.

TABLE 63

Canada – Corporations in the Mining Industry by Degree of Non-resident Ownership, 1965

	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	84	9.8	1,577.4	40.5	622.1	24.7	622.7	42.0	95.1	24.3
Under 50 per cent non-resident	425	49.8	2,179.3	56.0	1,818.5	72.2	801.9	54.1	297.2	76.0
Total reporting corporations	509	59.6	3,756.7	96.5	2,440.6	96.9	1,424.6	96.1	392.3	100.3
Other corporations	345	40.4	134.8	3.5	78.2	3.1	57.6	3.9	–1.3	–0.3
Total all corporations	854	100.0	3,891.5	100.0	2,518.8	100.0	1,482.2	100.0	391.0	100.0
Nonmetal mines (including mining services)										
Reporting corporations										
50 per cent and over non-resident	120	5.3	679.2	48.8	405.4	45.8	289.5	46.0	68.1	80.1
Under 50 per cent non-resident	454	20.1	593.5	42.6	409.4	46.2	281.3	44.8	21.4	25.2
Total reporting corporations	574	25.4	1,272.7	91.4	814.8	92.0	570.8	90.8	89.5	105.3
Other corporations	1,684	74.6	120.4	8.6	71.1	8.0	57.8	9.2	–4.5	–5.3
Total all corporations	2,258	100.0	1,393.1	100.0	885.9	100.0	628.6	100.0	85.0	100.0
Mineral fuels										
Reporting corporations										
50 per cent and over non-resident	165	22.2	3,121.7	82.0	2,069.7	83.0	998.6	88.8	148.9	83.1
Under 50 per cent non-resident	159	21.3	641.9	16.9	396.1	15.9	112.2	10.0	30.9	17.2
Total reporting corporations	324	43.5	3,763.6	98.9	2,465.8	98.9	1,110.8	98.8	179.8	100.3
Other corporations	421	56.5	43.2	1.1	26.3	1.1	13.6	1.2	–0.7	–0.3
Total all corporations	745	100.0	3,806.8	100.0	2,492.1	100.0	1,124.4	100.0	179.1	100.0
Total mining										
Reporting corporations										
50 per cent and over non-resident	369	9.6	5,378.4	59.2	3,097.2	52.5	1,910.7	59.1	312.1	47.6
Under 50 per cent non-resident	1,038	26.9	3,414.6	37.5	2,624.1	44.5	1,195.5	36.9	349.5	53.4
Total reporting corporations	1,407	36.5	8,793.0	96.7	5,721.3	97.0	3,106.2	96.0	661.6	101.0
Other corporations	2,450	63.5	298.4	3.3	175.5	3.0	129.0	4.0	–6.5	–1.0
Total all corporations	3,857	100.0	9,091.4	100.0	5,896.8	100.0	3,235.2	100.0	655.1	100.0

[1]Corporations include all resident and non-resident dominated corporations in the Canadian corporate community. [2]Assets include cash, receivables, 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 the gross revenue derived from the principal source of operations, and from rents, dividends or interest. [5]Profits include operating profits, investments income if any, capital gains, dividend income etc.

TABLE 64

Canada – Corporations in the Mining Industry by Degree of Non-resident Ownership, 1965

	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	80	16.1	1,560.2	39.6	553.1	22.5	565.5	38.9	64.4	16.8
Under 50 per cent non-resident	389	78.3	2,374.8	60.3	1,902.2	77.4	886.4	61.0	319.5	83.3
Total reporting companies	469	94.4	3,935.0	99.9	2,455.3	99.9	1,451.9	99.9	383.9	100.1
Other corporations	28	5.6	5.6	0.1	3.3	0.1	1.4	0.1	-0.2	-0.1
Total all corporations	497	100.0	3,940.6	100.0	2,458.6	100.0	1,453.3	100.0	383.7	15.5
Nonmetal mines (including mining services)										
Reporting corporations										
50 per cent and over non-resident	130	6.2	877.9	52.1	543.2	52.6	361.9	49.7	81.9	82.3
Under 50 per cent non-resident	526	25.0	685.0	40.6	424.3	41.0	291.6	40.0	24.3	24.4
Total reporting companies	656	31.2	1,562.9	92.7	967.5	93.6	653.5	89.7	106.2	106.7
Other corporations	1,447	68.8	123.5	7.3	66.3	6.4	75.2	10.3	-6.7	-6.7
Total all corporations	2,103	100.0	1,686.4	100.0	1,033.8	100.0	728.7	100.0	99.5	100.0
Mineral fuels										
Reporting corporations										
50 per cent and over non-resident	151	24.5	3,176.1	77.1	2,009.4	76.7	837.3	82.7	149.4	75.4
Under 50 per cent non-resident	169	27.5	925.6	22.4	606.6	23.1	164.7	16.3	48.6	24.5
Total reporting companies	320	52.0	4,107.7	99.5	2,616.0	99.8	1,002.0	99.0	198.0	99.9
Other corporations	296	48.0	22.1	0.5	5.3	0.2	10.1	1.0	0.1	0.1
Total all corporations	616	100.0	4,123.8	100.0	2,621.3	100.0	1,012.1	100.0	198.1	100.0
Total mining										
Reporting corporations										
50 per cent and over non-resident	361	11.2	5,614.2	57.5	3,105.7	50.8	1,764.7	55.3	295.7	43.4
Under 50 per cent non-resident	1,084	33.7	3,985.4	40.9	2,933.1	48.0	1,342.7	42.0	392.4	57.6
Total reporting companies	1,445	44.9	9,599.6	98.4	6,038.8	98.8	3,107.4	97.3	688.1	101.0
Other corporations	1,771	55.1	151.2	1.6	74.9	1.2	86.7	2.7	-6.8	-1.0
Total all corporations	3,216	100.0	9,750.8	100.0	6,113.7	100.0	3,194.1	100.0	681.3	100.0

[1] Corporations include all resident and non-resident dominated corporations in the Canadian corporate community. [2] Assets include cash, receivables, 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 the gross revenue derived from the principal source of operations, and from rents, dividends or interest. [5] Profits include operating profits, investments income if any, capital gains, dividend income etc.

TABLE 65

Canada – Corporations in the Mining Industry by Degree of Non-resident Ownership, 1967

	Corporation[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	60	14.2	1,838.9	42.0	905.3	32.5	685.0	39.5	130.7	29.1
Under 50 per cent non-resident	311	73.5	2,451.8	56.0	1,820.2	65.3	1,001.6	57.8	318.1	70.8
Total reporting corporations	371	87.7	4,290.7	98.0	2,725.5	97.8	1,686.6	97.3	448.8	99.9
Other corporations	52	12.3	89.4	2.0	61.5	2.2	46.2	2.7	0.4	0.1
Total all corporations	423	100.0	4,380.1	100.0	2,787.0	100.0	1,732.8	100.0	449.2	100.0
Nonmetal mines (including mining services)										
Reporting corporations										
50 per cent and over non-resident	155	6.7	1,044.2	50.0	594.6	45.8	374.4	46.3	63.0	74.7
Under 50 per cent non-resident	632	27.3	882.3	42.3	601.5	46.3	355.9	44.0	32.1	38.1
Total reporting companies	787	34.0	1,926.5	92.3	1,196.1	92.1	730.3	90.3	95.1	112.8
Other corporations	1,525	66.0	161.8	7.7	102.8	7.9	78.5	9.7	−10.8	−12.8
Total all corporations	2,312	100.0	2,088.3	100.0	1,298.9	100.0	808.8	100.0	84.3	100.0
Mineral fuels										
Reporting corporations										
50 per cent and over non-resident	185	25.2	3,759.7	81.7	2,278.6	80.9	1,027.9	86.2	171.2	79.4
Under 50 per cent non-resident	154	21.0	812.6	17.6	523.1	18.6	152.3	12.8	46.7	21.7
Total reporting companies	339	46.2	4,572.3	99.3	2,801.7	99.5	1,180.2	99.0	217.9	101.1
Other corporations	394	53.8	34.4	0.7	14.0	0.5	12.4	1.0	−2.3	−1.1
Total all corporations	733	100.0	4,606.7	100.0	2,815.7	100.0	1,192.6	100.0	215.6	100.0
Total mining										
Reporting corporations										
50 per cent and over non-resident	400	11.5	6,642.8	60.0	3,778.5	54.7	2,087.3	55.9	364.9	48.7
Under 50 per cent non-resident	1,097	31.7	4,146.7	37.4	2,944.8	42.7	1,509.8	40.4	396.9	53.0
Total reporting corporations	1,497	43.2	10,789.5	97.4	6,723.3	97.4	3,597.1	96.3	761.8	101.7
Other corporations	1,971	56.8	285.6	2.6	178.3	2.6	137.1	3.7	−12.7	−1.7
Total all corporations	3,468	100.0	11,075.1	100.0	6,901.6	100.0	3,734.2	100.0	749.1	100.0

[1] Corporations include all resident and non-resident dominated corporations in the Canadian corporate community. [2] Assets include cash, receivables, 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 the gross revenue derived from the principal source of operations, and from rents, dividends or interest. [5] Profits include operating profits, investments income if any, capital gains, dividend income etc.

TABLE 66

Canada – Financial Statistics – Mining and Mineral Fabricating Industries, 1967
($ million)

	Number of Corporations[1]	Assets[2]	Liabilities[3]	Equity[4]	Income[5]	Expense[6]	Net Profit[7]
Mining Industry							
Metal mines							
Gold	101	554.3	39.7	514.6	177.8	140.0	37.9
Iron	40	1,434.9	933.1	501.8	494.5	448.2	46.3
Other metal mines	269	2,492.1	644.5	1,847.6	1,290.0	965.5	324.4
Total	410	4,481.3	1,617.3	2,864.0	1,962.3	1,553.7	408.6
Nonmetal mines and mining services							
Nonmetal mines	114	912.9	292.9	620.0	364.0	314.7	49.3
Quarries	462	132.9	66.4	66.5	159.5	152.1	7.4
Mining services	1,730	948.6	369.6	579.0	287.4	289.0	–1.6
Total	2,306	1,994.4	728.9	1,265.5	810.9	755.8	55.1
Mineral fuels							
Coal mines	50	104.3	63.7	40.7	92.4	89.2	3.1
Oil and gas wells	683	5,507.1	1,976.8	3,530.2	2,445.8	2,175.6	270.3
Total	733	5,611.4	2,040.5	3,570.9	2,538.2	2,264.8	273.4
Total mining industry	3,449	12,087.1	4,386.7	7,700.4	5,311.4	4,574.3	737.1
Mineral Manufacturing							
Primary metals							
Iron and steel mills	92	2,314.8	1,053.3	1,261.5	1,477.8	1,388.6	89.3
Iron foundries	103	196.4	98.3	98.2	256.4	247.2	9.2
Smelting and refining	158	2,719.5	1,282.4	1,437.0	1,659.2	1,460.3	198.9
Total	353	5,230.7	2,434.0	2,796.7	3,393.4	3,096.1	297.4

TABLE 66 (Cont'd)

Nonmetallic mineral products							
Cement manufacturing	20	595.4	294.2	301.1	179.0	167.3	11.7
Concrete manufacturing	393	150.6	96.5	54.2	204.4	198.6	5.9
Ready mix concrete	251	213.5	126.5	87.0	362.7	352.6	10.0
Clay products	86	84.6	30.6	54.0	95.2	91.2	4.0
Glass and glass products	88	169.7	68.0	101.8	205.3	199.9	5.4
Other nonmetallic mineral products	164	250.8	80.0	170.8	260.3	241.7	18.6
Total	1,002	1,464.6	695.8	768.9	1,306.9	1,251.3	55.6
Petroleum and coal products							
Petroleum refineries	34	2,518.1	865.8	1,652.3	1,880.7	1,756.1	124.6
Other petroleum and coal products	28	53.1	24.1	29.0	36.3	33.5	2.8
Total	62	2,571.2	889.9	1,681.3	1,917.0	1,789.6	127.4
Total mineral manufacturing	1,417	9,266.5	4,019.7	5,246.9	6,617.3	6,137.0	480.4

[1]These corporations do not include certain groups of companies such as tax exempt corporations, cooperatives, 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, dividends 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 67

Estimated Book Value, Ownership and Control of Capital Employed in the Canadian 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	58	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*

The lightweight aggregate industry maintained its almost continuous growth reaching a value of over $8 million during 1969, an increase of 4.2 per cent over the previous year's value. Not all types of aggregate shared in this growth; vermiculite, perlite and pumice gained, while clay, shale and slag lightweight aggregates showed losses.

Pumice used as lightweight aggregate showed the greatest increase, a gain of 42.7 per cent in value. This almost equalled the loss of 52.8 per cent which occurred in 1968.

Expanded perlite had the next largest growth, an increase of 31.5 per cent in volume and 34.0 per cent in value. Nearly three quarters of this increase in production was from one plant, although four other plants also showed increases. Four plants, however, showed decreases in production. As in the two previous years, Silbrico Corporation, Hodgkins, Illinois, U.S.A., used portable expanding equipment to produce and install cryogenic insulation for liquid-gas storage in two locations in Canada.

Exfoliated vermiculite production of the six plants had the smallest growth during the year, 2.4 per cent in volume and 3.9 per cent in value. Five of the plants had increases of various degrees while the other had a decrease in production.

The expanded clays and shales decreased 4.3 and 0.9 per cent in volume and value respectively. One new plant was put into production, Avon Aggregates Ltd., at Minto, N.B. Only two of the previously operating plants increased their production; the other seven plants had decreases.

Production of expanded slag was down 9.3 per cent in both volume and value. Only one company produced expanded slag during the year. The installation of Sydney Steel Corporation, Sydney, N.S. was not operated during 1969.

In 1968, Enercon Limited began construction of a plant to produce lightweight aggregate by sintering fly ash at Mississauga, Ont. It was not in production in 1969 as had been anticipated.

Table 1 shows the volume and value of each type of lightweight aggregate produced in Canada in 1968 and 1969. Only the value of pumice used as lightweight aggregate during the two years is shown. The accompanying graph shows the volume of production of each of the four principal types of lightweight aggregate for the years 1954 to 1969.

CONSTRUCTION

The total value of construction in Canada increased 6.6 per cent reaching a new high of $13.022 billion during 1969. Table 2 shows the year-to-year changes in the value of construction from 1961 to 1969 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 1967 to 1968 and from 1968 to 1969. It also shows the percentage of each type making up the total value for 1967, 1968 and 1969. These figures are all on a current dollar basis.

*Mineral Processing Division, Mines Branch.

TABLE 1

Production of Lightweight Aggregates, 1968-69

	1968		1969	
	Cubic Yards	$	Cubic Yards	$
From domestic raw materials				
Expanded clay and shale	543,603	3,069,260	520,600	3,040,100
Expanded slag	310,797	806,010	282,087	731,336
From imported raw materials				
Exfoliated vermiculite	332,319	3,056,126	340,400	3,174,600
Expanded perlite	89,600	844,000	117,800	1,131,100
Pumice		66,000		95,000
Total		7,841,396		8,172,136

Source: Statistics supplied to Mineral Processing Division by producers.

TABLE 2

Annual Value of Construction

Year	Total Value ($xmillions)	Per Cent Change from Previous Year	
		Current Dollar Value	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	2.6
1968	12,214	5.1	1.0
1969p	13,022	6.6	..

Source: Dominion Bureau of Statistics.
p Preliminary; .. Not available.

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.

TABLE 3

Construction in Canada 1967-69

Type of Construction	Percentage Change		Percentage of Total Value		
	1967-68	1968-69p	1967	1968	1969p
Engineering	+3.9	+3.2	41.1	40.6	39.3
Residential	+17.0	+17.5	26.4	29.3	32.4
Commercial	−6.1	−4.0	10.5	9.4	8.4
Institutional	+9.6	−2.8	10.9	11.3	10.3
Industrial	−14.5	+11.7	7.5	6.1	6.4
Other building	−2.4	+4.5	3.6	3.3	3.2
Total construction	+5.3	+6.6	100.0	100.0	100.0

Source: Dominion Bureau of Statistics.
p Preliminary.

Expanded slag is a processed byproduct of the production of pig iron in blast furnaces. Introduction of water into the molten slag causes it to expand.

Pumice is a vesicular material of volcanic origin that is used in its natural state as a lightweight aggregate. It is imported into Canada from the western United States and Greece.

Fly ash is the finely divided ash particles collected from the exhaust gases by electrical and mechanical precipitators in coal-fired electric power plants.

Table 7 lists the lightweight aggregate plants, both producing and non-producing, during 1969.

CONSUMPTION

Tables 4, 5 and 6 give a break-down of end use consumption of expanded clay and shale, exfoliated vermiculite and expanded perlite.

As in previous years, between 98 and 99 per cent of expanded slag was used as aggregate in concrete block. The remainder was used as insulation, on running tracks and as lightweight fill.

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

TABLE 4

Consumption of Expanded Clay and Shale

	1967	1968	1969
Concrete:			
block	79%	74%	68%
precast structural	3	2	2
cast-in-place structural	17	22	29
Minor uses:			
sand blasting, horticulture, refractories, insulation, brick grog	1	2	1

TABLE 5

Consumption of Exfoliated Vermiculite

	1967	1968	1969
Loose insulation	78%	75%	71%
Insulating plaster	9	11	11
Insulating concrete	7	8	7
Minor uses:			
fireproofing, agriculture, underground pipe insulation, horticulture, barbecue base.	6	6	11

TABLE 6

Consumption of Expanded Perlite

	1967	1968	1969
Insulating plaster	69%	42%	52%
Insulation	10	25	34
	–	(20)*	(18)*
Industrial fillers	13	10	7
Insulating concrete	6	11	4
Minor uses:	2	12	3
agriculture, horticulture			

*Cryogenic insulation produced in Canada by Silbrico Corp.

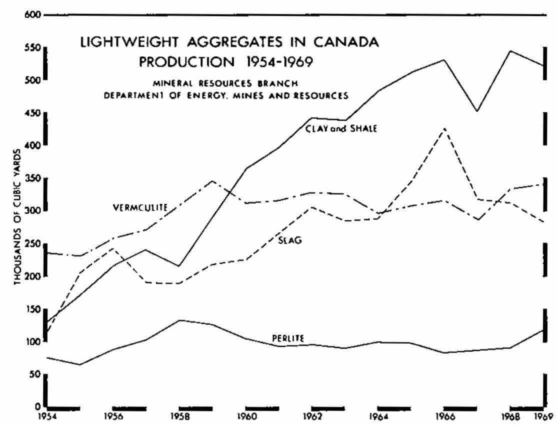


TABLE 7

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.
Cell-Rock Inc.	Lafleche, Que.
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	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	
Enercon Limited	Mississauga, Ont.
Sydney Steel Corporation	Sydney, N.S.

* Formerly Consolidated Block and Pipe Ltd.
** Formerly P & V Products.

PRICES

Expanded clay and shale	$4.50 to $6.85/cu yd	Exfoliated vermiculite	$0.30 to 0.42/cu ft
Expanded slag	$3.50/ton	Expanded perlite	$0.30 to 0.38/cu ft

All prices are f.o.b. plant.

Aluminum

ROBERT J. SHANK*

World demand for aluminum continued strong during 1969, particularly in Japan, Europe and United States. No change in this pattern is expected in the first half of 1970, but some easing of demand could occur later in the year.

CANADIAN INDUSTRY

Economic concentrations of the clay minerals gibbsite and boehmite that comprise the valuable component of bauxite, the main ore of aluminum, have not been found in Canada. Occurrences, of mineralogical interest only, have been noted at Steep Rock Lake in Ontario and at Sooke, British Columbia. Canadian production of primary aluminum, all of which comes from imported ores, is the third largest in the world after United States and USSR. The metallurgy of aluminum is analogous to that of the common base-metals in principle but differs in terminology and practice. Normally, 4 to 5 tons of bauxite are treated chemically in a refinery to make 2 tons of alumina, which in turn are smelted electrically to produce 1 ton of aluminum.

PRODUCTION

Canadian smelter production of primary aluminum in 1969 was 1,098,080 short tons, an increase of 12 per cent over 1968 production of 979,171 tons. Both companies operating smelters in Canada, Aluminum Company of Canada, Limited (Alcan) and Canadian British Aluminium Company Limited (CBA), operated their smelters at maximum levels most of the year.

Production by Alcan was 968,700 tons which was 96,200 tons more than in 1968. This was the first time since the early 1950's, when annual smelter capacity was 550,000 tons, that Alcan has had full, continuous employment of its Canadian ingot facilities. Further modest increases in capacity are expected due to smelter modernization. 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 fabricating plants in thirty countries and smelters in nine (Canada, Australia, Brazil, India, Italy, Japan, Norway, Spain, and Sweden). Another new smelter is under construction at Lynemouth in England, and some existing smelters are being expanded. At the end of 1969, smelting capacity of the Alcan group of companies in all countries was 1,898,000 tons as compared to 1,666,000 tons a year earlier.

CBA, controlled by Reynolds Metals Company, reported shipments of 110,700 tons of aluminum

Aluminum Smelter Capacity in Canada
Year-end, 1969
(short tons)

Company	Capacity
Aluminum Company of Canada, Limited	
Arvida, Quebec	450,000
Beauharnois, Quebec	48,000
Ile Maligne, (Alma), Quebec	130,000
Shawinigan, Quebec	95,000
Kitimat, British Columbia	300,000
Canadian British Aluminium Company Limited	
Baie Comeau, Quebec	115,000
Canadian total	1,138,000

*Mineral Resources Branch.

during 1969 which approximated the year's production. This was an increase of about 8,000 tons over the previous year. Work that began in 1968 on a 60,000-ton addition to the plant is expected to be completed late in 1970. As a result of a corporate re-organization CBA in 1970 became known as Canadian Reynolds Metals Company, Limited.

The geographic locations of Canadian smelters in relation to ore supply are shown on the accompanying map. The only alumina plant in Canada, at Arvida, Quebec, supplies Alcan's smelters in that province. It has an alumina capacity of 1.25 million tons annually, representing a throughput of bauxite of some 5 million tons. Actual imports of bauxite in 1969 were half this amount. Bauxite for the Arvida alumina plant is imported from Guyana via Trinidad, Surinam, and from Guinea. Other alumina requirements for Alcan smelters are imported from Jamaica, Guyana and Australia. The Baie Comeau smelter of CBA purchases alumina from Reynolds group companies. This alumina originates from Guinea or the Corpus Christi plant in the United States that processes Jamaican ores.

CONSUMPTION

The consumption of aluminum at the first processing stage in Canada is shown in Table 3. A substantial growth pattern for the past three years is developing. Total consumption increased by 10 per cent in 1969 over 1968 compared with 11.5 per cent in 1968 over 1967. The wrought products have shown the greatest growth for the past two years, indicating strength in the building industry and packaging. Some slowdown in building activity is indicated for 1970 but demand for packaging should continue to be strong.

TABLE 1

Canada, Aluminum Production and Trade, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Production				
Ingot	979,171		1,098,080	
Imports				
Bauxite ore				
Guyana	1,763,002	15,942,000	1,797,782	15,844,000
Surinam	668,977	7,154,000	532,491	6,641,000
Malaysia	50,609	264,000	116,508	602,000
Republic of Guinea	–	–	21,359	98,000
Other countries	27,813	293,000	23,019	281,000
Total	2,510,401	23,653,000	2,491,159	23,466,000
Alumina				
Jamaica	412,973	27,898,000	588,052	40,822,000
United States	205,146	14,969,000	233,399	17,096,000
Guyana	122,246	7,979,000	142,693	9,672,000
Australia	92,744	6,309,000	76,782	5,430,000
Other countries	17,381	1,106,000	22,098	1,486,000
Total	850,490	58,261,000	1,063,024	74,506,000
Aluminum and aluminum alloy scrap	16,286	1,754,000	15,579	4,970,000
Aluminum paste and aluminum powder	610	508,000	941	715,000
Aluminum pigs, ingots, shot, slabs, billets, blooms and extruded wire bars	15,043	8,831,000	11,531	7,258,000
Aluminum castings	1,047	3,453,000	1,385	3,470,000
Aluminum forgings	1,790	4,079,000	1,273	2,642,000
Aluminum bars and rods, n.e.s.	2,065	1,879,000	1,316	1,427,000
Aluminum plates	8,340	6,651,000	13,400	9,517,000
Aluminum sheet and strip up to .025 inch in thickness	11,840	9,221,000	9,653	7,673,000

TABLE 1 (Cont'd)

	1968		1969P	
	Short Tons	$	Short Tons	$
Imports (cont'd)				
Aluminum sheet and strip, over .025 inch up to .051 inch in thickness	3,834	3,644,000	3,853	3,717,000
Aluminum sheet and strip, over .051 inch up to 1.25 inch in thickness	43,449	28,952,000	47,678	28,700,000
Aluminum sheet and strip, over .125 inch in thickness	10,723	10,658,000	13,167	8,265,000
Aluminum foil or leaf	617	768,000	527	651,000
Coverted aluminum foil		1,639,000		1,986,000
Structural shapes, aluminum	1,122	2,805,000	1,722	3,508,000
Aluminum pipe and tubing	549	924,000	508	948,000
Aluminum wire and cable, excluding insulated	751	733,000	993	1,003,000
Aluminum and aluminum alloy fabricated materials n.e.s.		6,711,000		5,477,000
Exports				
Pigs, ingots, shot, slab, billets, blooms and extruded wire bars				
United States	482,179	225,883,000	408,921	201,486,000
Japan	101,975	45,864,000	130,242	60,738,000
Britain	133,737	71,613,000	128,829	73,192,000
Republic of South Africa	18,878	10,179,000	39,546	21,705,000
West Germany	15,413	6,853,000	31,081	14,394,000
Spain	6,389	2,957,000	19,599	10,235,000
Brazil	17,757	8,437,000	18,147	9,451,000
Argentina	9,826	4,799,000	17,434	9,276,000
Italy	5,939	2,665,000	11,695	6,041,000
Turkey	5,022	2,521,000	11,223	5,610,000
Netherlands	4,028	2,044,000	9,577	5,340,000
New Zealand	7,857	3,991,000	9,068	4,838,000
Ireland	3,872	2,025,000	7,453	4,197,000
Hong Kong	6,398	3,306,000	6,799	3,698,000
Belgium and Luxembourg	9,171	4,645,000	6,613	3,489,000
Other countries	34,192	17,433,000	30,459	16,465,000
Total	862,633	415,215,000	886,686	450,155,000
Castings and forgings*				
United States			2,484	3,384,000
Netherlands			35	811,000
Republic of Guinea			12	12,000
Other countries			14	107,000
Total			2,545	4,314,000
Bars, rods, plates, sheet, circles, castings and forgings				
United States	16,816	13,969,000	7,537	5,965,000
New Zealand	4,177	2,391,000	3,778	2,242,000
Republic of South Africa	2,169	1,156,000	1,840	1,035,000
Britain	822	998,000	888	830,000
Brazil	44	49,000	776	520,000
Jamaica	740	585,000	668	574,000
France	1,616	1,126,000	641	545,000

TABLE 1 (Cont'd)

	1968		1969p	
	Short Tons	$	Short Tons	$
Exports (cont'd)				
Venezuela	469	377,000	579	453,000
Trinidad-Tobago	164	133,000	534	355,000
Other countries	2,510	3,454,000	1,703	1,522,000
Total	29,527	24,238,000	18,944	14,041,000
Foil				
United States	221	240,000	151	213,000
Britain	19	29,000	36	59,000
Mexico	10	17,000	15	22,000
Ireland	–	–	9	7,000
Trinidad-Tobago	4	7,000	7	11,000
Other countries	19	28,000	3	6,000
Total	273	321,000	221	318,000
Fabricated materials, n.e.s.				
United States	2,546	2,151,000	3,841	3,508,000
Panama	126	93,000	565	498,000
Britain	441	587,000	217	308,000
Trinidad-Tobago	13	18,000	210	137,000
Peru	7	5,000	204	143,000
Other countries	2,325	2,502,000	1,289	1,329,000
Total	5,458	5,356,000	6,326	5,923,000
In ores and concentrates				
United States	11,878	1,325,000	13,459	1,421,000
France	663	74,000	2,388	277,000
Italy	1,153	127,000	2,197	242,000
Spain	710	136,000	1,508	297,000
Britain	436	100,000	206	30,000
Other countries	184	36,000	548	89,000
Total	15,024	1,798,000	20,306	2,356,000
Scrap				
United States	34,352	9,505,000	35,141	10,580,000
Italy	12,240	4,527,000	11,152	4,535,000
West Germany	835	208,000	2,841	1,125,000
Japan	2,974	1,032,000	1,695	642,000
Netherlands	692	174,000	611	231,000
Spain	509	161,000	194	42,000
Other countries	462	150,000	281	125,000
Total	52,064	15,757,000	51,917	17,280,000

Source: Dominion Bureau of Statistics.
*New class established in 1969, formerly included with bars, rods, plates, sheet, circles, castings and forgings.
pPreliminary; – Nil; n.e.s. Not elsewhere specified.

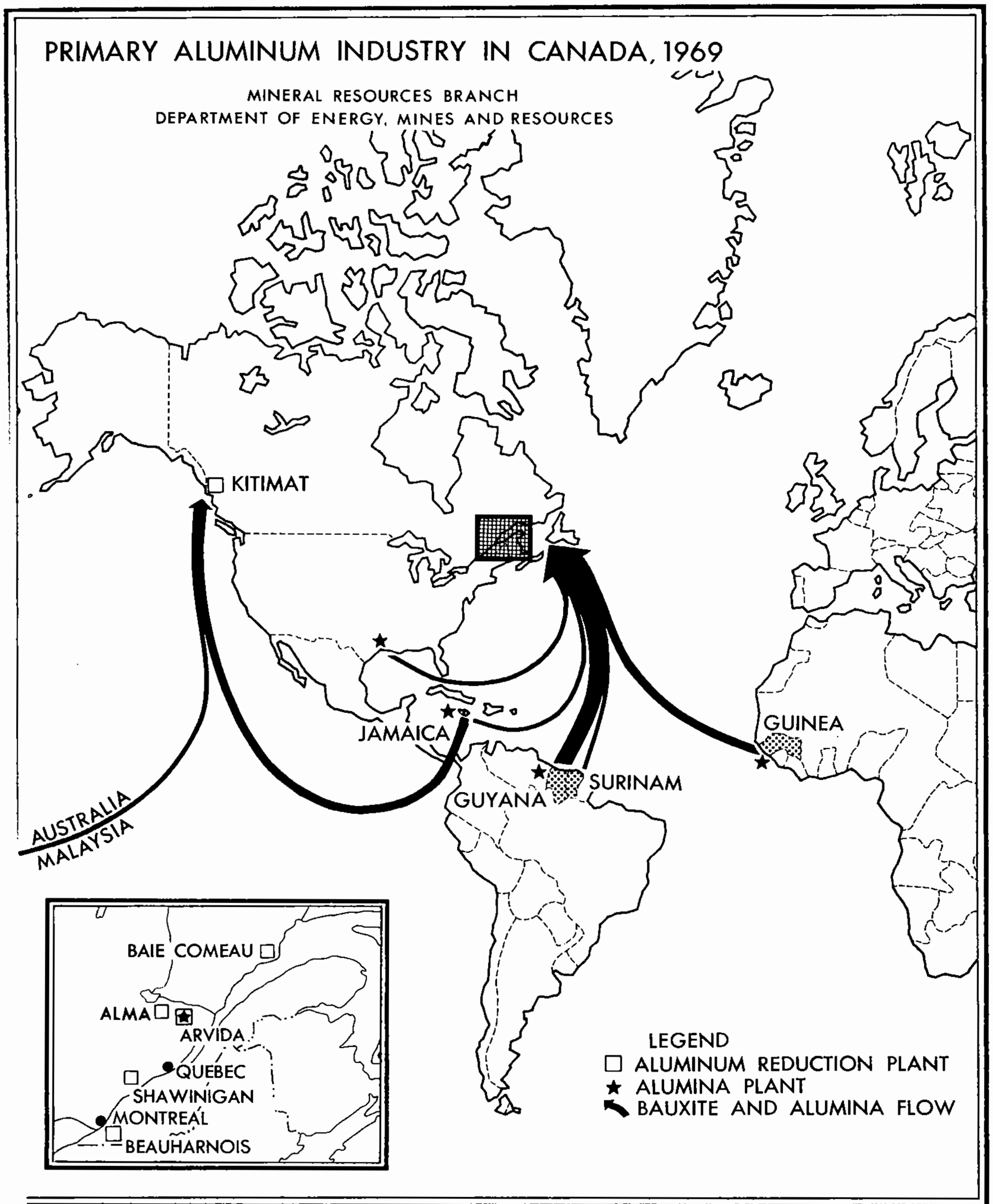

PRIMARY ALUMINUM INDUSTRY IN CANADA, 1969
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
KITIMAT
JAMAICA
GUYANA
SURINAM
GUINEA
AUSTRALIA
MALAYSIA
BAIE COMEAU
ALMA
ARVIDA
QUEBEC
SHAWINIGAN
MONTREAL
BEAUHARNOIS
LEGEND
ALUMINUM REDUCTION PLANT
ALUMINA PLANT
BAUXITE AND ALUMINA FLOW

TABLE 2

Canada, Primary Aluminum Production, Trade and Consumption, 1960-69
(short tons)

	Production	Imports	Exports	Consumption*
1960	762,012	501	552,155	120,831
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	963,343r	8,176	760,649	217,484
1968	979,171	15,043	862,633	242,390
1969p	1,098,080	11,531	886,686	266,746

Source: Dominion Bureau of Statistics.
*Including secondary as reported by consumers.
pPreliminary; rRevised.

WORLD INDUSTRY

World production of bauxite amounted to 56 million tons in 1969, of which 47.7 million tons was from non-communist countries. There were 27 producing countries, of which the largest were Jamaica (9.4 million tons), Australia (8.7), Surinam (6.8), USSR (5.6), Guyana (4.7), France (3.0), Yugoslavia (2.3), Greece (2.1), Hungary (2.1), and United States (2.0).

Rapid expansion of bauxite mining capability is occurring in many parts of the world, particularly Australia, Guinea, Greece and India, as the aluminum industry methodically develops ample supplies of bauxite to take care of smelter requirements. Among all the major ores, bauxite is unlikely to be in short supply. The major deposits are close to the surface and in reasonable proximity to seacoasts and shipping. The United States Geological Survey calculated world reserves of bauxite in 1965 at 5,800 million tons economically exploitable and a further 9,600 million tons in the potential category.

TABLE 3

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

	1966	1967	1968	1969p
Castings				
Sand	1,665	1,685	1,614	1,578
Permanent-mould	10,945	10,686	12,325	12,262
Die	15,647	17,481	19,747	21,888
Other	9,890*	62	92	103
Total	38,147	29,914	33,778	35,831
Wrought products				
Extrusions, including tubing	53,701	51,721	61,260r	68,153
Sheet, plate, coil and other (including rod, forgings and slugs)	145,216	126,589**	135,960r	151,509
Total	198,917	178,310	197,220r	219,662
Destructive uses				
Non-aluminum-base alloys, powder and paste, deoxidizers and other	6,237	9,260	11,392	11,253
Total	6,237	9,260	11,392	11,253
Total consumed	243,301	217,484	242,390r	266,746
Secondary aluminum produced	30,532	34,396	35,265	35,569

Receipts and Inventories at Plants	Metal Entering Plants		On Hand Dec. 31	
	1968	1969p	1968	1969p
Primary aluminum ingot and alloys	212,720r	239,670	50,106r	53,336
Secondary aluminum	21,542	27,216	2,248	1,975
Scrap originating outside plant	52,219r	59,697	3,377	14,809

Source: Dominion Bureau of Statistics.
*Includes smelter busbar. **Includes reroll stock imported from United States.
pPreliminary; rRevised.

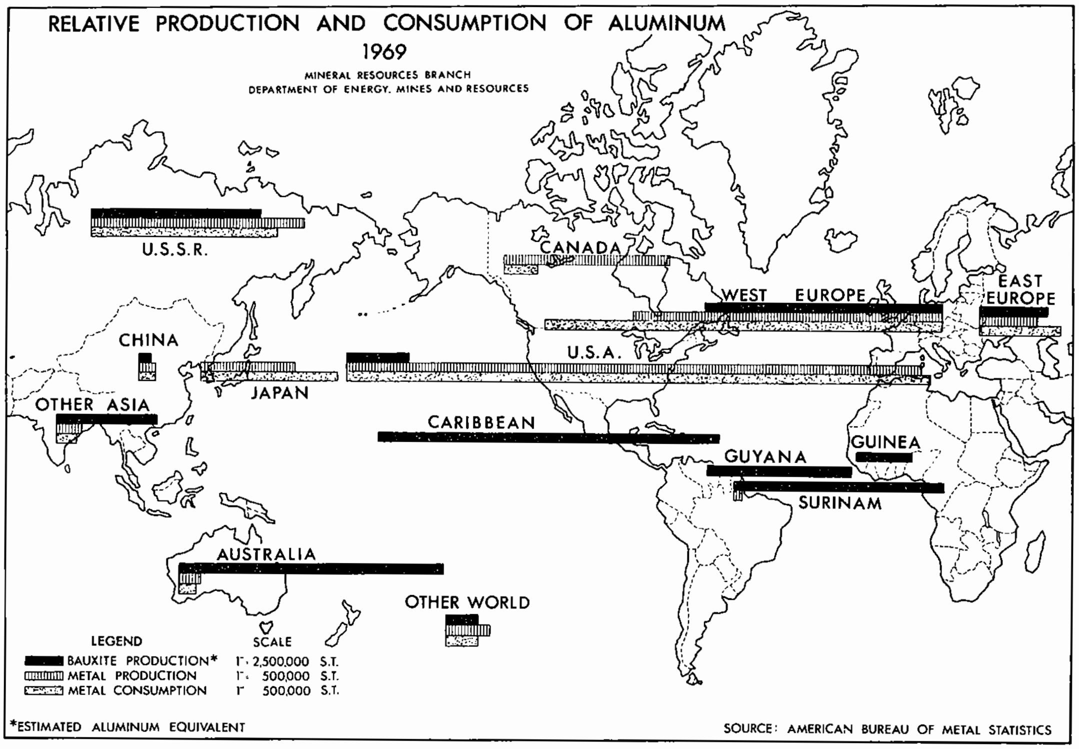


TABLE 4

World Primary Aluminum Production and Consumption, 1969
(thousand short tons)

	Production	Consumption
Canada	1,078	216
United States	3,793	3,832
Europe	2,069	2,611
Japan	627	900
Australia	145	119
India	146	135
Africa	175	61
Sub-total (includes countries not listed)	8,219	8,035
Communist countries	1,915	1,868
Total	10,134	9,903

Source: American Bureau of Metal Statistics.

These estimates are now considered to be conservative. Of the economically exploitable bauxite, 35 per cent is in Australia (2,000 million tons) with the remainder mainly in Guinea and those other countries that are among the leading producers.

The minimum permissible content of metal grade bauxite is in the order of 40 per cent, and the maximum silica content 5 per cent. Ores in which gibbsite predominates are preferred as less costly processing techniques can be used to recover the alumina content. Other clay minerals, such as kaolinite or halloysite containing silica, are major impurities. Impurities such as iron oxides, quartz and titanium oxides are less critical as these are essentially inert to the Bayer process of extracting alumina.

World production of aluminum ingot continued to rise strongly in 1969, amounting to 10.1 million tons, which was 11½ per cent more than in 1968 and 19 per cent more than in 1967. Production should increase by about 5 per cent in 1970. The leading producing countries in 1969 were United States (3.79 million tons), USSR (1.40), Canada (1.08), Japan (0.62), Norway (0.56), France (0.41), and West Germany (0.29).

The aluminum industry is undergoing a significant change in the criteria on which smelter construction is based. Previously, smelters tended to be located near low-cost hydro-electric power developments, many of which were located remote from both the metal-consuming and bauxite-mining areas. Continuing expansion of demand reached the point a few years ago where smelters of economic size (60,000 to

100,000 tons) could be sited to serve regional markets. The viability of such projects is dependent, firstly, on delivered costs of alumina and petroleum coke, plus electricity costs (the main cost input), and secondly, on savings in metal transportation charges, savings in tariffs, and benefits accruing from local industrial incentives. The future trend in choosing a smelter location will be toward that which promises maximum return on invested capital in relation to near-term markets.

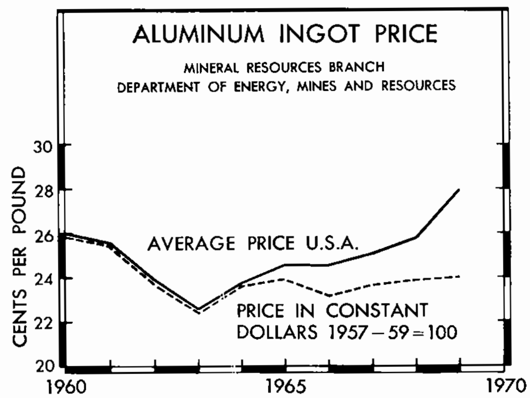
Canada and Norway have historically been large exporters of the metal because their domestic consumption, though appreciable, has been considerably less than their smelter capacity developed originally on abundant cheap hydro-electric power. Canadian aluminum producers have developed certain export trade patterns mainly to the United States, Britain, and Japan. Norwegian aluminum has found markets principally in European countries, including Britain. Britain, which has at present an insignificant smelting capacity, will be close to self-sufficiency in two or three years. Other European countries and Japan are rapidly expanding their smelter capacity. Thus, Canadian trade patterns are changing and competition for available markets can be expected, keeping in mind that these markets are expanding.

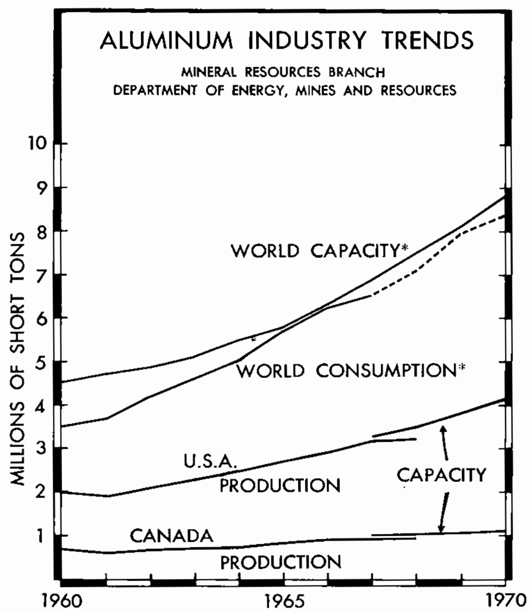
The United States is the largest market place for aluminum, as well as being the largest producer and the biggest importer of crude metal. Unwrought imports for 1969 were 468,273 tons and crude exports were 344,413 tons. Sales from the government stockpile were 140,000 tons, leaving 850,255 tons at year-end available for disposal. A further 450,000 tons of aluminum is in the stockpile to meet government objectives.

Of the total amount of aluminum supplied to the United States market, it is estimated that 22 per cent is used for building and construction, 18 per cent for transportation, 13 per cent for electrical purposes, 11 per cent for containers and packaging, 10 per cent for consumer durables, 7 per cent for machinery and equipment, 10 per cent for miscellaneous uses, and 9 per cent is exported. The fastest growing segment of the market is in containers and packaging. Efforts are continually being made to increase aluminum's share of the automobile market through the introduction of aluminum engine blocks and radiators.

USES

Some 95 per cent of bauxite mined is of metal grade. The remainder has important industrial uses. Chemical grades of bauxite are used for clarifying edible oils, for processing to make aluminum sulphate which has a substantial market in sizing paper, and for the manufacture of high alumina cement; calcined bauxite in limited amounts is important in abrasives and refractories. Calcined alumina is used in abrasives, ceramics and refractories; the low-soda variety in electrical insulators. Hydrated alumina is the basis of aluminum chemicals such as iron-free aluminum sulphate, aluminum acetate, aluminum stearate and others. Tabular alumina has applications as catalyst carriers, fillers, pigments, and special refractories. Activated alumina is used to remove moisture from gases.





*Excludes Communist Countries.

Aluminum smelter products such as remelt ingot, sheet ingot, extrusion ingot, wire bars etc., are distributed to a number of markets. Aluminum castings have varied end-uses such as automotive parts, electrical appliances and items for structural or decorative purposes. End-uses for sheet include building sheathing, cans, household utensils, foil and slugs for making collapsible tubes. Extrusions are typically used in conjunction with sheet in curtain wall systems of building construction, in the manufacture of trucks, trailer bodies, railway cars, doors and windows, for pipe, and as tubing for lightweight furniture. Aluminum rod goes into the making of electrical wire and cable. A new electrical wire for building construction, called Copperclad, is being introduced in the United States and Britain. This consists of an outer skin of copper metallurgically bonded to an aluminum core. It is expected that Copperclad will combine the light weight of aluminum with the electrical conducting properties of copper at a competitive price.

The main destructive uses are as a deoxidizer in steel manufacture, as an alloy with other metals such as magnesium or zinc, and as powder in the manufacture of paint and explosives.

PRICES

In the United States there were two general price increases for aluminum that were supported by all producers during 1969. On January 18 the price for ingot containing a guaranteed minimum of 99.5 per cent aluminum was raised from 26 to 27 cents a pound. In August, an attempt by some United States producers to raise the price to 28 cents failed when the larger producers did not agree to the increase. A general increase to 28 cents took place on October 13.

In Canada, 99.5 per cent aluminum ingot was priced at 27.5 cents a pound at the first of the year, rose to 28.5 cents on January 18, and to 29.5 cents on October 8.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General
CANADA				
32910-1	Bauxite	free	free	free
35301-1	Aluminum, pigs, ingots, blocks, notch bars, slabs, billets, blooms and wire bars – per lb (effective 1/1/68)	free	1¢	5¢
35302-1	Aluminum, bars, rods, plates, sheets, strips, circles, squares, discs and rectangles – per lb (effective 4/6/69)	free	2¢	7.5¢
35303-1	Aluminum, channels, beams, ties and other rolled, drawn or extruded sections and shapes (effective 4/6/69)	free	12½%	30%
35305-1	Aluminum pipes and tubes	free	12½%	30%
	Various tariffs are in effect on more advanced forms of aluminum			
UNITED STATES				
601.06	Bauxite			
	On and after Jan. 1, 1969	30¢ per lt.		
	" " Jan. 1, 1970	20¢ "		
	(duty suspended to July 15, 1971)			
618.01	Unwrought aluminum, in coils, uniform cross-section not greater than 0.375 inch			
	On and after Jan. 1, 1969	2¢ per lb		
	" " Jan. 1, 1970	1.7¢ "		
618.02	Unwrought aluminum, other excluding alloys			
	On and after Jan. 1, 1969	1.1¢ per lb		
	" " Jan. 1, 1970	1¢ "		
618.04	Unwrought aluminum alloy, aluminum silicon			
	On and after Jan. 1, 1969	1.5¢ per lb		
	" " Jan. 1, 1970	1¢ "		
618.06	Unwrought aluminum alloys, other			
	On and after Jan. 1, 1969	1.1¢ per lb		
	" " Jan. 1, 1970	1¢ "		

TARIFFS (Cont'd)

Item No.		British Preferential	Most Favoured Nation	General
618.10	Aluminum scrap			
	On and after Jan. 1, 1969	1.2¢ per lb		
	" " Jan. 1, 1970	1¢ "		
	(duty suspended to June 30, 1971)			
	Various tariffs are in effect on the more advanced fabricated forms of aluminum.			

NOTE: **The above U.S. aluminum tariffs will be further reduced on Jan. 1, 1971 and Jan. 1, 1972.**

Antimony

J.G. GEORGE*

Canada's production of primary antimony is a by-product 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 1969 was 0.85 million pounds compared with 1.16 million pounds in 1968.

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. A total of 789,400 pounds of antimony oxide were imported in 1969 with Britain supplying almost 75 per cent; the remainder came from the United States and Mainland China. 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 sole producer of primary antimonial lead in Canada. The antimonial lead has a variable antimony content up to 23 per cent, depending on the customer's requirements. Secondary smelters recovered antimonial lead from scrap metal but no recent information is available concerning this production.

*Mineral Resources Branch.

DOMESTIC SOURCES AND OCCURRENCES

The main source 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, New Brunswick, East Coast Smelting and Chemical Company Limited, a subsidiary of Brunswick Mining and Smelting Corporation Limited, produced 499 tons of antimonial dross in 1969 compared with 550 tons in 1968.

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.

TABLE 1

Antimony–Canadian Production, Imports and Consumption
1968-69

	1968		1969ᵖ	
	Pounds	$	Pounds	$
Production				
Antimony content of antimonial lead alloys	1,159,960	614,779	845,000	507,000
Imports				
Antimony oxide				
Britain	661,400	259,000	579,600	270,000
United States	86,800	34,000	143,400	63,000
Mainland China	44,500	13,000	66,400	25,000
Total	792,700	306,000	789,400	358,000
Consumption				
Antimony regulus (metal) in production of:				
Antimonial lead alloys	802,484		803,454	
Babbitt	137,325		145,779	
Solder	27,770		22,127	
Type metal	157,421		188,800	
Other commodities*	44,631		145,582	
Total	1,169,631		1,305,742	

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

TABLE 2

Antimony–Canadian Production, Imports and Consumption, 1960-69
(pounds)

	Production* (all forms)	Imports (regulus)	Consumption** (regulus)
1960	1,651,786	843,794	952,000
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
1969ᵖ	845,000	..	1,306,000

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.

WORLD REVIEW

World mine production of antimony in 1969, as estimated by the United States Bureau of Mines, totalled 68,800 short tons, 1,000 tons more than in 1968. 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 and Yugoslavia. National Lead Company operates the world's largest antimony smelter for ores and concentrates at Laredo, Texas, where it produces antimony metal, 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.

Antimony ore and metal prices rose spectacularly in 1969 to record highs because of a major shortage in supply. Virtual withdrawal of Mainland China from the market, as a supplier to European consumers, was a major contributing factor. Some reports indicate that China may be building a strategic stockpile of metals, among which is antimony. Russian buying in Western markets, now that it is unable to obtain antimony from China, also aggravated the supply-demand balance. Purchases by India late in the year placed an additional strain on available supplies. Imports into the United States were affected by an 8-week dock strike that did not end until late in February. Although consumption in the United States, Japan and other highly industrialized countries was substantially higher in 1969, there were only relatively small increases in world mine output of antimony to fill the increased demands. Reports indicate that increased requirements for antimony oxide, as a flame retardant in the manufacture of plastics, both in the United States and abroad, contributed to the price pressures in 1969. An increasing use for antimony in the production of ammunition could also be a clue to its current short supply. Antimony is alloyed with lead to harden small-arms bullets, while tracer bullets contain a light-emitting antimony sulphide mixture that permits visual tracking of their trajectory.

The United States in 1969 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. Antimony metal contained in the United States Government stockpile, for conventional war requirements, totalled 46,746 tons as at December 31, 1969, or 2,451 tons less than at the beginning of that year. The sales of 2,451 tons were made prior to August 1, 1969 and represented the final balance of 5,000 tons of antimony authorized for disposal by the Office of Emergency Preparedness (OEP) in October 1964. On August 1, OEP announced that the stockpile objective, for non-nuclear war requirements, had been raised from 25,500 to 50,500 tons, leaving a shortage of 3,754 tons. The stockpiled antimonial lead, which amounted to 10,336 tons at the beginning of 1969, was completely sold out during the latter part of the year. A stockpile objective had not been established for antimonial lead.

OUTLOOK

The world outlook for antimony is favourable and, barring any sharp break in the general economic picture, a strong demand is expected to prevail for both antimony ore and metal in 1970. Although supplies are expected to increase, it will take some time for new production to catch up with greater anticipated demand. What quantity, if any, will be made available by Mainland China, could affect overall market behaviour. The upward revision to 50,500 tons, which occurred August 1, 1969 in the United States Government's stockpile objective, removed a substantial quantity of stockpiled antimony which had been overhanging the market. Observers generally feel that prices will continue their upward trend at least for part of 1970. The continuing shortage could, however, stimulate efforts to find and use substitute materials where technically and economically feasible.

TABLE 3

Canadian Consumption of Antimonial Lead Alloy*, 1967-69
(pounds)

	1967	1968	1969p
Storage batteries	1,863,805	1,975,184	..
Other uses, including babbitt, solder, type metal	632,227	149,719	..
Total	2,496,032	2,124,903	..

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*, 1960-69
(pounds)

1960	2,269,507
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
1969p	..

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, 1967-69
(short tons)

	1967	1968p	1969p
Republic of South Africa	13,666	18,511	19,000
Mainland China[e]	13,200	13,200	*
Bolivia	12,432	12,188	12,200
USSR[e]	7,000	7,000	*
Mexico	4,121	3,819	4,000
Turkey	2,244	3,446	*
Yugoslavia (metal)	2,533	1,935	2,000
Morocco	1,753	1,336	*
Czechoslovakia[e]	1,200	1,200	*
Australia	1,009	931	*
United States	892	856	980
Canada	634	580	422
Other countries	3,165	2,783	30,178
Total	63,849	67,785	68,780

Source: Dominion Bureau of Statistics for Canada for all three years, Minerals Yearbook 1968, United States Department of the Interior, for other 1967 and 1968 figures, and Commodity Data Summaries, January 1970, Bureau of Mines, United States Department of the Interior, for other 1969 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 flame-proofing 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 ceramics field, antimony adds hardness and acid resistance to enamel coverings for such products as bathtubs, sinks, refrigerators, etc. The pentasulphide of antimony is employed as a vulcanizing agent by the rubber industry.

High-purity antimony metal is used by manufacturers of intermetallic compounds for semi-conductor use. An aluminum-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 23,664 tons in 1967 and 23,699 tons in 1968. These tonnages, added to the amounts of primary antimony consumption shown in Table 6, give a total use in the United States of about 41,014 tons in 1967 and 42,219 tons in 1968.

TABLE 6

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

Product	1967	1968
Metal products:		
Ammunition	209	156
Antimonial lead	5,539	6,817
Bearing metal and bearings	653	755
Cable covering	141	178
Castings	54	46
Collapsible tubes and foil	31	50
Sheet and pipe	118	105
Solder	184	255
Type metal	382	423
Other	223	258
Total	7,534	9,043
Nonmetal products:		
Ammunition primers	30	33
Fireworks	43	37
Flameproofing chemicals and compounds	3,454	2,774
Ceramics and glass	1,884	2,037
Matches	*	*
Pigments	665	859
Plastics	1,785	2,318
Rubber products	948	440
Other	1,007	979
Total	9,816	9,477
Grand total	17,350	18,520

Source: United States Bureau of Mines Minerals Yearbook 1968.
*Included with "other" to avoid disclosing individual company confidential data.

PRICES

Antimony prices throughout the world rose spectacularly in 1969. Between mid-March and mid-December, the United States domestic price of antimony metal, as quoted in *Metals Week*, in bulk, 99.5 per cent, f.o.b. Laredo, Texas, rose from 44.0 cents a pound to a record high of $1.04 a pound; the latter price remained in effect at year-end. From June 1964 until mid-March 1969 this United States price had been pegged at 44.0 cents.

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 43½-44 cents a pound at the beginning of 1969. It remained at this level until about mid-March when it was increased to 50 cents a pound. Thereafter the price rose continually and frequently, reaching a year-end high of $3.00 a pound.

TARIFFS

	Most Favoured Nation
CANADA	
Antimony, or regulus of, not ground, pulverized or otherwise manufactured	free
Antimony oxides	12½% ad val.

UNITED STATES	
Antimony ore	free
Antimony metal, unwrought	1.4¢ per lb*

Source: 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
*On and after January 1, 1970.

Arsenic Trioxide

J. G. GEORGE*

During the past five years, Canadian output of arsenic trioxide fluctuated with the varying demand for the product. It rose from 164 short tons in 1964 (when the last mineral review on this subject was issued), to 353 tons in 1967, and then declined to 170 tons in 1969. Kam-Kotia Mines Limited, Refinery Division, at Cobalt, Ontario has remained the only domestic producer of arsenic trioxide, deriving it as a byproduct in the processing of silver-cobalt ores and concentrates. This plant, which has a rated annual capacity of 400 short tons of refined arsenic trioxide, produced 170 tons of saleable product in 1969 and 337 tons in 1968.

Refined arsenic trioxide (As_2O_3) is the most common compound of arsenic and, in trade and commerce, is also known as white arsenic or arsenious oxide. It is a white, deadly toxic powder refined from greyish white crude arsenic trioxide. The crude arsenic trioxide must be recovered during the smelting of ores and concentrates containing arsenic in order to prevent severe air pollution. Consequently, it is basically a smelter byproduct, derived principally from copper and lead smelting operations and from the recovery of other metals, notably gold and silver.

During the 1950's and in 1960, production of arsenic trioxide was higher than in subsequent years because of the substantial byproduct output by Deloro Smelting & Refining Company, Limited at Deloro, Ontario. The Deloro plant had been in existence since the 1880's and had been operated since 1907 primarily to smelt and refine arsenical cobalt-silver ores and concentrates. In January 1961, this smelter and refinery were closed due to a decline in the selling price of cobalt oxides and salts and the inability of the company to obtain a sufficient supply of good quality smelter feed required for economic plant operation. Production of arsenic trioxide was resumed in Ontario in 1962, shortly after Cobalt Refinery Limited began operating a silver smelter and refinery near Cobalt. In June 1963, the company became a wholly-owned subsidiary of ViolaMac Mines Limited, which changed its name, early in 1966, to Kam-Kotia Mines Limited. Later in 1966, the silver smelter and refinery became known as Kam-Kotia Mines Limited, Refinery Division. The plant treats the complex silver-cobalt ores and concentrates produced in the Cobalt-Gowganda area of northern Ontario primarily for their silver content. In addition to refined silver, it produces byproduct arsenic trioxide, silver-cobalt speiss, gold-silver bullion, copper, cobalt and nickel oxides.

Prior to 1961, sales of refined arsenic trioxide depended mainly on an export market that fluctuated considerably from year to year. Since then, Canada's output has been much smaller because the product has been recovered in the processing of silver ores and concentrates rather than ores and concentrates high in cobalt and associated arsenides. Since this production has been well below domestic requirements, it has found a small, but steady, domestic market and has been dependent on the export trade only to a slight degree.

Canadian export statistics have not been available since 1963, when only 2 tons of arsenic trioxide valued at $264 were exported to the United States. United States import statistics indicate that 8 tons of arsenic acids and arsenious oxide, valued at $1,558 (U.S.), were shipped to the United States in 1968, possibly representing total Canadian exports. Canada imports arsenic trioxide as well as arsenic acid, arsenic pentoxide and refined arsenic metal. Although

*Mineral Resources Branch.

TABLE 1

Canada, Arsenic Trioxide Production, Trade and Consumption, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Production				
Arsenic trioxide				
Ontario	337	. .	170	. .
Exports*				
Arsenic acids and arsenic trioxide				
United States	8	1,558	–	–
Imports				
Botanical arsenical formulations not elsewhere specified				
United States	475	227,000	327	136,000
Peru	91	43,000	53	28,000
Netherlands	–	–	1	1,000
Belgium and Luxembourg	66	8,000	–	–
Total	632	278,000	381	165,000

	1967	1968
	Short Tons	Short Tons
Consumption		
Arsenic trioxide		
Glass and glass products	95	. .
Metal rolling, casting, extruding	116	. .
Miscellaneous chemicals	235	. .
Total	446	. .

Source: Dominion Bureau of Statistics and company reports (for production figures).
*United States imports of merchandise for consumption, Report F.T. 135.
pPreliminary; –Nil; . .Not available.

statistics are not available covering these imports, Canada was again, in 1969, a net importer of arsenic trioxide.

Canada is a minor contributor to the world output of white arsenic trioxide which, based on the published statistics shown in Table 3, amounted to 64,884 tons in 1968. Sweden was the world's largest recorded producer of arsenic trioxide; other leading producers in 1968 were France and Mexico. In Sweden, the major producer of the compound is the Boliden Group of companies which recovers it as a byproduct in the processing of complex arsenical copper-gold ores. Other important producers are American Smelting and Refining Company at Tacoma, Washington, in the United States, Société Minière et Métallurgique de Penarroya in France and Asarco Mexicana, S.A. in Mexico.

CANADIAN PRODUCERS AND OTHER DOMESTIC SOURCES

Kam-Kotia Mines Limited, Refinery Division, was the only Canadian producer of arsenic trioxide. It was recovered as a byproduct during the custom smelting of arsenical silver-cobalt ores and concentrates mined in the Cobalt-Gowganda area of northern Ontario. The flue gases from the roaster are collected in fibreglass bags under controlled temperature conditions, cooled, condensed and then recovered as a fine crude powder in a baghouse. At Trail, British Columbia, Cominco Ltd. produces high-purity arsenic, for use in semiconductors.

To reduce toxic air pollution, crude arsenic trioxide is removed from gases produced during the roasting of arsenical gold ores at the Yellowknife, Northwest Territories, plants of Giant Yellowknife

TABLE 2

Canada, Crude and Refined Arsenic Trioxide Production, Exports and Consumption, 1955-69
(short tons)

	Production	Exports	Consumption**
1955	786	470	217
1956	895	584	217
1957	1,849	1,615	230
1958	1,162	852	199
1959	789	565	175
1960	862	527	247
1961	210	144	307
1962	80	–	344
1963	94	2	318
1964	164	35*	359
1965	201	–	386
1966	350	–	426
1967	353	98*	446
1968	337	8*	. .
1969p	170	–	. .

Source: Dominion Bureau of Statistics and company reports (for 1967-69 production figures).
*United States imports from Canada, reported in United States imports of merchandise for consumption, Report F.T. 135. **Available data on consumption of arsenic trioxide.
pPreliminary; –Nil; . . Not available.

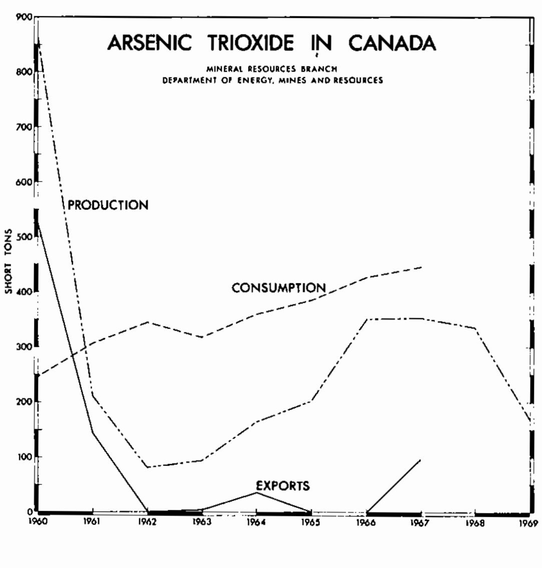
TABLE 3

World Production of White Arsenic (arsenic trioxide) 1967-68*
(short tons)

	1967	1968p
Sweden	22,266	23,210
France	15,588	15,000
Mexico	16,498	14,915
U.S.S.R.e	7,716	7,716
Peru	298	1,352
West Germany	583	882
Japan	709	756
Canada	353	337
United States	. . .	. . .
Other countries	690	716
Total**	64,701	64,884

Source: U.S. Bureau of Mines Minerals Yearbook, 1968, and company reports for Canadian statistics.
*Arsenic may be produced in Argentina, Austria, Belgium, Mainland China, Czechoslovakia, East Germany, Finland, Hungary, Territory of South-West Africa, Britain and Yugoslavia, but there is too little information to estimate production. The listed figures include calculated trioxide equivalent for output reported as elemental arsenic and arsenic compounds.
**Total is of listed figures only.
pPreliminary; eEstimated; . . . Not available for publication.

Mines Limited and Cominco Ltd. The crude arsenic dust is carefully disposed of in dumps or in special underground workings. Arsenic is a constituent in many other metalliferous deposits in Canada. The arsenic minerals contained in many gold, silver and base-metal ores and concentrates are usually considered to be undesirable impurities.



USES

Arsenic trioxide is the raw material used in the production of other arsenic compounds (both metallic and organic), arsenic metal and arsenic alloys.

Arsenic compounds are used throughout the world chiefly for their poisonous effects. The toxicity of arsenic and arsenical compounds, both organic and inorganic, ranges from very low to extremely high depending on the chemical state. Arsenic's major use is in the argricultural field in the form of calcium arsenate, arsenic acid, lead arsenate and sodium arsenite. Calcium and lead arsenate are the more important end-products and are commonly used in pesticides. In recent years, however, other organic and inorganic poisons have become popular as substitutes for the arsenates. The organic substitutes include dichlorodiphenyltrichloroethane (DDT), benzene hexachloride (BHC), toxaphene, and organic phosphate compounds. Notwithstanding, there appears to be a current trend toward an increased application of organic arsenic-bearing compounds for use in weed and pesticide control.

The demand for arsenic acid as a cotton defoliant has increased substantially in recent years and now ranks second to that for calcium arsenate. Sodium arsenate is employed in the control of weeds and as a soil sterilizer in rubber plantations in Malaya and along railroad right-of-ways. Sodium arsenite is widely used to defoliate potato plants prior to harvesting and to control weeds. It has also been used to kill and debark trees for the pulp and paper industry. Arsenic chemicals are also used in wood preserving, hide tanning and in the manufacture of paint pigments. Arsenic trioxide and some of its derivatives are used in cattle and sheep dips, crabgrass control and aquatic weed control.

A significant use of white arsenic not based on its poisonous characteristics is in glassmaking where it assists in the decolorization and firing of glass products.

Metallic arsenic is used primarily as an alloying agent because it lacks the properties of ductile metals. Additions of small amounts, up to 3 per cent, of arsenic, harden lead and minimize softening of lead-base bearing alloys used in internal combustion engines where elevated temperatures are encountered. A small amount of arsenic may be added to lead-base battery grids and cable sheathing to increase the hardness of these materials. When a minor amount of arsenic is alloyed with copper, it increases corrosion and erosion resistance, raises the annealing temperature and possibly serves as a deoxidizer. Copper with 0.15 to 0.50 per cent arsenic content is recommended for elevated-temperature applications such as locomotive stay bolts and firebox straps. When a small amount of arsenic, 0.02 to 0.05 per cent, is added to brass it prevents or minimizes dezincification, and reduces season cracking. A familiar metallurgical application of arsenic is in manufacturing lead shot. The addition of 0.5 to 2.0 per cent arsenic changes the surface tension of lead and improves the sphericity of the shot.

Over the past several years there has been a limited demand for very high-purity arsenic metal, 99.999 + per cent, as a semi-conductor in the electrical and electronics industries. High-purity arsenic forms semiconductor compounds when alloyed with aluminum, gallium and indium. Gallium arsenide has been used to make tunnel diodes, varactor diodes, light emitting diodes (LED's), transistors, solar cells, experimental lasers and Gunn effect devices. Indium arsenide has been used to produce Hall-effect and infra-red devices. High-purity arsenic is usually sold in units of 50, 100, 200 and 500 grams sealed in evacuated glass ampuls to prevent oxidation.

OUTLOOK

The world outlook for arsenic trioxide is favourable and a continuing, but fluctuating, demand is expected to obtain during the next few years. No appreciable change is anticipated in the price structure or the growth rate of production or consumption. Because of its byproduct relationship to other metals, principally copper and lead, output of white arsenic cannot be readily adjusted to changing demand.

Although research has enhanced the prospects for greater consumption of arsenical compounds in many of their old uses, and has uncovered some relatively new applications, overall demand may continue to be restricted because of the poisonous nature of arsenic and its compounds. Also, technological development of substitutes has retarded the growth of arsenical compounds in some important use areas.

PRICES

United States price for arsenic as quoted in the *Oil, Paint and Drug Reporter* issue of December 29, 1969, was as follows:

Arsenic trioxide, NF, powdered, drums of 300 lb f.o.b. works . . . 4.8¢/lb

Prices in the United States as quoted in *Metals Week* issue of December 29, 1969 were as follows:

Arsenious trioxide: refined, white
- Domestic, bulk, ton, carloads f.o.b. shipping point
  - Laredo, 99.5 per cent $120.00
  - Tacoma, 95 per cent min. $94.00
- Imported, NY docks, 99.5 per cent, barrels, lb 6 1/4 – 6 3/4¢

TARIFFS

CANADA* Item No.		British Preferential	Most Favoured Nation	General
92811-1	Arsenic trioxide, arsenic pentoxide and acids of arsenic	10%	15%	25%

UNITED STATES Item No.		
416.05	Arsenic acid	free
417.60	Arsenic sulphide	free
417.62	Arsenic trioxide (arsenious acid)	free
417.64	Other arsenic compounds	7%**

* On and after January 1, 1969.
**On and after January 1, 1970.

Asbestos

W.G. JEFFERY*

Asbestos output in Canada in 1969 reached a record high level of 1,596,450 tons, a slight increase over production in 1968. The total value, at $196,759,000 was also a new high, up about 6 per cent from 1968. About 84 per cent of the tonnage came from the Province of Quebec, between 5 and 6 per cent from each of British Columbia and the Yukon Territory, 3.5 per cent from Newfoundland, and a little over 2 per cent from the Province of Ontario. World fibre demand remained strong in 1969 and Canada retained its dominant position as the major supplier of asbestos to world markets. Of total exports amounting to 1.56 million tons, United States absorbed 41 per cent with a value of $72.6 million. Total exports of asbestos manufactured products increased substantially from $3.2 million in 1968 to $4.1 million in 1969.

Asbestos is a commercial term applied to fibrous varieties of several minerals differing in composition, 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 anthophyllite. 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 satisfactory quality and economic quantity 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 more 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, crude Nos. 1 and 2 through Group 3, down to the shortest Group 7.

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 Resources Branch.

TABLE 1

Canada, Asbestos Production and Trade, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Production (shipments)				
By type				
Crude (groups 1 and 2)	290	226,000		
Milled fibres (groups 3,4,5)	777,006	137,485,662		
Shorts (groups 6,7,8)	818,655	47,313,000		
Total	1,595,951	185,024,662*	1,596,450	196,759,000*
By province				
Quebec	1,370,955	147,975,582	1,336,000	154,410,000
Yukon	63,592	8,684,125	88,000	12,701,400
British Columbia	74,667	14,413,336	81,950	15,323,600
Newfoundland	69,183	11,844,605	55,500	10,100,000
Ontario	17,554	2,107,014	35,000	4,224,000
Total	1,595,951	185,024,662	1,596,450	196,759,000
Exports				
Crude				
Japan	89	66,000	69	52,000
United States	89	71,000	22	19,000
West Germany	21	20,000	20	23,000
Other countries	3	4,000	24	10,000
Total	202	161,000	135	104,000
Milled fibre (groups 3,4 and 5)				
United States	217,805	43,881,000	213,881	45,560,000
Britain	63,850	13,653,000	61,230	14,019,000
West Germany	56,324	12,303,000	60,284	12,981,000
Japan	33,560	5,916,000	46,564	8,064,000
France	39,273	7,615,000	46,182	9,453,000
Australia	40,112	7,225,000	37,848	7,061,000
Belgium and Luxembourg	35,798	6,922,000	32,573	6,822,000
Spain	15,189	3,023,000	32,051	6,416,000
Mexico	26,424	5,040,000	23,775	4,788,000
Italy	14,128	2,881,000	17,653	3,682,000
Netherlands	18,689	3,848,000	16,936	3,551,000
Austria	11,308	2,277,000	16,173	3,424,000
Brazil	20,403	4,058,000	16,117	3,354,000
Poland	6,619	1,429,000	15,508	2,612,000
Other countries	123,636	23,721,000	141,866	23,317,000
Total	723,118	143,792,000	778,641	160,104,000
Shorts (groups 6,7,8 and 9)				
United States	443,436	26,276,000	429,107	26,984,000
Japan	63,831	5,702,000	109,548	10,026,000
West Germany	34,459	2,467,000	50,184	3,421,000
Britain	55,304	3,295,000	39,672	2,532,000
France	19,233	1,245,000	28,380	1,793,000
Belgium and Luxembourg	18,594	1,625,000	19,687	1,659,000
South Korea	10,963	1,111,000	16,873	1,818,000
Spain	11,213	1,023,000	13,658	1,351,000
Netherlands	12,163	733,000	10,374	714,000
Australia	11,144	815,000	10,196	796,000

TABLE 1 (Cont'd)

	1968		1969p	
	Short Tons	$	Short Tons	$
Mexico	4,919	404,000	5,431	471,000
Sweden	4,287	264,000	5,190	347,000
Other countries	46,784	3,986,000	47,686	4,155,000
Total	736,330	48,946,000	785,986	56,067,000
Grand total, crude, milled fibres and shorts	1,459,650	192,899,000	1,564,762	216,275,000
Manufactured products				
Brake linings and clutch facings				
United States		261,000		554,000
Cuba		124,000		419,000
Lebanon		41,000		61,000
Equador		90,000		38,000
France		17,000		35,000
Guatemala		36,000		22,000
Greece		8,000		17,000
Other countries		173,000		100,000
Total		750,000		1,246,000
Asbestos and asbestos cement building materials				
United States		638,000		929,000
Australia		171,000		181,000
Japan		53,000		138,000
Netherlands		129,000		95,000
New Zealand		25,000		58,000
Belgium and Luxembourg		1,000		23,000
Syria		–		23,000
Other countries		498,000		117,000
Total		1,515,000		1,564,000
Asbestos and asbestos cement basic products, n.e.s.				
United States		659,000		1,061,000
Switzerland		47,000		53,000
Britain		72,000		21,000
Finland		9,000		20,000
New Zealand		53,000		20,000
Japan		1,000		12,000
West Germany		2,000		7,000
Other countries		87,000		57,000
Total		930,000		1,251,000
Total exports, asbestos manufactured products		3,195,000		4,061,000

TABLE 1 (Cont'd)

	1968		1969p	
	Short Tons	$	Short Tons	$
Imports				
Asbestos, unmanufactured	5,932	1,118,000	7,449	1,425,000
Asbestos, manufactured,				
cloth, dryer felts, sheets				
woven or felted		737,000		1,205,000
packing		896,000		995,000
brake linings		3,840,000		4,191,000
clutch facings		427,000		946,000
Asbestos-cement,				
shingles and siding		229,000		274,000
board and sheets		1,011,000		1,137,000
Asbestos and asbestos-cement				
building materials, n.e.s.		1,049,000		944,000
Asbestos and asbestos-cement				
basic products, n.e.s.		1,647,000		2,002,000
Total asbestos, manufactured		9,836,000		11,694,000
Total asbestos, unmanufactured and manufactured		10,954,000		13,119,000

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

CANADIAN INDUSTRY AND DEVELOPMENTS

A chief source of the world's asbestos supply is from 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 operation at Asbestos, where the concentrating mill can process 32,000 tons of ore a day and produces approximately 45 per cent of all asbestos produced 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.

During 1969, Canadian Johns-Manville Company, Limited continued with its mill expansion plans that should lead to an increase in productive capacity of 100,000 tons of fibre a year. Part of this increase comes from the retreatment of old tailings containing appreciable amounts of short fibre for which there was originally no demand. In addition a further $70 million expansion plan is underway to enlarge the open pit; this will require purchase of new equipment and the relocation of some buildings and plant. The completion of this five-year expansion will allow an increase in total ore and waste rock handled from 30 million to 40 million tons a year.

At Thetford Mines, Quebec, Asbestos Corporation Limited continued with development of the deep-lying Penhale asbestos zone adjacent to the Normandie Mine. At the King-Beaver mine modern ore handling and storage facilities were completed late in 1969. Subsequent to the year-end a decision has been reached on the company's plans for fibre production from Asbestos Hill in the Ungava area, northern Quebec. The company proposed that, because of the limited shipping season, the Ungava production will be exported in bulk as a partially concentrated fibre-bearing crushed rock. The proposal involves about 300,000 tons of concentrate annually that would be transported by ship to a grading and packing plant in Europe, an important market for high-quality asbestos-cement grade fibre. Final production would amount to 100,000 tons of asbestos a year. Early in 1969 General Dynamics Corp. of New York through its subsidiary Canadair Ltd., obtained a 54 per cent interest and corporate control of Asbestos Corporation.

Also in Quebec, Bell Asbestos Mines, Ltd., proceeded with its new shaft at Thetford Mines. One producer, Nicolet Asbestos Mines Ltd., closed at the end of January 1969, due to exhaustion of ore.

Asbestos production from the sole producer in Newfoundland declined from the 1968 level, due to a two-month strike in mid-year at Advocate Mines Limited's mine at Baie Verte.

TABLE 2

Canada-Asbestos Production and Exports, 1960-69
(short tons)

	Crude	Milled	Shorts	Total
Production*				
1960	330	483,183	634,943	1,118,456
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
1969p	..	..	..	1,596,450
Exports				
1960	241	458,053	610,199	1,068,493
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
1969p	135	778,641	785,986	1,564,762

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

In British Columbia, Cassiar Asbestos Corporation Limited announced a $4.3 million expansion of mill capacity at its asbestos mine at Cassiar. The expansion, from 75,000 to 110,000 tons of fibre a year, is planned for completion by the end of 1970.

Outside the operations of the producing companies there are a number of asbestos prospects across Canada. Of these, two in Quebec, the properties of McAdam Mining Corporation Limited at Chibougamau, and Abitibi Asbestos Mining Company Limited north of Amos, received considerable attention in 1969. At Chibougamau, detailed diamond drilling and an underground sampling program has established 90 million tons of rock grading 3.87 per cent asbestos. Abitibi Asbestos carried out exploration work that has indicated 102 million tons of fibrebearing rock worth $4.80 a ton at 1969 prices.

WORLD REVIEW

Approximately 90 per cent of total world asbestos output of about 4.5 million tons comes from Canada, USSR, and southern Africa. Canada accounts for about 35 per cent of the world's production and for 70 to 75 per cent of world exports of fibre.

World demand was strong throughout 1969 and it appears that most asbestos producing facilities around the world operated close to capacity. USSR is the largest producer with output in the order of 2 million tons of fibre a year, most of which comes from one region centred on Asbest, about 40 miles east of Sverdlovsk in the central Ural Mountains. Most of USSR's asbestos output is consumed within the country, a large part being used in asbestos-cement construction materials. The USSR has exported about 15 per cent of production in the last few years, mostly to east European countries, France and Japan. In 1968, export shipments at 303,600 metric tons exceeded 300,000 tons for the first time.

Asbestos production from southern Africa includes chrysotile, crocidolite and amosite. The Republic of South Africa is the world's major producer of crocidolite or blue asbestos although this fibre forms less than 10 per cent of world trade.

The Republic of South Africa produces about 260,000 tons of asbestos a year. The major development in 1969 was the start-up of a new $6 million plant, that replaces old facilities, at the Msauli asbestos mine near Barberton, eastern Transvaal. Almost the entire output from South Africa together with that from mines in Rhodesia moves to world markets.

Elsewhere in the world there was interest in a number of reported occurrences of asbestos. There was news of a Canadian company proceeding with plans for a 4,800-ton-a-day mill to produce 65,000 tons of fibre a year from a deposit near Barraba, New South Wales, Australia. The short fibre asbestos, mainly groups 4 through 7, is to be marketed through Japanese interests. In Greece, feasibility studies were underway to open up an asbestos deposit in Zidani Kozanis in northeastern Greece. Early in the year the United States Geological Survey released a report that indicated interesting asbestos mineralization in Alaska, close to the Canadian border. Canadian mining companies obtained an interest in the Alaska occurrence shortly after the announcement. In Mexico, an asbestos deposit near Ciudad Victoria in southern Mexico is to be developed to provide feed to a 300-ton-a-day milling plant; production of short-fibre chrysotile is expected in 1971.

TABLE 3

Canada, Asbestos Producers, 1969

Company	Location	Mill capacity tpd	Remarks
Canadian Johns-Manville Company, Limited Jeffrey Mine	Asbestos, Que.	32,000	Open pit. Mill expansion for further 100,000 tons fibre a year by 1970. Commencing 5-year open-pit expansion.
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. New $2-million replacement processing plant.
Normandie Mine	Black Lake, Que.	6,000	Open pit.
Bell Asbestos Mines, Ltd.	Thetford Mines, Que.	3,000	Underground. Sinking new shaft.
National Asbestos Mines Limited	Thetford Mines, Que.	3,500	Open pit.
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.
Nicolet Asbestos Mines Ltd.	Norbestos, Que.	2,500	Mine ceased production Jan. 1969.
Advocate Mines Limited	Baie Verte, Newfoundland	6,000	Open pit. 2-month strike in 1969.
Cassiar Asbestos Corporation Limited			
Cassiar Mine	Cassiar, British Columbia	2,400	Open pit.
Clinton Creek Mine	Clinton Creek, Yukon Territory	3,000	Most northerly open-pit mine in Canada.
Johns-Manville Mining and Trading Limited			
Reeves Mine	Timmins, Ont.	5,000	Open pit. First full year of operation in 1969.
Hedman Mines Limited	Matheson, Ont.	300	New plant tune-up in 1969.

MARKETS AND TRADE

Asbestos is of use in industry because of its shape as a slenger fibre, other physical characteristics and 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.

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

Crudes No. 1 and 2 (+¾ inch and ⅜ 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, asbestos-cement shingles, flat and corrugated sheets, pipe.

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

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

TABLE 4

World Production of Asbestos, 1968-69
(short tons)

	1968	1969e
USSR	2,000,000	2,000,000
Canada	1,595,951	1,596,450p
Republic of South Africa	260,530	285,000p
China	165,000	165,000
Rhodesia	150,000	150,000
United States	120,690	127,000p
Italy	116,845	120,000
Swaziland	45,000	45,000
Other countries	60,000	60,000
Total	4,514,016	4,550,000

Source: Publications of the U.S. Bureau of Mines, and various trade journals.
pPreliminary; eEstimated except where indicated.

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.

Consumption of asbestos in Canada in 1969 was in the order of 70,000 tons; less than 5 per cent of production. The balance of production is exported to more than 80 countries around the world. The United States takes about 45 per cent of Canadian exports. This large market has been essentially stable over the past decade; exports from Canada increased from 582,000 tons in 1958 to 643,010 tons in 1969. A future growth of about 2 per cent annually is expected in the United States. The European Economic Community countries now import more than 200,000 tons and Britain between 100,000 and 125,000 tons a year. Asbestos from Canada provides about 48 per cent of Japan's fibre imports and Canadian sales have steadily increased to a level of about 100,000 tons a year.

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.

OUTLOOK

The outlook for asbestos in 1970 is good. A balanced situation of world production and consumption is expected to continue. The most sensitive factor will continue to be the sustained demand from the United States for Canadian fibre. In the longer term to 1975, the market outlook remains strong and a steady growth of approximately 4 per cent in both consumption and sales is forecast. The strength of the outlook relies on the increasing demand for asbestos in the manufacture of asbestos-cement products for construction. There have been some forecasts that within the next five-year period there will be a shortage of asbestos. Although there may be periods of tight supply, especially for some fibre grades more than others, it is unlikely that a severe shortage will occur. The USSR asbestos production has become so large that minor changes in their domestic consumption pattern could release fibre for additional exports in amounts that are small in terms of total output but of considerable size in relation to world trade.

PRICES

Canadian asbestos prices quoted in "Asbestos" throughout 1969 were as follows:

f.o.b. mines, Quebec, per short ton

Crude No. 1	$1,480.00
Crude No. 2	800.00
Group No. 3 (spinning fibre)	385.00 to 630.00
Group No. 4 (shingle fibre)	212.00 to 360.00
Group No. 5 (paper fibre)	152.00 to 180.00
Group No. 6 (waste, stucco, plaster)	110.00
Group No. 7 (refuse, shorts)	50.00 to 92.00

Cassiar, f.o.b. North Vancouver, B.C. per short ton

Canadian Group No. 3	
AAA grade (non ferrous spinning fibre)	$845.00
AA grade (non ferrous spinning fibre)	673.00

PRICES (Cont'd)

A grade (nonferrous spinning fibre)	508.00
Canadian Group No. 4 AC grade (asbestos cement)	363.00
Canadian Group No. 4 AK grade (shingle fibre)	249.00
Canadian Group No. 4 CP grade (shingle fibre)	234.00
Canadian Group No. 4 AS grade (shingle fibre)	217.00
Canadian Group No. 4 CT grade (shingle fibre)	211.00
Canadian Group No. 5 AX grade (shingle fibre)	193.00
Canadian Group No. 5 CY grade (shingle fibre)	136.00
Canadian Group No. 5 AY grade (shingle fibre)	136.00

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General
CANADA				
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 (effective 4 June 1969)	7½%	7½%	25%
31200-1	Asbestos in any form other than crude, and all manufactures thereof, n.o.p.	15%	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 fabrics, wholly or in part of asbestos, for use in manufacture of clutch facings and brake linings	12½%	12½%	30%

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, tubing	
	On and after Jan. 1, 1969	6%
	" " " Jan. 1, 1970	5.5%
	Articles in part of asbestos and hydraulic cement	
518.41	Pipes and tubes and fittings thereof	
	On and after Jan. 1, 1969	0.24¢ per lb
	" " " Jan. 1, 1970	0.2¢ " "
518.44	Other	
	On and after Jan. 1, 1969	7%
	" " " Jan. 1, 1970	6%
518.51	Asbestos articles not specially provided for	
	On and after Jan. 1, 1969	7%
	" " " Jan. 1, 1970	6%

Further tariff reductions will occur on January 1, 1971 and on January 1, 1972.

Barite

W.G. JEFFERY*

Production of barite in Canada in 1969 was 141,392 tons valued at $1,419,568, a tonnage increase of 2.4 per cent above 1968, when production at the sole mine in Nova Scotia was suspended over several months due to a fire.

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 1969.

The mine at Walton, Nova Scotia, operated by Dresser Minerals Division of Dresser Industries, Inc. is the main producer of barite in Canada. Barite ore is extracted from a large replacement deposit by a block caving method and hoisted through the same shaft as lead-zinc-silver sulphides mined in conjunction with barite ore. 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 grinding plants in Louisiana and Texas. A small proportion of the barite is crushed, classified, ground, pulverized and bagged for sale either in domestic markets or for shipment to Caribbean countries. Some barite is recovered in the flotation processing of the argentiferous sulphides.

In British Columbia, Baroid of Canada, Ltd., recovers barite from tailings at an abandoned lead-zinc mine near Spillimacheen, south of Golden. The tailings are fed as a slurry to separation tables and the barite concentrate is dewatered and shipped by rail for further processing in a grinding plant at Onoway, Alberta. Also in British Columbia, Mountain Minerals Limited mined barite underground from vein deposits near Parson and Brisco in the eastern part of the province. Lump ore is shipped by rail to the company's grinding plant at Lethbridge, Alberta.

During 1969, Mountain Minerals Limited moved ahead with plans to process tailings from the now inoperative Mineral King base-metal mine. Production began in 1969 from a new plant similar to that at the

*Mineral Resources Branch.

TABLE 1

Canada, Barite Production, Trade and Consumption, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Production (mine shipments)	138,059	1,262,687	141,392	1,419,568
Imports				
United States	7,841	375,000	6,176	337,000
West Germany	60	3,000	67	3,000
Total	7,901	378,000	6,243	340,000
Exports				
United States	110,638	1,041,000	108,610	1,064,000
Venezuela	2,997	28,000	–	–
Trinidad-Tobago	2,856	53,000	–	–
Total	116,491	1,122,000	108,610	1,064,000
	1967		1968	
Consumption[1]				
Well drilling	16,000e		16,000e	
Paints	1,437		2,094	
Glass	935		2,711[3]	
Rubber goods	224		287	
Other[2]	528		305	
Total	19,124		21,403	

Source: Dominion Bureau of Statistics.
[1]Available data reported by consumers, breakdown by Mineral Resources Branch. [2]Includes miscellaneous chemicals, cleansers, detergents and miscellaneous products. [3]Includes glass fibre and glass wool.
pPreliminary; – Nil; eEstimated.

Baroid operation. Barite concentrate is trucked 24 miles to rail at Invermere, British Columbia for shipment to the company's grinding plant at Lethbridge, Alberta.

In Ontario, Extender Minerals of Canada Limited, subsidiary of L.V. Lomas Limited, constructed facilities for extraction of barite from a vein deposit on the west shore of Mistinikon Lake, Yarrow Township, about 6 miles southwest of Matachewan.

There are many occurrences of barite across Canada in most provinces. 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.

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 21,402 tons of barite were consumed in Canada of which about 16,000 tons, or 74.7 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

TABLE 2

Canada, Barite Production, Trade and Consumption 1960-69
(short tons)

	Production[1]	Imports	Exports	Consumption[2]
1960	154,292	2,021	134,972	25,483
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
1969P	141,392	6,243	108,610	..

Source: Dominion Bureau of Statistics.
[1]Mine shipments. [2]Source data from Dominion Bureau of Statistics, from Consumers' reported consumption (coverage incomplete). Overall totals partially estimated by Mineral Resources Branch.
PPreliminary; .. Not available.

per cent $BaSO_4$, particle size at least minus 200 mesh and a high degree of whiteness or light reflectance. Consumption in this industry in Canada in 1968 was 9.8 per cent of total consumption, a figure of 2,094 tons.

The glass industry uses barite to increase the workability, act as a flux, assist decolouration 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 1968 included glass fibre and glass wool and amounted to 2,717 tons or 12.7 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 1968 approximately 1.3 per cent of Canada consumption, 287 tons, was reported consumed as a filler in rubber goods.

The balance of Canada's barite consumption of approximately 305 tons or 1.4 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 77 per cent of production almost wholly to United States. In 1969 exports were down to 108,610 tons from 116,491 in 1968. Imports at 6,243 tons were slightly less than in 1968 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 1968 was estimated at 3.95 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

TABLE 3

Canada – Barium Compounds, Imports, 1967-69

	1967		1968		1969	
	Short Tons	$	Short Tons	$	Short Tons	$
Imports						
Lithopone (70% $BaSO_4$)	316	44,000	404	53,000	*	*
Barium carbonate	3,952	316,000	3,495	304,000	4,005	386,000

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

TABLE 4

World Production of Barite, 1968-69
(short tons)

	1968	1969e
United States	926,729	938,000
West Germany	502,561	500,000
USSR	286,601	. .
Mexico	271,762	275,000
Italy	224,849	225,000
Greece	165,347	. .
Ireland	157,630	. .
Canada	138,059	141,392p
China	132,000	. .
Peru	121,254	120,000
North Korea	121,254	. .
France	110,231	110,000
Iran	104,719	. .
Other countries	652,841	1,645,000
Total	3,915,837	3,950,000

Source: U.S. Bureau of Mines Minerals Yearbook, Preprint 1968 and U.S. Bureau of Mines Commodity Data Summaries, January, 1970. Canada totals from Dominion Bureau of Statistics.
pPreliminary; eEstimated; . . Not available.

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.

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 1970 is expected to remain at about the level of 1969. 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.

CELESTITE

Celestite ($SrSO_4$) is the main source of strontium and there was increased interest in celestite in 1969. Strontium compounds, mainly strontium carbonate, are in demand for use in glass face plates in colour television sets where strontium carbonate improves the absorption of x-rays emitted by picture tubes operated at high voltages. Another new developing use is to make 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 Edwards, near Sydney. Two new operating companies will be formed, Kaiser Celestite Mining Limited and Kaiser Strontium Products Limited. Production is planned to begin by mid-1970. The current producers of strontium carbonate in the United States obtain most of their celestite from Mexico.

PRICES

According to *Engineering and Mining Journal of December 1969*, prices in the United States were:

Chemical grade	
Hand-picked, 95% $BaSO_4$, 1% Fe	$20 – 20.50
Flotation or magnetic separation 97-98% $BaSO_4$, 0.3 - 0.5% Fe	25 – 26.50
Add $3 for 100-lb bags	
Water ground; 99½% $BaSO_4$, 325 mesh, in 50-lb bags	45 – 49
Drilling mud grade, 83-93% $BaSO_4$, 3-12% Fe, specific gravity 4.2 to 4.3	
Crude, in bulk	$12 – 16
Ground	31 – 34
Imported, 4.2-4.3 specific gravity, crude, bulk, c.i.f. Gulf ports	14 – 18
from Canada, long tons, in bulk, crude, f.o.b. shipping point	14
Ground, short tons, in 100-lb bags f.o.b. shipping point	20

TARIFFS

CANADA

Item No.		Most Favoured Nation Jan. 1, 1969	Most Favoured Nation Jan. 1, 1970
49205-1	Drilling mud and additives	free	free
68300-1	Barytes	16%	14%
92842-1	Barium carbonate	15%	15%
93207-5	Lithopone	12½%	12½%

UNITED STATES

Item No.			
472.02	Barium carbonate, natural, crude	free	free
472.04	Barium carbonate, natural, ground	10%	8.5%
472.10	Barium sulphate, natural, crude	$2.04/1.t	$1.78/1.t
472.12	Barium sulphate, natural, ground	$5.20/1.t	$4.55/1.t

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1909) TC Publication 272.

Bentonite

W.G. JEFFERY*

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 bentonites also possess 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.

*Mineral Resources Branch.

TABLE 1

Canada, Bentonite Imports and Consumption, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Imports				
Bentonite				
United States	292,699	2,664,000	246,153	2,545,000
Greece	15,000	161,000	47,818	564,000
Total	307,699	2,825,000	293,971	3,109,000
Activated clays and earths				
United States	6,206	905,000	7,490	1,197,000
France	138	48,000	109	37,000
West Germany	–	–	10	3,000
Total	6,344	953,000	7,609	1,237,000
Fuller's earth				
United States	9,050	263,000	9,745	292,000
Britain	–	–	2	...
Total	9,050	263,000	9,747	292,000
Consumption[1] (available data)				
Pelletizing iron ore	173,367			
Well drilling	21,109			
Foundries	31,651			
Chemicals	1,895			
Rubber products	433			
Paint and varnish	581			
Paper and paper products	318			
Other products[2]	1,995			
Total	231,349			

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, refining of vegetable oils, and other miscellaneous minor uses.
pPreliminary; – Nil; ... Less than one thousand dollars.

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 and bagged. The main use is for decolourizing 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 use 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.

TABLE 2

Canada, Bentonite Imports and Consumption, 1960-69

	Imports[1]		Consumption[2]
	Short Tons	$	Short Tons
1960	..	1,590,441	64,871
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
1969p	311,327	4,639,000	..

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

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

Swelling bentonite serves as a binder in moulding sands used by iron and steel foundries. 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 subsurface 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 decolourizing 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 decreased in 1969. 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 concentrates and suitable bentonite will continue to be imported from United States. As the surge of building new pelletizing capacity has slowed, imports in 1970 will be approximately the same as those of 1969. Canadian production and consumption in industries other than iron pelletizing will remain at roughly the same levels.

PRICES

United States bentonite prices quoted in *Oil, Paint and Drug Reporter, December 30, 1968* were as follows:

Bentonite, domestic 200 mesh, bags, car lots, f.o.b. mines	per ton $14.00
Bentonite, imported Italian, white, high gel, bags, 5-ton lots, ex-warehouse	per ton $91.00

TARIFFS

CANADA

Item No.		Most Favoured Nation Jan. 1/69	Jan. 1/70
29500–1	Clays, not further mfg. than ground	free	free
93803–2	Activated clay	15%	15%

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

UNITED STATES

Item No.			Jan. 1/69	Jan. 1/70
521.61	Bentonite	per lt.	65¢	56¢
521.87	Clays, artificially activated		0.08¢/lb +10%	0.07¢/lb +8.5%

Source: Tariff Schedules of the United States Annotated, TC Publication 272.

Bismuth

J.G. GEORGE*

In Canada, bismuth is a minor constituent 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 1969 totalled 720,698 pounds valued at $3,260,200 compared with 648,232 pounds valued at $2,457,600 in 1968.

World production of bismuth in 1968, according to an estimate prepared by the United States Bureau of Mines, was 7.6 million pounds. Peru was again the leading producer with output of 1.8 million pounds, derived mainly from the mines of Cerro de Pasco Corporation. Other substantial producers in declining order of output were Japan, Bolivia, Mexico and Mainland China. The United States, although a producer, does not publish its production statistics.

World demand for bismuth exceeded supply during 1969, and demand in the United States reversed a downward trend that began in 1966. Much of the new demand for bismuth came in cosmetics. The increase in this application countered a decline in the use of bismuth in catalysts, therapeutics, and medicinal compounds. Reduced availability of the metal resulted in a substantial rise in merchant prices but a more moderate increase in producer prices. Between June 23, 1965 and August 1, 1969, the United States producer price had remained pegged at $4 a pound. On August 1, this price was raised to $5-$5.25, and on November 1, it was further increased to $6. European quotations went to over $7 a pound in October and by December the London price had reached $10. Substantial sales of surplus bismuth from the United States government's strategic stockpile had a stabilizing influence on the market.

Bolivia, traditionally a major supplier of bismuth ore, began construction late in 1969 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 during the latter part of 1970. 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.

Authorized sales of bismuth from the United States government stockpile totalled 501,576 pounds in 1969. It was expected that sale of the 1.2 million pounds of stockpiled bismuth, released for sale in November 1967, would be completed by the end of June 1970. Stockpiled bismuth at the end of 1969 amounted to 2,904,606 pounds. In December, the stockpile objective, for conventional war requirements, was reduced from 2,400,000 pounds to 2,100,000 pounds, leaving a surplus of 804,606 pounds.

* Mineral Resources Branch.

OUTLOOK

The world outlook for bismuth is favourable and, barring any sharp break in the general economic picture, a strong demand is expected to obtain for the metal during 1970. Supply continues to be tight, and there does not appear to be any real likelihood of a substantial increase in production. Since much of bismuth output is derived as a byproduct of lead production, its supply is directly related to trends in the lead market. The surplus of 804,600 pounds of bismuth in the United States government's strategic stockpile, as at December 31, 1969, must also be considered when assessing the overall supply-demand situation. Some observers also feel that the fear of a greater use of cheaper substitutes could prevent any appreciable or sustained rise in bismuth prices in 1970.

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, 1969, treated 164,863 short tons of ore and recovered 68,938 pounds of bismuth in impure metal ingots from its operations in Lacorne Township 12 miles northeast of Malartic. The period of production did not cover a full year since the new mill, built to replace the former one destroyed by fire in October 1967, did not begin operations until December 1968. 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 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.

Operations continued at the molybdenum-bismuth property of Cadillac Moly Mines Limited in the Township of Preissac, 16 miles northwest of Malartic. Production statistics have not been reported for 1969, but in 1968 the company processed 405,895 tons of ore and recovered 212,659 pounds of bismuth in ingots of about 96 per cent purity. Proven ore reserves at the end of 1968 were calculated at 483,300 tons grading 0.24 per cent molybdenite (MoS_2) and 0.042 per cent bismuth. Probable ore was estimated at 187,500 tons grading 0.28 per cent MoS_2 and 0.035 per cent bismuth. Mining and milling operations also 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 1969 but in 1968 the company recovered 19,635 pounds of byproduct bismuth.

TABLE 1

Bismuth-Canadian Production and Consumption, 1968-69

	1968		1969p	
	Pounds	$	Pounds	$
Production all forms*				
Quebec	407,346	1,446,387	502,398	2,181,797
British Columbia	207,783	868,533	142,000	701,480
New Brunswick	33,103	142,674	76,300	376,922
Total	648,232	2,457,594	720,698	3,260,199
Consumption, refined metal				
Fusible alloys and solders	40,297		. .	
Other uses**	19,049		. .	
Total	59,346		. .	

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.

TABLE 2

Bismuth-Canadian Production, Exports and Consumption, 1960-69 (pounds)

	Production (all forms)[1]	Exports[2]	Consumption[3]
1960	423,827	286,000	44,700
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
1969p	720,698	. .	. .

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.

TABLE 3

Estimated World Production of Bismuth, 1968p (pounds)

Peru	1,790,000e
Japan (metal)	1,549,000e
Bolivia	1,235,000e
Mexico	1,146,000e
Canada (metal)	648,232
Mainland China (in ore)	550,000e
Yugoslavia	243,000
South Korea (metal)	216,000e
Other countries	220,000
Total	7,597,232*

Source: Dominion Bureau of Statistics for Canada, Minerals Yearbook 1968, 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)

	1968	1969^{p}
Fusible alloys	675,416	724,166
Other alloys	454,519	481,149
Pharmaceuticals*	1,210,396	1,259,159
Experimental uses	215	–
Other uses	7,222	$6,000^{e}$
Total	2,347,768	2,470,474

Source: Mineral Industry Surveys, United States Department of the Interior, Bureau of Mines, Bismuth in the fourth quarter 1969.

*Includes industrial and laboratory chemicals.

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

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. Bismuth's use as a catalyst in the production of acrylic plastics declined again in the United States mainly because of its partial replacement by a less expensive substitute.

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.

TARIFFS

CANADA

Bismuth metal enters Canada duty free.

UNITED STATES*

Bismuth metal, unwrought	0.5% ad val.
Alloys of bismuth:	
Containing by weight not less than 30 per cent of lead	free
Other	12.5% ad val.
Bismuth metal, wrought	12.5% ad val.

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.

*On and after January 1, 1970.

PRICES

Bismuth prices throughout the world increased substantially in 1969. The United States price, as published by *Metals Week* and expressed in United States currency, remained at $4 a pound in ton lots until August 1, 1969 when a dual price of $5-$5.25 came into effect. On October 1, the higher price of $5.25 became firmly established. On November 1 the price was raised to $6 and this quotation obtained for the rest of the year. In December, the London quotation for merchant metal was reported to have gone as high as $10 a pound.

The Canadian bismuth price, as quoted by Cominco Ltd., for bars 99.99+per cent pure, remained at $4.25 a pound in lots of one ton or more and $4.50 a pound in lots of less than one ton until early August when the first increases to $5.50 and $5.75 occurred. Early in October, these prices were again revised upward to $5.70 and $5.95. Late in November, there was a final increase to $6 and $6.25 and these quotations obtained for the rest of the year.

Cadmium

ROBERT J. SHANK*

Cadmium occurs predominantly as a sulphide, greenockite, which is closely associated with sphalerite, the most common ore of zinc. Because cadmium resembles zinc chemically, it follows zinc through the various metallurgical processes used to concentrate sphalerite and produce zinc metal. Cadmium is separated from zinc during the process either chemically or by distillation. Canadian zinc ores contain from 0.001 per cent to 0.067 per cent of recoverable cadmium, but it is the cadmium content of the zinc concentrates that determines the commercial value of the ores.

Canadian production, all forms, of cadmium in 1969, as reported by the Dominion Bureau of Statistics, is shown in Table 1. These figures represent the amount of cadmium produced by mines for which payment was received by the mines. However, it appears that some domestic refined production was not credited back to the mines, and some smelter products that were exported for refining were not recorded. It is estimated that there were at least 6 million pounds of cadmium contained in zinc concentrates produced in Canada in 1969.

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. East Coast Smelting and Chemical Company Limited recovers a cadmium-zinc alloy at its Belledune, New Brunswick, lead-zinc smelter, and exports this alloy to Europe for refining. In 1969, metallic cadmium produced in Canada totalled 2,123,955 pounds, compared with 2,113,949 pounds in 1968.

The United States continued to be the world's leader in cadmium production in 1969 with output amounting to 6,400 short tons. The USSR, Japan and Canada follow in that order. Total world production in 1969 was estimated by the World Bureau of Metal Statistics to be 18,434 tons, a gain of 15 per cent over 1968 production of 16,010 tons.

Canadian industry consumes about 6 per cent of the refined cadmium produced in Canada, the remainder being exported to ten countries in 1969. These exports amounted to 1,686,573 pounds, of which 67 per cent went to Britain and 31 per cent to the United States.

Internationally, cadmium was in short supply during most of 1969, partly due to strong demand from the pigment industry and from the plastic stabilizer market. As a result, the United States price rose on four occasions during the year to $4.05 a pound, at year-end, some 50 per cent above the price in effect at the start of the year. Unusually strong demand from Europe and Japan was met by exports from the United States made possible by the sale of 2,640,000 pounds of cadmium from the government stockpile. By October, all available cadmium had been released and legislation had been introduced in Congress for authority to release a further 4,180,000 pounds from the national and supplemental stockpiles. This would leave 6 million pounds of cadmium in the United States government stockpile that is considered "essential". Some easing in demand in North America was noted late in 1969 due to the general slow-down of business activity, especially in the automobile industry.

In Japan, some forced curtailment of cadmium and zinc production has been reported due to traces of cadmium found in a river near one of the zinc smelters being blamed for causing a chronic bone disease known as "itai-itai".

*Mineral Resources Branch.

TABLE 1

Cadmium – Production, Exports and Consumption, 1968-69

	1968		1969p	
	Pounds	$	Pounds	$
Production				
All forms[1]				
Ontario	2,732,729	7,788,278	2,463,820	8,453,383
British Columbia	1,318,659	3,758,178	1,074,800	3,740,443
Quebec	252,930	720,850	329,968	1,076,998
Manitoba	223,192	636,097	232,957	810,690
New Brunswick	68,179	194,310	113,400	394,632
Saskatchewan	95,846	273,161	83,460	290,440
Yukon	51,830	147,716	70,000	243,600
Northwest Territories	271,600	774,060	–	–
Total	5,014,965	14,292,650	4,368,405	15,010,186
Refined[2]	2,113,949		2,123,955	
Exports				
Cadmium metal				
Britain	1,111,116	2,914,000	1,136,953	3,209,000
United States	661,666	1,559,000	527,112	1,558,000
Netherlands	–	–	9,000	36,000
West Germany	–	–	6,100	44,000
Belgium and Luxembourg	15,308	43,000	5,000	22,000
Other countries	14,690	40,000	2,408	9,000
Total	1,802,780	4,556,000	1,686,573	4,878,000
Consumption (cadmium metal)[3]				
Plating	94,728		98,384	
Solders	704		2,884	
Other products[4]	30,132		30,868	
Total	125,564		132,136	

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.
pPreliminary; – Nil.

DOMESTIC PRODUCTION

Because cadmium is a minor constitutent of zinc ores, statistics of its occurrence are incomplete. In Table 4, pertinent information of those mines that report their cadmium production is listed. Other mines, that have cadmium in their zinc concentrates but do not report this as production, are discussed in the general review of the Canadian industry below.

NEWFOUNDLAND

Exploration work by Cominco Ltd. on the cadmium-bearing, iron-free, sphalerite deposit of Newfoundland Zinc Mines Limited at Daniel's Harbour was continued. The deposit was reported to contain 5.4 million tons that averaged 7.7 per cent zinc and commercial amounts of cadmium.

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 near Bathurst. The smelter treats concentrates from Brunswick's mines only and produces cadmium in the form

TABLE 2

Cadmium Production, Exports and Consumption, 1960-69
(pounds)

	Production		Exports	Consumption[3]
	All Forms[1]	Refined[2]	Cadmium Metal	
1960	2,357,497	2,238,000	2,056,333	190,000
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[r]	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[p]	4,368,405	2,123,955	1,686,573	132,136

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. [p]Preliminary; [r]Revised.

of a cadmium-zinc alloy. In 1969, 95 tons of this alloy was produced and shipped to Europe for refining.

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 0.06 to 0.16 per cent cadmium except for those from Manitou-Barvue Mines Limited which run about 0.3 per cent. Canadian Electrolytic Zinc Limited recovers cadmium both as refined metal and as an impure sponge. The sponge is suitable for use as a paint pigment. Output of cadmium in 1969 by Canadian Electrolytic Zinc amounted to 625,000 pounds.

ONTARIO

Ecstall Mining Limited, at Timmins, is the largest producer of cadmium in Canada. Ecstall is constructing an electrolytic zinc plant that is expected to be in operation by 1972. It is presumed this plant will also recover cadmium metal. The remaining copper-zinc mines in the Timmins area and those at Manitouwadge produce zinc concentrates carrying low to moderate cadmium values.

MANITOBA AND SASKATCHEWAN

Virtually 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. This plant recovered 333,959 pounds of cadmium in 1969.

TABLE 3

World Production of Cadmium
(short tons)

	1968	1969[e]
United States	5,325	6,400
USSR	2,425	. .
Japan	2,420	2,500
Canada	1,039	2,184
Belgium	882	1,000
France	608	650
Poland	551	. .
Australia	506	600
Federal Republic of Germany	377	400
Republic of Congo (Kinshasa)	353	150
Other countries	1,524	4,550
Total	16,010	18,434

Source: World Bureau of Metal 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. 1969 figures from United States Bureau of Mines, Commodity Data Summaries, Jan. 1970. [e]Estimated; . . Not available.

BRITISH COLUMBIA

Metallic cadmium, amounting to 715 tons, was recovered at the metallugical works of Cominco Ltd. at Trail. Cominco treats ores and concentrates from its

TABLE 4

Companies Reporting Cadmium Production – 1969 and (1968)

Company Location	Mill Capacity –tons ore/day	Grade of Zinc Concentrate % Cadmium	% Zinc	% Lead	oz/ton silver	Zinc concentrate produced –tons	Cadmium contained in zinc conc. –pounds	Remarks
NEWFOUNDLAND								
American Smelting and Refining								
Company, Buchans Unit,	1,250	0.22	56.90	4.18	4.76	66,645	290,000	
Buchans	(1,250)	(0.22)	(57.78)	(3.85)	(4.48)	(68,550)	(304,000)	
NEW BRUNSWICK								
Nigadoo River Mines Limited,	1,000	0.71	46.03	1.53	4.09	13,503	191,719	Exploring new zone
Robertville	(1,000)	(0.70)	(45.86)	(2.12)	(4.91)	(9,841)	(141,211)	on 700 level.
QUEBEC								
Sullivan Mining Group Ltd.,								
Stratford Center	1,500	0.28	57.75	0.53	1.40	10,832	..	Opening three new
Cupra Division	(1,500)	(0.28)	(56.42)	..	..	(11,165)	(64,619)	levels.
Solbec Division	–	0.28	54.89	0.52	3.04	11,874	66,494	Mine on salvage
	–	(0.28)	(54.11)	..	..	(18,133)	(101,000)	basis.
ONTARIO								
Ecstall Mining Limited,	9,000	..	..	..	..	582,146	3,012,957	Preparing for under-
Timmins	(9,000)	(0.27)	(52.24)	..	(3.96)	(562,493)	(3,091,444)	ground mining. Constructing electrolytic zinc plant to be ready in 1972.
Zenmac Metal Mines Limited,	200	0.13	52.12	–	–	8,277	22,111	Mine to be closed
Schreiber	(200)	(0.13)	(52.90)	–	–	(7,488)	(36,321)	first half of 1970.
MANITOBA AND SASKATCHEWAN								
Hudson Bay Mining and	6,000	..	47.00	0.30	1.00	119,800	333,959	Production at
Smelting Co., Limited,	(6,000)	..	(47.60)	(0.30)	(1.00)	(131,300)	(330,900)	Anderson Lake Mine
Flin Flon								to begin late in 1970.
BRITISH COLUMBIA								
Anaconda Britannia Mines Ltd.,	3,000	0.24	53.77	–	0.76	497	2,379	Developing new 040
Britannia Beach	(3,000)	..	..	–	..	..	..	ore zone below 4,100 level.

Company Location	Mill Capacity —tons ore/day	Grade of Zinc Concentrate % Cadmium	% Zinc	% Lead	oz./ton silver	Zinc concentrate produced —tons	Cadmium contained in zinc conc. —pounds	Remarks
Canadian Exploration, Limited, Salmo	1,900 (1,900)	0.46 ..	56.95 (56.70)	1.54 (1.70)	– –	22,673 (25,576)	207,086 ..	Reserves declining. Operations expected to end late 1970 or early 1971.
Cominco Ltd., Sullivan Mine, Kimberley	10,000 (10,000)	0.12 (0.12)	48.60 (50.05)	6.30 (5.93)	2.80 (4.48)	167,151 (131,829)	.. (316,390)	
Mastodon-Highland Bell Mines Limited, Beaverdell	115 (115)	0.21 (0.37)	27.81 (34.53)	1.69 (2.18)	40.01 (55.19)	578 (291)	2,389 (2,142)	
Reeves MacDonald Mines Limited, Remac	1,200 (1,200)	0.33 (0.36)	51.93 (53.11)	1.75 (1.92)	0.67 (0.88)	16,172 (19,127)	106,388 (138,966)	Operating rate reduced pending production from new Annex mine scheduled for mid-1970.
Western Mines Limited, Buttle Lake, V.I.	1,000 (1,000)	0.26 (0.25)	53.05 (54.98)	4.34 ..	3.66 (4.36)	46,251 ..	239,927 (226,220)	Intensive exploration continuing, surface and underground.
YUKON TERRITORIES								
United Keno Hill Mines Limited, Elsa	500 (500)	0.72 ..	52.11 ..	0.50 ..	7.98 ..	6,985 (3,106)	100,740 (74,042)	Husky mine being developed. No Cash mine to be rehabilitated.

– Nil; . . Not available.

own Sullivan and Bluebell mines, from its subsidiary Pine Point Mines Limited, and, on a custom basis, from various mining operations in British Columbia.

YUKON TERRITORY

United Keno Hill Mines Limited continued to mine the highest grade of ore in terms of cadmium content in Canada, and to turn out the highest grade of concentrate. Operations have been on a reduced scale for the past three years. Exploration work continued on the property of Venus Mines Ltd. where a small tonnage of lead-zinc-silver ore that averages 0.093 per cent cadmium is indicated. Milling of this ore at a rate of 300 tons a day is scheduled to start in 1970.

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 five to ten 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 one 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 fin-stock, 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 small portable items such as battery-operated shavers, toothbrushes, drills and hand saws.

PRICES

The Canadian price of cadmium throughout 1969, as quoted in the *Northern Miner* was as follows:

sticks, bars, balls,
99.98% per lb

	Lots, 5,000 lb and over	Lots under 5,000 lb
Jan. 2	$2.85	$3.05
Jan. 9	3.00	3.20
Mar. 6	3.25	3.45
June 26	3.80	4.00
Dec. 4	4.30	4.50

The United States cadmium prices throughout 1969, as quoted by *Metals Week* were as follows:

	one ton lots	less than one ton
Jan. 1, 1969	$2.65/lb	$2.70/lb
Jan. 2, 1969	2.80 "	2.85 "
Mar. 3, 1969	3.00 "	3.05 "
June 16, 1969	3.50 "	3.55 "
Dec. 1, 1969	4.00 "	4.05 "

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General
CANADA				
32900–1	Cadmium in ores and concentrates	free	free	free
35102–1	Cadmium metal, not including alloys, in lumps, powders, ingots or blocks (effective June 4, 1969)	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, 1969	2¢ per lb		
	" " " Jan. 1, 1970	1¢ per lb		
633.00	Cadmium metal, wrought			
	On and after Jan. 1, 1969	14%		
	" " " Jan. 1, 1970	12.5%		
632.84	Cadmium alloys, unwrought			
	On and after Jan. 1, 1969	14%		
	" " " Jan. 1, 1970	12.5%		

Note: The above U.S. tariffs will be further reduced on Jan. 1, 1971 and Jan. 1, 1972.

Calcium

D.B. FRASER*

Calcium metal is produced in only three countries in the non-communist world. The Canadian producer, Dominion Magnesium Limited, is the leading supplier in international trade. Charles Pfizer and Co. Inc., Minerals, Pigments and Metals Division in the United States, and Planet-Wattohm S.A., a subsidiary of Compagnie de Mokta, in France, are the other producers. All three use thermal reduction methods. Statistics on world production and consumption of calcium are not available.

DOMESTIC INDUSTRY

Dominion Magnesium Limited at its Haley smelter in Ontario produces calcium metal in addition to its main product, magnesium. Four grades of calcium are produced: Domal-Grade 1, Grade 2, Grade 4 and Grade 5. To produce Grade 4 calcium, purchased high-purity powdered lime (CaO) of 200 mesh and commercial-purity aluminum of 20 mesh are briquetted and then charged into horizontal retorts made of chrome-nickel-iron alloy. Under vacuum and at temperatures of about 1,170°C the aluminum reduces the lime. The water-cooled head sections of the retorts project through the furnace wall and calcium vapour condenses as crystalline rings in a temperature range of 680°C to 740°C. Higher purities are obtained by subsequent refining operations.

Grade 1 is nominally 99.9 per cent pure. Minor impurities are similar to those of Grade 2 which contains 99.5 per cent calcium or 99.9 per cent calcium plus magnesium. In both grades the impurity content is low, the maximum being 0.004 per cent manganese, 0.005 iron, 0.025 nitrogen and 0.010 aluminum. Such elements as nickel, lithium, boron, sodium and cadmium are extremely minor impurities. Grade 4 contains 98 to 99 per cent calcium, 0.5 to 1.5 per cent magnesium, 1 per cent nitrogen maximum and 0.35 per cent aluminum maximum. Grade 5 is nominally 95 per cent calcium.

Shipments of calcium metal were reported by the Dominion Bureau of Statistics to be 444 tons in 1969, compared with 234 tons in 1968. Exports totalled 362 tons. In addition to magnesium and calcium, Dominion Magnesium Limited produced minor quantities of the following metals: thorium (919 lb), titanium (500 lb), magnesium zirconium master alloy (741 lb), barium (1,867 lb), and strontium (1,027 lb).

Eldorado Nuclear Limited, at Port Hope, Ontario, began the production of zirconium metal and nuclear-grade zirconium-base alloys in 1969, using calcium metal as a reductant.

USES

Because of its chemical activity and relatively low strength, pure calcium and its alloys are not suited for use as structural materials. Calcium is a powerful reducing agent and its main uses are in the metallurgical production industries.

Calcium is employed to reduce refractory metals from their oxides, chlorides, and fluorides. Among the metals which may be reduced are thorium, chromium, titanium, uranium, vanadium, zirconium, and beryllium. As a purifier, calcium removes residual sulphur, phosphorous, and oxygen from steel and other metals, and removes bismuth, antimony and arsenic from lead. Calcium is used as an alloying metal with aluminum, copper, lead, magnesium, and nickel.

In the production of chemicals, calcium acts as a reducing and dehydrating agent, and is used to separate nitrogen from argon.

*Mineral Resources Branch.

TABLE 1

Canadian Calcium Production and Exports, 1968-69

	1968		1969p	
	Pounds	$	Pounds	$
Production (metal)*	468,512	450,946	888,361	925,831
Exports (metal)				
United States	323,600	303,000	662,200	619,000
Belgium and Luxembourg	–	–	22,000	12,000
West Germany	17,600	20,000	13,200	14,000
India	–	–	11,500	18,000
Other countries	12,500	18,000	15,700	20,000
Total	353,700	341,000	724,600	683,000

Source: Dominion Bureau of Statistics.
*Shipments of calcium metal, and calcium metal used in production of calcium alloys.
pPreliminary; –Nil.

TABLE 2

Canadian Calcium Production and Exports, 1960-69

	Production* (pounds)	Exports (pounds)
1960	134,801	74,800e
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	468,512	353,700
1969p	888,361	724,600

Source: Dominion Bureau of Statistics.
*Production for 1960; shipments from 1961.
pPreliminary; eEstimated.

PRICES

The Canadian price in 1969 quoted by Dominion Magnesium Limited, f.o.b. Haley, Ontario ranged from 70 cents a pound for Grade 5 to $3.50 a pound for Grade 1.

TARIFFS

Item No.		Most Favoured Nation Tariff (per cent ad valorem)
CANADA		
92805-1	Calcium metal	15%
UNITED STATES		
632.16	Calcium metal, unwrought	
	On and after Jan. 1, 1969	12%
	On and after Jan. 1, 1970	10%
633.00	Calcium metal, wrought	
	On and after Jan. 1, 1969	14%
	On and after Jan. 1, 1970	12.5%

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 admixed with gypsum 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.

Portland cements are grouped under five types by ASTM (American Society for Testing and Materials)– Type I, general-purpose cement; Type II, moderate-heat cement; Type III, high-early-strength cement; Type IV, low-heat cement; and Type V, high-sulphate resisting cement. Masonry cement is a mixture of portland cement, finely ground limestone or lime and a plasticizer, prepared for use as a mortar for laying bricks, blocks or building stone.

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 rose in 1969 to $13.3 billion from $12.2 billion in 1968, despite a series of work stoppages within the industry and in face of high interest rates. However, cement production at 8,102,899 tons** in 1969 does not reflect a proportionate increase over 1968 production but rather it indicates that less cement was used per dollar value of construction. This is because the volume of construction was less per unit of value and there were fewer projects of the type that would use large amounts of concrete. Price indices for concrete products and ready-mix concrete at the end of 1969 were about 3.8 per cent above those at the end of 1968 and the average hourly earnings in the construction industry increased by $0.48 over the same period.

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

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 four of the nine provinces in which cement is manufactured was lower in 1969 than in 1968, the remainder showed increases. Currently the apparent total capacity of the industry is 14.8 million tons a year, exclusive of three plants which only grind clinker; and including some capacity which could be reactivated only at considerable expense. On a regional basis, producers in the Atlantic area operated at 64 per cent of capacity, western Canadian producers at 62 per cent of capacity, and Ontario and Quebec, which have a greater capacity concentration, operated at 57 and 45 per cent respectively. Capacity will be increased in Quebec by 437,500 tons and in British Columbia by 210,000 tons during 1970.

*Mineral Resources Branch.

**Revised. During 1969 the Canadian cement industry converted shipping units from the 350-lb barrel and 87½-lb bag to the standard 2000-lb ton and 80-lb bag for all portland cement.

TABLE 1

Canada, Cement – Production and Trade, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Production[1]				
Ontario	3,103,849	53,683,873	3,269,284	59,337,443
Quebec	2,391,600	40,012,228	2,390,206	47,377,602
Alberta	832,588	18,072,409	856,544	19,138,991
British Columbia	656,363	13,634,166	852,500	17,878,440
Manitoba	528,522	11,937,900	491,101	11,261,502
Saskatchewan	220,470	6,517,576	270,023	7,970,111
Nova Scotia	..	3,527,140	..	4,164,083
New Brunswick	..	2,695,752	..	2,169,715
Newfoundland	..	1,922,695	..	1,960,000
Total	8,165,805	152,003,739	8,543,622	171,257,887
By type				
Portland	7,879,822	145,741,021	8,230,075	164,233,848
Masonry[2]	285,983	6,262,718	313,547	7,024,039
Total	8,165,805	152,003,739	8,543,622	171,257,887
Exports				
Portland cement				
United States	365,897	6,073,000	634,122	11,364,000
Other countries	609	14,000	86	2,000
Total	366,506	6,087,000	634,208	11,366,000
Cement and concrete basic products				
United States		492,000		1,368,000
Other countries		90,000		87,000
Total		582,000		1,455,000
Imports				
Portland cement, white				
United States	16,336	706,000	17,234	752,000
Belgium and Luxembourg	6,784	209,000	8,537	291,000
Japan	4,192	119,000	3,478	98,000
Britain	1,149	29,000	388	9,000
Other countries	1,664	51,000	–	–
Total	30,125	1,114,000	29,637	1,150,000
Cement, n.e.s.[3]				
Britain	13,321	474,000	9,850	330,000
United States	5,750	340,000	8,502	573,000
France	385	10,000	3,419	99,000
West Germany	1,919	101,000	1,969	108,000
Australia	–	–	19	1,000
Total	21,375	925,000	23,759	1,111,000
Total cement imports	51,500	2,039,000	53,396	2,261,000
Refractory cement and mortars				
United States		1,511,000		1,596,000
Ireland		273,000		462,000
Other countries		53,000		26,000
Total		1,837,000		2,084,000

TABLE 1 (Cont'd)

	1968		1969p	
	Short Tons	$	Short Tons	$
Cement and concrete basic products, n.e.s.				
United States		147,000		166,000
Sweden		1,000		13,000
Other countries		9,000		11,000
Total		157,000		190,000
Cement clinker				
United States	13,773	356,000	15,545	401,000

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.

TABLE 2

Canada, Cement–Production, Trade and Consumption, 1960-69
(short tons)

	Production[1]	Exports[2]	Imports[2]	Apparent Consumption[3]
1960	5,787,225	181,117	22,478	5,628,586
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
1969p	8,543,622	634,208	53,396	7,962,810

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.

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, was established in 1951 and 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 and dropped by about 13 per cent in 1969. The values of building permits issued and of heavy construction awards were reduced in Newfoundland over the same period. Increased markets will depend on the level of activity in the building industry. It is at present unlikely that production of cement will increase greatly in the near future.

Nova Scotia's only cement manufacturing facility was established in 1965 by Canada Cement Company, Limited at Brookfield, a single-kiln, dry process plant incorporating the most modern analytical and control devices. 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 close to the plant. 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 1969 Nova Scotia cement production was up about 18 per cent over the previous year. Housing starts were up in number and the values of heavy construction awards and of building permits issued during the year were also up.

Canada Cement Company also operates a cement manufacturing plant at Havelock, New Brunswick. This plant, built in 1951 and expanded in 1966, by the addition of a second kiln, has a capacity of 350,000 tons a year and ships portland cement in bulk or in bags. Shipments in 1969 were increased 26 per cent over those of 1968 and, as in Nova Scotia, values of heavy construction awards and of building permits in New Brunswick were greater in 1969 than in the previous year.

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 maintained last year's level despite general disruptions caused by labour unrest during 1969. Total cement production in Quebec was slightly less than in 1968 while the industry operated at an average of only 45 per cent of recognized rated capacity.

The Montreal East plant of Canada Cement Company, Limited 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 one 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's Hull operation is on the site where cement was first produced in Canada. From this location areas of the Ottawa Valley are served.

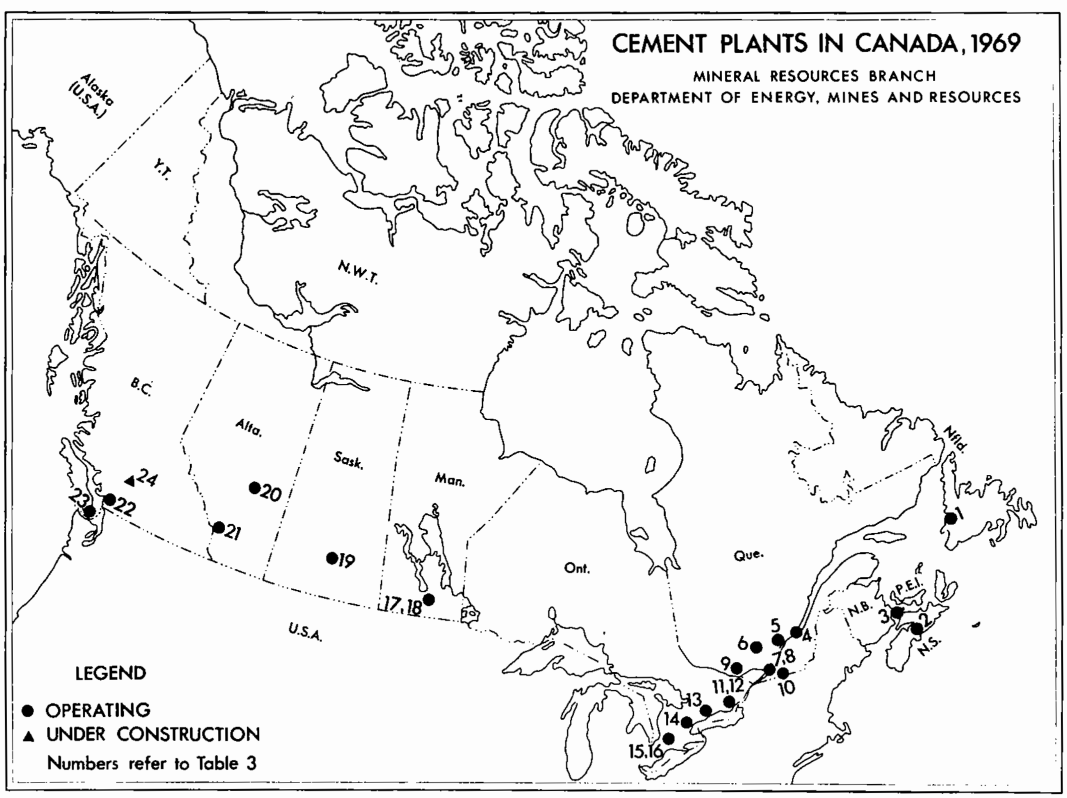


TABLE 3

Cement Plants – Approximate Annual Capacities 1969

Company	Plant Location	Process	Short Tons
Newfoundland			
1. North Star Cement Limited	Corner Brook	dry	175,000
Nova Scotia			
2. Canada Cement Company, Limited	Brookfield	dry	245,000
New Brunswick			
3. Canada Cement Company, Limited	Havelock	dry	300,000
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	437,500*
7. Miron Company Ltd.	St. Michel	dry	1,050,000
8. Canada Cement Company, Limited	Montreal	wet	1,400,000
9. Canada Cement Company, Limited	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 Company, Limited	Belleville	wet	770,000
13. St. Mary's Cement Co., Limited	Bowmanville	wet	385,000
14. St. Lawrence Cement Company	Clarkson	wet/dry	1,750,000
15. Canada Cement Company, Limited	Woodstock	wet	595,000
16. St. Mary's Cement Co., Limited	St. Mary's	wet	752,500
Medusa Products Company of Canada, Limited	Paris		grinding only
Manitoba			
17. Canada Cement Company, Limited	Fort Whyte	wet	922,000
18. Inland Cement Industries Limited	Winnipeg	wet	350,000
Saskatchewan			
19. Inland Cement Industries Limited	Regina	dry	227,500
Canada Cement Company, Limited	Floral		grinding only
Alberta			
20. Inland Cement Industries Limited	Edmonton	wet	577,500
21. Canada Cement Company, Limited	Exshaw	wet	542,500
Canada Cement Company, Limited	Edmonton		grinding only
British Columbia			
22. Lafarge Canada Ltd.	Lulu Island	wet	612,500
23. Ocean Cement Limited	Bamberton	wet	840,000
24. Lafarge Canada Ltd.	Kamloops	dry	210,000**
Total Capacity (56 kilns)			14,767,000

Source: Published data.
*Adding 437,500 tons capacity (2 kilns) in 1970.
**Not included in total – onstream early 1970.

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

TABLE 4

World Production of Cement
(thousand short tons)

	1958	1968	Production increase %
USSR	36,713	96,397	163
United States	61,354	74,700	22
Japan	16,518	52,890	102
West Germany	21,374	36,466	71
Italy	14,135	32,539	130
France	14,786	28,061	89
Britain	13,063	19,632	50
Spain	5,864	16,635	184
India	6,819	13,154	93
Poland	5,576	12,779	129
China	10,251	9,915	−3
East Germany	3,922	8,318	112
Canada	6,153	8,166	33
Czechoslovakia	4,530	7,069	56
Other countries	68,484	144,511	111
Total	289,542	561,232	94 Avg.

Source: U.S. Bureau of Mines Minerals Yearbook Preprint 1968.

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. Such a merger would make the surviving company one of the largest cement producers in North America with 11 plants and an annual capacity of 6.4 million tons. 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.

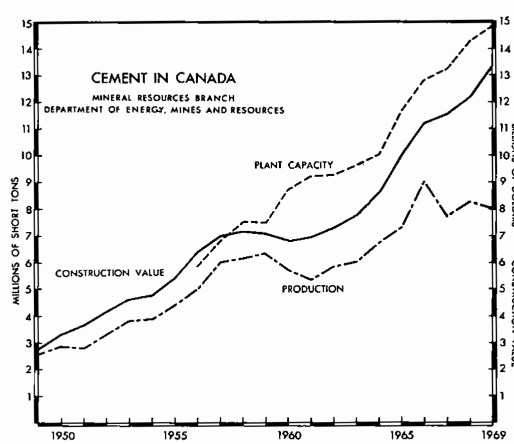
Independent Cement Inc. began construction of its cement manufacturing plant at Joliette, Quebec, in 1965 and went on stream in the fall of 1966 with a two-kiln operation capable of producing about 435,000 tons a year. A third kiln, adding about 220,000 tons a year to plant capacity was scheduled to start up early in 1970 and later in the same year 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. Type I, high early strength and masonry cements are produced.

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 were lower during 1969 in Ontario as were dwelling starts. The value of building permits issued, however, increased over that of 1968. 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 1969 the company replaced production equipment in the quarry with larger and more efficient trucking and loading units. A new bulk cement transfer system to service the boat loading silos was also installed. The company reported its cement sales in Ontario in 1969 as the highest in its history.

The Belleville plant of Canada Cement Company is one of the original operations acquired by the company in 1909. The cement manufacturing equipment has been replaced over the years and the three-kiln, wet process now has an annual capacity of about 770,000 tons. Deep water docking facilities permit both shipping and receiving bulk cargoes. Gypsum is brought in by boat from Nova Scotia, coal from United States and finished cement is shipped to Great Lakes and St. Lawrence Seaway ports. The plant is also served by highway and rail transportation.

Canada Cement operates a second 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 a 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 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. Mary's Cement Co., 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 initially 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 62 per cent of rated capacity during 1969 despite work stoppages in the construction industry. The value of heavy construction awards rose by 18 per cent while the value of building permits rose by about 4 per cent over 1968 totals for the western region. The increase in heavy construction activity was totally in British Columbia while the other three provinces showed declines. The value of building permits issued increased in three provinces but declined in Saskatchewan.

Canada Cement Company, Limited, has operated its plant at Fort Whyte, near Winnipeg, Manitoba, since 1911. 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, Canada Cement has operated a plant 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, 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 one million tons a year. A limestone quarry at Mafeking, Manitoba, near the Manitoba – Saskatchewan border supplies limestone to the Winnipeg and Regina plants while the Edmonton plant is supplied from Cadomin, Alberta. 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.

Lafarge Canada Ltd. produces cement at Richmond on Lulu Island near Vancouver, British Columbia, from 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 is being constructed at Kamloops, British Columbia, at a cost of $12 million. With the proposed merger of Lafarge with Canada Cement Company, Limited, these two plants will serve the west coast markets, an area where Canada Cement had no prior influence.

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. During 1969 additional storage silos were constructed at Bamberton to enable servicing a new export contract and an additional 1,750 hp finish mill is scheduled for installation.

TABLE 5

World Cement Production Per Capita

Country	Pounds of cement 1958	Pounds of cement 1968	Increase %
Belgium	987	1,360	37
West Germany	821	1,257	53
Italy	576	1,233	114
France	651	1,116	71
Japan	360	1,046	190
Spain	393	1,019	159
Czechoslovakia	672	984	46
USSR	348	810	133
Canada	720	775	7
United States	701	742	6

TABLE 6

Canada, Destination of Domestic Cement Shipments*, 1969
(short tons)

Ontario	3,011,842
Quebec	1,786,130
Manitoba, Saskatchewan, Alberta and British Columbia	2,325,483
Newfoundland, Prince Edward Island, Nova Scotia and New Brunswick	484,805
Yukon and Northwest Territories	14,329
Canada, total	7,622,589
Exports	506,530
Total shipments	8,129,119

Source: Dominion Bureau of Statistics.
* Special Compilation. Direct sales from producing plants.

WORLD REVIEW

Cement is produced in 107 countries on 6 continents. Because most cement is used to make concrete for construction purposes, both annual production and changes in production capacity are influenced by trends in the construction industry. Construction activity is a direct reflection of the rate of development of a country. When industrial expansion is forecast, construction materials are in demand to provide the necessary facilities and infrastructure to accommodate new industry. World production of cement in 1968 was 561,232,000 tons, an increase of 6.1 per cent over 1967.

EUROPE

About 56 per cent of world cement production in 1968 originated in Europe and of that amount about 55 per cent was from OECD member countries (Organization for Economic Co-operation and Development) which in total showed an increase over 1967 output of 6.3 per cent. Of 27 European countries from which production data is either available or is estimated, 24 produce more than 1 million tons of cement a year.

Spain and Italy showed particularly large increases in production in 1968. Italy and France each added about 2 million metric tons to their production capacity during 1968 and Turkey added 1.3 million metric tons. A new dry-process cement plant rated at 2 million metric tons is being built in Hungary for start up in 1970. At Split, Yugoslavia, a 1,200-tons-a-day plant was under construction during 1969. Poland is planning to establish one new cement plant annually to cope with the domestic and export demand for cement. Output of cement in Poland rose by 4.1 per cent in 1968 to 11.6 million metric tons and projections indicate a target of 18 million metric tons for 1975.

ASIA

Asian countries accounted for about 20 per cent of the reported 1968 world production; only 13 of 29 countries produced in excess of 1 million tons. In Japan, production rose by 11.7 per cent while new capacity increased by 3 per cent as that country strengthened its hold on third place in world production. 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. Over a 10-year period cement production in India has shown a 93 per cent increase. Capacity of individual plants has grown and 1 million ton plants are now planned. By the end of 1971, installed capacity is expected to be 25 million tons. Marketing of cement is done through the state-owned Cement Corporation of India.

Production of cement in mainland China increased by 12.5 per cent in 1968 although over a 10-year period it has decreased by 3 per cent. Taiwan cement production has shown great percentage increases as the industry was expanded to meet an unprecedented demand for cement, especially in the export market area consisting of much of southeast Asia.

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. Production has generally increased from year to year and a 22 per cent gain was indicated over the 10-year period 1958-1968. A slight drop in production was recorded in 1967. In 1968 North American produced cement amounted to 17 per cent of recorded world production.

SOUTH AMERICA

In 1968, at 21.7 million tons, 10 South American countries accounted for 4 per cent of world cement production, six countries producing more than 1 million metric tons each. In Brazil, the largest single producer, cement companies underwent dramatic expansion. Thirty plants were operated, eight new plants were under construction and six more were being planned. Argentina, Venezuela and Colombia also added to their productive capacities although not to such a large degree.

AFRICA

Of 23 countries producing cement in Africa only three produce in excess of 1 million tons a year–South Africa, United Arab Republic and Morocco. White's South African Portland Cement Company Ltd. is proceeding with an expansion at its Lichtenburg plant which will make it the largest plant of its kind in the southern hemisphere, capable of an annual output of 1.5 million metric tons of cement. Total African cement production accounts for about 2 per cent of world production.

TABLE 7

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

Commodity	1967	1968
Shale	443,975	485,981
Limestone	11,058,249	10,780,377
Gypsum	372,128	346,361
Sand	293,189	309,118
Clay	1,146,172	1,164,894
Iron Oxide	71,271	67,253

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 and water transportation to a distribution system could extend a plant's market area even farther. Because raw materials for cement manufacture are available in nearly all areas, most countries can supply their own cement requirements if the market volume warrants a plant. Few countries 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. During 1969 Canadian and United States producers were eyeing each others markets in the Great Lakes area where water transportation and a distribution system can be utilized and where construction activity continues to increase.

Canadian market areas are reflected in the distribution of shipments from Canadian producers, shown in Table 6.

Although cement is mainly used in the construction industry, significant amounts are used in the mining industry to consolidate backfill where such mining methods are employed. 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.

Company mergers, continued diversification and vertical integration by cement producers will eventually result in the write-off of some comparatively inefficient production capacity as the emphasis on a cement-concrete industry increases.

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.

SPECIFICATIONS

Portland cement used in Canada must 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 must conform to the CSA Standard A8-1956. 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 1968 amounted to $18.61 per ton. This increased to $20.05 in 1969 and ranged from a high of $29.52 per ton for Saskatchewan shipments to a low of $18.15 per ton for Ontario shipments.

TABLE 8

Canada – Production of Concrete Products

	Unit	1968	1969p
Concrete bricks	(no.)	88,989,498	100,523,503
Concrete blocks (except chimney blocks)			
Gravel	(no.)	159,372,311	171,210,760
Cinder	(no.)	4,211,273	*
Other	(no.)	45,771,397	47,982,546
Concrete drain pipe, sewer pipe, water pipe and culvert tile	(ton)	923,290	1,010,614
Concrete, ready mix	(cu.yd.)	14,030,936	13,844,831

Source: Dominion Bureau of Statistics.
* Not now available, included under "other".

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Portland and other hydraulic cement, n.o.p; cement-clinker			
Jan. 1 to June 3, 1969 per 100 lbs	1½¢	3¢	6¢
effective June 4, 1969 " " "	free	free	6¢
White, non-staining Portland cement			
Jan. 1 to June 3, 1969-per 100 lbs	4½¢	6¢	8¢
effective June 4, 1969 " " "	4¢	4¢	8¢

UNITED STATES	
White, non-staining Portland cement	
On and after Jan. 1, 1969	2¢ per 100 lbs incl. weight of container
On and after Jan. 1, 1970	2¢ per 100 lbs incl. weight of container
Other cement and cement clinker	
On and after Jan. 1, 1969	1.3¢ per 100 lbs incl. weight of container
On and after Jan. 1, 1970	0.9¢ per lbs incl. weight of container
Hydraulic cement concrete	
On and after Jan. 1, 1969	3%
On and after Jan. 1, 1970	2%
Other concrete mixes	
On and after Jan. 1, 1969	12%
On and after Jan. 1, 1970	10%

Note: Further tariff reductions for the above United States cement items will be in effect Jan. 1, 1971 and Jan. 1, 1972.

Chromium

G.P. WIGLE*

Canada's imports of chromium in ores and concentrates in 1969 were 41,924 tons (Cr content) valued at $2,889,000 compared with 22,401 tons valued at $1,735,000 in 1968. Imports of ferrochromium were 25,123 tons valued at $5,812,000 compared with 15,045 tons valued at $3,639,000 in 1968. Chromite ($FeOCr_2O_3$) consumption was 77,075 tons in 1968 and 70,549 tons in 1967. Canadian companies manufacturing refractories as a primary product used 55,205 tons of chromite valued at $2.34 million in 1968 compared with 49,104 tons valued at $2.07 million in 1967.

Canada is not a producer of chromite ($FeOCr_2O_3$) which is the principal ore mineral of chromium. During periods of emergency, it has been mined in the Eastern Townships of Quebec where many small, irregular, and disseminated occurrences are found. Chromite discoveries, of no present commercial value, are also known in Manitoba, Newfoundland and British Columbia. The Bird River deposits in the Lac du Bonnet district of Manitoba are large low-grade occurrences averaging about 26 per cent Cr_2O_3 and 12 per cent iron with a low chromium-to-iron ratio of about 1.4 to 1.

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 pigments, dyes, leather tanning, electroplating and fungicides.

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; Crucible Steel of 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.

CHROMIUM PRODUCTION AND TRADE

Estimated world mine production of chromite, not including Rhodesia, was 4.94 million tons in 1969 compared with 4.95 million tons in 1968. The Republic of South Africa, USSR, Turkey and the Philippines supplied the major part of the world's chromite. The United Nations embargo on chromium ore from Rhodesia curtailed supplies from that country, previously a principal supplier of high-grade chromite. The price of Russian chromite, 54-56 per cent Cr_2O_3, 4:1 chromium to iron ratio, was published at U.S. $30.50 – $33 in 1967, U.S. $36.50 – $40 in 1968, and U.S. $45.20 – $49.20 on December 29, 1969. Russia supplied 56 per cent of United States imports of highgrade (over 46 per cent Cr_2O_3) chromite in 1969.

*Mineral Resources Branch.

TABLE 1

Canada, Chromium Trade and Consumption, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Imports				
Chromium in ores and concentrates				
United States	9,688	861,000	12,924	1,068,000
Philippines	4,099	333,000	9,139	635,000
Turkey	522	51,000	7,464	417,000
USSR	–	–	6,495	381,000
Republic of South Africa	3,826	156,000	3,095	153,000
Cyprus	3,276	215,000	2,125	153,000
Other countries	990	119,000	682	82,000
Total	22,401	1,735,000	41,924	2,889,000
Ferrochromium				
Republic of South Africa	11,686	2,675,000	21,604	4,713,000
United States	2,169	622,000	2,756	885,000
Norway	125	30,000	447	122,000
Japan	12	2,000	121	21,000
Other countries	1,053	310,000	195	71,000
Total	15,045	3,639,000	25,123	5,812,000
Chromic acid[1] (chromium trioxide)				
United States	143	92,000	..	..
Britain	31	19,000	..	..
Japan	16	8,000	..	..
Other countries	32	12,000	..	..
Total	222	131,000	..	..
Chromium sulphates, basic, for tanning				
United States	548	134,000	2,493	247,000
Japan	133	22,000	347	57,000
Britain	268	50,000	130	24,000
Other countries	102	15,000	30	4,000
Total	1,051	221,000	3,000	332,000
Chromium oxides and hydroxides[2]				
Britain	..	..	178	116,000
Japan	..	..	141	73,000
United States	..	..	87	70,000
West Germany	..	..	10	8,000
Total	..	..	416	267,000
Chrome dyestuffs				
Britain	21	34,000	24	45,000
Japan	37	40,000	24	29,000
France	6	17,000	18	38,000
Switzerland	15	67,000	15	49,000
West Germany	15	39,000	13	38,000
United States	15	39,000	11	32,000
Other countries	6	10,000	6	11,000
Total	115	246,000	111	243,000
Consumption				
Chromite	77,075		..	

Source: Dominion Bureau of Statistics.

[1]Included under new class "chromium oxides and hydroxides", effective Jan. 1, 1969. [2]New class effective, Jan. 1, 1969.

pPreliminary; – Nil; . . Not available.

TABLE 2

Canada, Chromium Trade and Consumption, 1960-69
(short tons)

	Imports		Exports	Consumption[2]	
	Chromite[1]	Ferro-chromium[2]	Ferro-chromium[2]	Chromite	Ferro-chromium
1960	59,023	..	4,611	54,331	8,827
1961	71,268	..	1,642	52,134	8,046
1962	71,969	..	6,602	70,342	9,452
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
1969p	41,924	25,123	..	..	..

Source: Dominion Bureau of Statistics.
[1]To 1963, gross weight; from 1964, chromium content. [2]Gross weight.
pPreliminary; .. Not available; – Nil.

TABLE 3

World Production of Chromium Ore, 1967-69
(thousands of short tons)

	1967	1968	1969e
USSRe	1,731	1,820	1,800
Republic of South Africa	1,267	1,271	1,240
Turkey	409	416r	460
Philippines	463	446	490
Albania	360	360e	360
India	125r	227	230
Irane	165	176	170
Yugoslavia	52	52e	50
Finland	7	40	40
Sudane	20	33	30
Japan	50	31	30
Pakistan	29	29	30
Brazil	8	15	10
New Caledonia	2	..	..
Total	4,688	4,946	4,940

Sources: U.S. Bureau of Mines, Minerals Yearbook 1968; company reports, author's revisions indicated.
eEstimated; rRevised; .. Not available.

The United States is the principal importer and consumer of chromite and relies exclusively on imported supplies. United States imports of chromite in 1969 were 1,106,424 tons and consumption was 1,405,046 tons compared with 1,084,651 tons imported and 1,315,853 tons consumed in 1967*. The metallurgical industry used approximately 61 per cent of 1968 United States consumption, the refractory industry 24 per cent, and the chemical industry 15 per cent. The largest supplier to the United States was the Republic of South Africa followed by the USSR, the Philippines and Turkey.

Chromite production in the Republic of South Africa was 618,649 tons in the first 6 months of 1969 compared with 632,953 tons in the first half of 1968. Local sales of chromite in South Africa, principally to supply the growing domestic ferrochromium industry, increased to 149,055 tons during January to June from 142,576 tons in the same period of 1968. Exports of chrome sands, a relatively new product prepared for use in foundry moulds, totalled 17,531 tons during January to June 1968**.

CHROMIUM ORE AND ITS USES

Chromite is the only commercially important ore-mineral of chromium. The theoretical composition of chromite is $FeO.Cr_2O_3$ with a chromic oxide (Cr_2O_3) content of 68 per cent. In ore occurrences, most chromite is a combination of oxides of chromium and iron with varying amounts of magnesium and aluminum and has the general formula (Fe,Mg) $O(Cr,Al,Fe)_2O_3$. Chromite seldom contains more than 50 to 55 per cent chromic oxide but Russia does, however, produce high-grade chromite containing 54 to 56 per cent Cr_2O_3. Representative analyses of chromium ores are listed in Table 5.

Variations in chemical and physical properties are the basis for grading the ores into three main groups: metallurgical, refractory and chemical grades. The metallurgical industry of the United States, during the years 1963 to 1967 inclusive, used about 58 per cent of United States chromite consumption; the refractory industry 28 per cent and the chemical industry about 14 per cent.

METALLURGICAL CHROMITE

In 1968, 97 per cent of the chromite used by the United States metallurgical industry averaged 50.1 per cent Cr_2O_3. Eighty-five per cent of this metallurgical-grade ore had a chromium-to-iron ratio of 3:1 or more; 12 per cent was between 3:1 and 2:1; and only 3 per cent was less than 2:1.

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

*U.S. Bureau of Mines, Mineral Industry Surveys.
**Minerals – A Report for the Republic of South Africa, January-June 1969.

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	
Year	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

Source: Preprint from 1968 U.S. Bureau of Mines Minerals Yearbook.

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 open-top submerged-arc electric furnaces. 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 as a refractory because of its high melting point, moderate thermal expansion, and its chemically neutral nature. 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 silica and iron content should be not over 10 and 5 per cent respectively; chromic oxide (Cr_2O_3) and alumina (Al_2O_3) combined should be not less than 57 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. Chromite refractories have a chemically neutral character and are used extensively for the lining of furnaces and hot-metal ladles. 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

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 FeO and 3 per cent silica.

Most chromium chemicals are derived from sodium dichromate manufactured from chromite. Chromium chemicals are used in pigments, leather tanning, electroplating, 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 industry use.

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	.08	5.6	2.4 :1
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.

PRICES

Chrome prices in United States, as published by *Metals Week*, December 29, 1969, were:

Chrome ore

per long ton, dry basic, subject to penalties if guarantees not met, f.o.b. cars Atlantic ports.

Transvaal	
44% Cr_2O_3, no ratio	\$19 - \$21.50
Turkish	
48% Cr_2O_3, 3 to 1 ratio	\$37.50 / \$38.50
Russian	
48% Cr_2O_3, 4 to 1 ratio	\$40 - \$42
54-56% Cr_2O_3, 4 to 1 ratio	\$45.20 - \$49.20

Note: 1970 prices on Turkish and Transvaal ore are \$10 higher.

Chromium metal	
- electrolytic, 99.8%, f.o.b. shipping point, per lb	101¢
- vacuum melting (pellets) per lb	104¢
- 9% C per lb	142¢
- aluminothermic, delivered, per lb	
98.5%	96¢
99.25%	99¢
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¢
Charge chrome, 63-71% Cr, 3% Si max., 0.04% S, 4.5-6% C	18.0¢
Imported charge chrome, delivered	19.25 - 19.50¢
Blocking chrome 10-14% Si	20.6¢
14-17% Si	21.6¢

Chromsol, 62% Cr, 5% Mn, 1.5% Si 5.25% C, per lb alloy, f.o.b. shipping point	12.65¢	Imported low carbon, delivered	
HS Chrome .66	29.80¢	0.05% C	29-29.5¢
Low Carbon		0.025% C	30-30.5¢
67-73% Cr, 0.025% C	28.6¢	Ferrochrome silicon, per lb of alloy	
67-71% Cr, 0.05% C	27.6¢	36/40, 0.05% C	13.50¢
Simplex "L", 0.01% Max C	28.6¢	40/43, 0.05% C	14.35¢
Simplex, 0.025%, Max C	27.6¢	41/41, 0.05% C	13.90¢
		"L", 0.02% C	14.80¢

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, 1970	free		
	with the exception of the following:			
	Chromic oxide			
	Chromium trioxide			
92838-8	Chromium potassium sulphate	free	free	10%
92838-9	Chromium sulphate, basic	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, 1969		8%	
	" " " Jan. 1, 1970		7%	
633.00	Chromium metal, wrought			
	On and after Jan. 1, 1969		14%	
	" " " Jan. 1, 1970		12.5%	
532.84	Chromium alloys, unwrought			
	On and after Jan. 1, 1969		14%	
	" " " Jan. 1, 1970		12.5%	
	Ferrochromium			
607.30	Not containing over 3% by weight of carbon			
	On and after Jan. 1, 1969		6.5%	
	" " " Jan. 1, 1970		5.5%	
607.31	Containing over 3% by weight of carbon		0.625¢ per lb on Cr content	

416.45	Chromic acid	
	On and after Jan. 1, 1969	10%
	" " " Jan. 1, 1970	8.5%
422.92	Chromium carbide	
	On and after Jan. 1, 1969	10%
	" " " Jan. 1, 1970	8.5%
531.21	Chrome brick	
	On and after Jan. 1, 1969	20%
	" " " Jan. 1, 1970	17%
473.10	Chrome colours	
473.20	On and after Jan. 1, 1969	8%
	" " " Jan. 1, 1970	7%
420.98	Chromate and dichromate	
	On and after Jan. 1, 1969	1.4¢ per lb
	" " " Jan. 1, 1970	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 (1969), TC Publication 272.

Clays and Clay Products

J.G. BRADY*

Canada is deficient in high-quality clays such as kaolins, fireclays and ball clays and consequently a substantial proportion of these materials is imported. Common clays and shales that are suitable for brick and tile occur in most regions of Canada and are used extensively by the ceramic industry. The central provinces of 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 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. 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 1969 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 1966, 1967 and 1968. Some prices and tariffs are shown at the end of the review.

One hundred and thirty plants manufactured clay products using domestic or imported clays. Twenty of this total includes 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 plants make up the largest group, where 61 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.

*Mineral Processing Division, Mines Branch.

Five 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 fireclay and ball clay consumed are available. About 2.5 million tons of domestic clay are consumed in the products included in Table 1.

TABLE 1

Canada, Production of Clay and Clay Products from Domestic Sources, 1968-69

		1968		1969P	
		Quantities	$	Quantities	$
Production, shipments from domestic sources					
By main classes					
Clays, including bentonite			1,291,413		1,300,000e
Clay products from					
Common clay			37,966,485		40,761,892
Stoneware clay			6,952,813		6,125,151
Fireclay			904,759		900,000e
Other			1,605,974		1,908,308
Total			48,721,444		50,995,351
Byproducts					
Clay					
Fireclay	s.t.	4,238	70,381		
Other clay, including bentonite		..	1,221,032		
Fireclay blocks and shapes		..	14,284		
Firebrick	No.	6,209,950	890,475		
Brick					
Soft mud process					
Face	No.	18,540,031	1,043,607		
Common	No.	2,225,315	54,902		
Stiff mud process					
Face	No.	413,563,333	21,588,834		
Common	No.	21,720,819	497,765		
Dry process					
Face	No.	74,769,995	4,872,708		
Common	No.	778,837	15,918		
Fancy or ornamental	No.	25,569,288	1,743,811		
Sewer brick	No.	2,722,000	118,203		
Paving brick	No.	419,390	44,108		
Structural tile	s.t.	43,332	1,085,076		
Floor tile	sq.ft.	160,000	80,646		
Drain tile	No.	86,822,762	6,820,907		
Sewer pipe	ft.	6,969,049	3,857,480		
Flue linings	ft.	1,796,140	1,166,533		
Pottery		..	1,928,800		
Other products		..	1,605,974		
Total			48,721,444		50,995,351

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

TABLE 2

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

		1968		1969p	
		Quantities	$	Quantities	$
Imports					
Clay, clay products and refractories					
Bentonite	s.t.	307,699	2,826,000	293,972	3,110,000
Drilling mud	s.t.	8,141	884,000	7,988	1,351,000
China clay, ground or unground	s.t.	180,296	4,325,000	229,965	5,312,000
Fireclay, ground or unground	s.t.	50,146	744,000	69,481	958,000
Clays, ground or unground	s.t.	59,070	990,000	73,608	1,014,000
Clays and earth, activated	s.t.	6,205	953,000	7,609	1,237,000
Brick, building					
glazed	M	2,349	177,000	2,702	215,000
n.e.s.	M	19,863	1,220,000	20,819	1,329,000
Building blocks	M	..	298,000	..	289,000
Earthenware tile					
under 2-1/2 x 2-1/2"	sq.ft.	12,325,694	2,587,000	18,402,915	4,490,000
over 2-1/2 x 2-1/2"	sq.ft.	13,041,300	2,365,000	17,164,990	3,082,000
Claybrick, blocks, and tiles, n.e.s.	M	..	110,000	..	145,000
Firebrick					
Alumina	M	3,520	3,450,000	3,593	4,369,000
Chrome	M	1,066	695,000	543	674,000
Magnesite	M	749	2,135,000	427	1,820,000
Silica	M	1,153	977,000	949	881,000
n.e.s.	M	37,909	11,579,000	38,763	11,809,000
Refractory cements and mortars		..	1,837,000	..	2,084,000
Pottery settings and firing supplies		..	272,000	..	302,000
Crude refractory materials	s.t.	5,312	450,000	6,189	519,000
Grog (refractory scrap)	s.t.	15,690	635,000	15,787	649,000
Refractories, n.e.s.		..	1,490,000	..	1,500,000
Acid-proof brick		..	228,000	..	236,000
Tableware, ceramic		..	21,233,000		25,003,000
Porcelain insulating fittings		..	2,971,000	..	3,951,000
Total clay products and refractories			65,431,000		76,329,000
By main countries					
United States			36,041,000		38,990,000
Britain			17,905,000		20,801,000
Japan			6,849,000		9,807,000
West Germany			1,409,000		1,738,000
France			472,000		883,000
Ireland			332,000		615,000
Italy			305,000		565,000
Hong Kong			726,000		375,000
East Germany			164,000		203,000
Denmark			76,000		202,000
Other countries			1,152,000		2,150,000
Total			65,431,000		76,329,000

TABLE 2 (Cont'd)

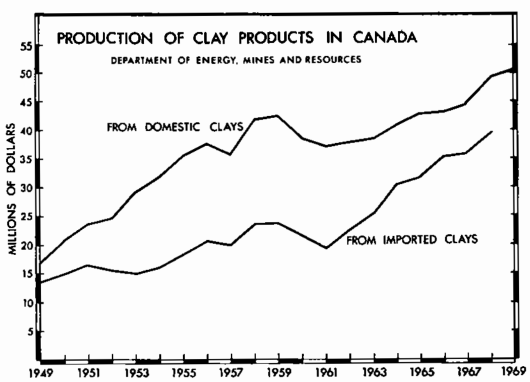
		1968		1969P	
		Quantities	$	Quantities	$
Exports					
Clays, clay products and refractories					
Clay, ground and unground	s.t.	732	43,000	832	33,000
Crude refractory materials	s.t.	900,384	1,476,000	1,121,596	1,493,000
Building brick, clay	M	15,412	1,545,000	12,821	1,596,000
Clay bricks, block tiles n.e.s.		..	383,000	..	341,000
Firebrick and similar shapes		..	5,341,000	..	6,804,000
Refractories, n.e.s.		..	313,000	..	910,000
High tension insulators and fittings		..	1,134,000	..	900,000
Tableware		..	1,589,000		1,950,000
Total clays, clay products and refractories			11,824,000		14,027,000
By main countries					
United States			8,432,000		10,042,000
Mexico			478,000		542,000
Chile			526,000		321,000
Australia			145,000		235,000
Sweden			98,000		212,000
Puerto Rico			107,000		193,000
Bahamas			72,000		188,000
Ireland			1,000		178,000
Greece			158,000		171,000
Italy			106,000		158,000
Other countries			1,701,000		1,787,000
Total			11,824,000		14,027,000

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

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,

TABLE 3

Canada, Shipments of Clay Products Produced from Imported Clays*, 1966-68

		1966		1967		1968P	
		Quantities	$	Quantities	$	Quantities	$
Glazed floor or wall tile	sq.ft.	11,566,676	5,575,000	12,695,874	5,360,000	11,878,031	5,154,000
Electrical porcelains		..	12,259,000	..	12,350,000	..	12,310,000
Pottery, art and decorative ware		..	2,976,000	..	2,015,000	..	2,304,000
Pottery, tableware		..	1,534,000	..	1,638,000	..	1,506,000
All other products		..	13,734,000	..	14,361,000	..	18,656,000
Total			36,078,000		35,724,000		39,930,000

Source: Dominion Bureau of Statistics.
*Does not include refractories.
. .Not available; PPreliminary.

TABLE 4

Canada, Shipments of Refractories

		1966		1967		1968	
		Quantities	$	Quantities	$	Quantities	$
Fireclay blocks and shapes		..	98,183	..	17,729		
Firebrick	M	4,836	669,011	6,709	851,676	140,902*s.t.	19,971,000
Other firebrick and shapes*		..	15,942,806	..	16,686,595		
Cements, mortars, castables and other refractory products		..	12,894,000	..	14,449,000	52,653 s.t.	8,437,000

Source: Dominion Bureau of Statistics.
*Includes rigid firebrick, stove linings, and other shapes made from imported clay, chrome ore, magnesite, etc. Silicabrick not included.
. .Not available; M=1,000.

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. 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 fireclay 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 have also been reported near Kergwenan. Some clay exploration was carried out by two companies during the year.

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. The possibility of there being a larger-than-suspected tonnage of kaolin at the Brébeuf deposit is being investigated by a commercial clay company.

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 have undertaken a large development program on deposits along the Missinaibi River, north of Hearst. This company has found substantial quantities of kaolin-silica mixtures and exploration was continued. The distance from markets, and the difficult terrain and climate of the area have hindered development.

TABLE 5

Canada, Clay and Clay Products Production, and Trade, 1960-1969
($ millions)

	Production				
	Domestic Clays[1]	Imported Clays[2]	Total	Imports[3]	Exports[3]
1960	38.2	21.5	59.7	46.7	5.3
1961	37.0	19.4	56.4	47.1	5.8
1962	37.8	22.5	60.3	48.3	5.4
1963	38.2	25.2	63.4	43.9	7.6
1964	40.8	30.2	71.0	54.7	8.9
1965	42.8	31.4	74.2	59.4	10.3
1966	43.0	36.1r	79.1r	71.7	12.6
1967	44.3	35.7r	80.0r	70.7	13.7
1968	48.7	39.9	96.1	65.4	11.8
1969p	50.9	..	..	76.3	14.0

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; from 1961 does not include refractories. [3]Includes refractories.
pPreliminary; ..Not available; rRevised.

TABLE 6

Canada, Consumption (Available Data) of China Clay by Industries, 1967-68
(short tons)

	1967	1968
Ceramic products	14,354	15,633
Paint and varnish	2,848	3,189
Paper and paper products	122,475	121,768
Rubber and linoleum	9,992	8,796
Other products*	18,384	14,861
Total	168,053	164,247

Source: Dominion Bureau of Statistics.
*Includes miscellaneous chemicals, cleaners, detergents, soaps, medicinals and pharmaceuticals and other miscellaneous products.

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 terfere 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 fireclays. 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.

FIRECLAY

Canadian fireclays are used principally for the manufacture of medium and high-duty firebrick and refractory specialties. High-duty refractories require raw materials having a PCE (pyrometric cone equivalent) of about 31½ to 32½ (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 fireclays 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 fireclays occur in the Whitemud formation in Saskatchewan. At a large plant at Claybank, fireclays from nearby pits are used for the manufacture of medium and high-duty refractories and refractory specialties. Good-quality fireclays 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 fireclay from the Sumas deposit is exported to the United States, and a small quantity is used at plants in Vancouver.

Fireclay 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. Preliminary work has been done on their use for the 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 fireclay. These industrial provinces import most of their requirements from the United States.

STONEWARE CLAY

Stoneware clays are similar to low-grade plastic fireclays. They are used extensively in sewer pipe, flue liners, facing brick, pottery, stoneware crocks and jugs and chemical stoneware. As in fireclays 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 fireclays 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 fireclays. 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, fireclays and ball clays. Since 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 29, 1969, United States clay prices were as follows:

Ball clay	
Domestic, air floated, bags, car lots, f.o.b. Atlantic ports – per ton	$49.00 – $50.75
Domestic, crushed, moisture-repellant, bulk, car lots, f.o.b. Tennessee – per ton	$ 8.00 – $11.25
Imported, air floated bags, car lots, f.o.b. Atlantic ports – per ton	$49.50 – $50.75
Lump, bulk, f.o.b. Atlantic ports – per ton	$31.50 – $37.50
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

Item No.			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								
29500-1	Clays, 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.							
UNITED STATES								
521.41	China clay or kaolin	per l.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	"	81.25¢	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%	0.08¢ per lb + 10%	0.07¢ per lb + 8.5%	0.06¢ per lb + 7%	0.05¢ per lb + 6%

Varying tariffs are in effect on clay products.

Coal and Coke

L.P. CHRISMAS*

Although the 1969 Canadian coal production did not indicate a resurgence of the western Canada industry, a dramatic revival of the western Canada coal industry will begin in April 1970. Western Canada coal companies have so far contracted to supply the Japanese steel industry by 1985 with over 180 million long tons of coking coal having an estimated f.o.b. west coast value of $2.5 billion. During 1969, three coal companies, Kaiser Resources Ltd., Cardinal River Coals Ltd. and McIntyre Coal Mines Limited reached final stages of preproduction development and planned full-scale production in early 1970. Capital investment by the coal production and transportation industries to 1972 to serve the coal export market to Japan is expected to surpass $350 million. Based on large resources of high quality coking coal in the west, Canada of course is in an excellent position to supply larger amounts to Japan and in view of the present world shortage of coking coal, other world metallurgical markets as well.

As summarized in Table 1, coal production in 1969 was slightly below that for 1968. Production trends were similar to the previous year. In Nova Scotia, New Brunswick, and Saskatchewan there were decreases while production of Alberta subbituminous coal, and Alberta and British Columbia bituminous coal increased substantially. Exports, principally to Japan, were about 1.4 million tons** similar to 1968 exports, whereas about 17.3 million tons of bituminous coal were imported from the United States for Ontario and Quebec consumers.

The two largest group industrial consumers of coal in Canada are the thermal electric power industry and the iron and steel industries. Approximately 12 million tons or 45 per cent of the estimated 27 million tons of coal consumed in Canada in 1969 were used to generate electricity. During the same period 6.9 million short tons of bituminous coal were carbonized to produce 5.0 million tons of coke.

OUTLOOK FOR THE 1970's

The last two years have seen a remarkable turn of events in the Canadian and world coal industries. Mining companies in all coal resource countries are striving to bring in new coal mines or renovate old mines to meet the growing demand for coal by the thermal electric and iron and steel industries. In Canada, the industry has been most affected by the apparently insatiable demand by the Japanese steel industry for coking coal. Based on contracts finalized to the end of 1969, exports to Japan will approach 5 million long tons in 1970, reach 11 million tons in 1972 and surpass 14 million tons per year by 1975. Expansion of these contracts or signing of additional contracts by new companies are likely as the growth rate of the Japanese steel industry indicates that an additional 30 million tons of coking coal will be needed by 1975 in Japan. At that time Canada will likely rank a fairly close third to the United States and Australia as a supplier of coking coal to Japan. Exemplifying the shortage of supply for metallurgical coal is the long term contracts the Japanese steel companies are prepared to sign at increasingly higher prices.

Coal and coke shortages have been reported by most European countries particularly by France and Italy whose current offshore supplier, the United States, is also having coal shortages. Some of the western Canada producers are evaluating the prospects for coking coal sales in western Europe, the west coast of South America and the United States. To be tenable, such sales would likely be large to take advantage of the economies of scale not only in the mining but in overland and marine bulk transportation of coal. Hence any success in these areas would result in significant expansion in output and of facilities to move these volumes to market.

The long term availability of United States coal in eastern Canada is of concern due to supply problems resulting from the growing demand by the electric

*Mineral Resources Branch.

**The short ton (2,000 pounds) is used throughout unless otherwise noted.

utilities in the United States, the new underground safety regulations which some mines are having difficulty in meeting, and the declining availability of low sulphur coal. These factors along with higher labour and transportation costs have led to higher prices, particularly for the high-quality United States coal. As a result, Ontario coke producers examined the possibility of using coking coal from western Canada. Indeed a shipment of 200,000 tons is planned to be made in 1970. Thus there is a distinct possibility that western Canada coal may at least partially displace imports particularly for carbonization.

TABLE 1

Coal Production, by Types, Provinces and Territories, 1968-69

	1968r		1969p	
	Short Tons	$*	Short Tons	$*
Bituminous				
Nova Scotia	3,131,745	30,412,539	2,621,330	22,149,740
New Brunswick	797,359	7,371,169	701,952	5,699,679
Alberta	950,564	7,478,530	1,231,108	8,394,405
British Columbia and Yukon Territory	889,564	6,466,587	902,432	7,164,377
Total	5,769,232	51,728,825	5,456,822	43,408,201
Subbituminous				
Alberta	2,969,556	5,237,457	3,194,952	5,403,341
Lignite				
Saskatchewan	2,250,219	4,164,841	2,020,105	3,726,698
All types				
Canada Total	10,989,007	61,131,123	10,671,879	52,538,240

Source: Dominion Bureau of Statistics.

pPreliminary; rRevised.

*Coal production values include subvention payments. These payments ceased in April 1968, for Nova Scotia coal.

TABLE 2

Coal–Production, Imports, Exports and Consumption, 1959-69
(short tons)

	Production	Imports	Exports	Reported Consumption
1959	10,513,541	14,236,118	473,768	24,710,787
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	1,447,013	27,317,782
1969	10,671,879	17,347,404	1,377,872	–

Source: Dominion Bureau of Statistics.

– Not available.

TABLE 3

Contracted Western Canada Coal For Japan

Company	Mine Location	Exports Begin	Type of Coal	Estimated Tonnage (long tons)	Estimated Contract Value*	Transportation Route
Coleman Collieries Limited	Coleman, Alberta	April 1967	Mvb	13,300,000 over 15 years	$160,500,000	Via CPR to Port Moody 750 miles
Kaiser Resources Ltd.	Natal, British Columbia	April 1970	Lvb	75,000,000 over 15 years	$1,000,000,000	Via CPR to Roberts Bank 700 miles
Cardinal River Coals Ltd.	Luscar, Alberta	April 1970	Lvb	15,000,000 over 15 years	$200,000,000	Via CNR to Vancouver 700 miles
The Canmore Mines, Limited	Canmore, Alberta	1971	Lvb	3,800,000 over 10 years	$50,000,000	Via CPR to Port Moody 575 miles
McIntyre Coal Mines Limited	Grand Cache, Alberta	1970	Lvb	30,000,000 over 15 years	$450,000,000	Via Alberta Resources Railway and CNR to West Vancouver 690 miles
Fording Coal Limited	Elk River, British Columbia	1972	Mvb	45,000,000	$650,000,000	Via CPR to Roberts Bank 730 miles

*f.o.b. West Coast Ports.

The outlook for coal consumption in Canada depends on the two main industry consumers–thermal power and the iron and steel industries. The amount of coal used to generate electricity has been increasing at the rate of 15 per cent per annum over the last five years and this is expected to continue for the 1970's. In Ontario, where the future of coal-fired power plants depends more on availability of coal supply, competition from alternative energy sources and environmental factors, projections indicate an increase of 8 million tons in the next 10 years. In the four western provinces, forecasts indicate that consumption of coal for thermal power by 1978 will attain 20 million tons per annum.

In Alberta and British Columbia, the coal companies hope to be able to sell the large quantities of coal middlings, that will be available from the beneficiation plants producing specification coals, for use as thermal coal for electricity generation in western Canada and the United States. It is estimated that the tonnage of middlings (about 10,000 Btu/lb) available for thermal power generation is in the order of 20 per cent of the tonnage of metallurgical coal produced. Thus such coal volumes may be anticipated to rise from 1 million tons in 1970 to about 3 million tons in 1975. The opportunities for power intensive industries to locate in the west are considerable.

In order to meet the demand for coal for electrical power in Canada and for export, Canada will need to produce about 33 million tons of coal by 1975 assuming imports will amount to 16 million tons.

PRODUCTION AND MINE DEVELOPMENTS

BRITISH COLUMBIA

The principal coal producing region in British Columbia, the Crowsnest Pass area, has large resources of low and medium volatile bituminous coal that has excellent coking properties. The thick coal-seams, which occur within faulted and disturbed Lower Cretaceous rocks, have been extensively mined since about 1898. In the interior of the province, coal ranging in rank from lignite to medium volatile bituminous occurs in isolated smaller coal-basins.

In the Crowsnest Pass coal area of British Columbia, the coal mining scene in 1969 was dominated by the rapidly progressing developments of Kaiser Resources Ltd. Although Kaiser's production from its Michel colliery remained below one million tons, production will rise sharply in 1970 when coal is strip-mined from the 50 foot thick No. 10 Balmer seam on Harmer Ridge. Annual production initially will be 8 million tons, of which 5 million tons will be exported. This will make it one of the larger if not the largest coal-mines in North America. Kaiser will provide new mining, beneficiation and transportation facilities which in total will cost an estimated $100 million. To indicate what is expected to be generally a standard of operations in large strip mines reference might be made specifically to Kaiser's operation. The overburden will be drilled with rotary rigs using 12 or 15-inch rock bits and after blasting will be removed by two methods. The overburden down to about 100 feet of the coal-seam will be moved by 200-ton diesel-electric trucks which will be loaded by 25-cubic yard shovels. A 54-cubic yard, dragline will remove the remaining overburden and cast it into previously mined areas. It will then deposit the exposed coal on the dragline bench from which it will be loaded by front end loaders and power shovels into 100-ton trucks. The trucks will carry the coal to the breaker station. The scale of Kaiser's operations is illustrated by the size of the preparation plant which is built to handle 1,400 tons of raw coal per hour.

Only a portion of the coal can be mined by surface methods in the Crowsnest Pass area due to the steeply dipping and faulted coal seams in this mountainous area. Therefore Kaiser is studying other possible underground mining methods as longwall mining techniques are extremely difficult or impossible. The company is planning to carry out hydraulic mining on an experimental basis using equipment successfully developed in Japan. Kaiser produced coal during the year from the Michel colliery, which consists of two underground mines, some small strip pits, and a coal preparation plant and a coke oven plant situated on the colliery site. Kaiser's coal was sold to industrial plants and 300,000 tons were shipped to Japan. A large amount of fines was used in the coke plant.

In 1969 Fording Coal Limited, a subsidiary of Canadian Pacific Investments Limited (60 per cent) and Cominco Ltd. (40 per cent), announced the signing of a contract with Japanese interests for 45 million tons of medium volatile coking coal over a 15-year period. The property is situated 35 miles north of Natal along the Fording River valley. An open-pit mine is planned for operation in 1972 and the company announced that CPR would build a 35-mile long spur line into the property. Cominco will develop and operate the mine under a management agreement with Fording Coal. An estimated $80 million will be invested to bring this mine into production.

Canpac Minerals Limited, the exploration subsidiary for Canadian Pacific companies will continue to evaluate its vast coal holdings in western Canada. In December 1969 Cascade Pipe Line Limited, another wholly-owned Canadian Pacific subsidiary, applied for a permit to build a $200 million pipeline to carry coal 460 miles from southeastern British Columbia to

Roberts Bank. This company is now conducting feasibility studies.

In 1969, Forestburg Collieries Limited continued to mine on a small scale, the remaining coal at the Bulkley Valley Colliery near Smithers in central British Columbia.

During the year exploration for coal was widespread spurred by the opportunities for further markets. Companies were active in the following principal areas: Groundhog, Bowron River, Pine Pass, Tulameen, Merritt, Crowsnest, Flathead River and Upper Elk River.

ALBERTA

Most of the Province of Alberta's coal resources are of bituminous and subbituminous rank, but coals of all ranks from lignite to anthracite are present. Resources of subbituminous coal occur in the Plains Region whereas bituminous coal, much of which is of excellent 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 per year. In 1969 Alberta coal production reached 4.4 million tons, the highest in 14 years.

On the Alberta side of the Crownest Pass, Coleman Collieries Limited produced coking coal from its Vicary Creek underground mine with supplemental production from some small strip pits, to supply coal mainly to Japanese steel mills under the terms of a contract signed in 1967. During 1969, the company completed construction of a new coal preparation plant at Coleman adjacent to its old wash plant. The new, highly-mechanized operation using a Baum jig and Deister tables can clean 1.5 million tons per year (300 tons hourly capacity) to Japanese export specifications. To increase productivity, Coleman is establishing a mechanical mining system using continuous mining machines and shuttle cars. The mine was shut down for a short time in October due to lack of rail cars and storage space resulting from the British Columbia dock workers strike.

To the north of the Crowsnest Pass in the Cascade coal area, The Canmore Mines, Limited produced coal mainly from its underground mine with supplementary output from small strip operations. Canmore has an export contract to Japan for 3.8 million long tons over 10 years. By the end of the year, construction of a 30-inch twin diesel coal auger for Canmore at the minesite was nearly complete. This auger, which is expected to be in production in early 1970, is designed for recovery of coal that is steeply dipping into the hillside for a distance of up to 300 feet.

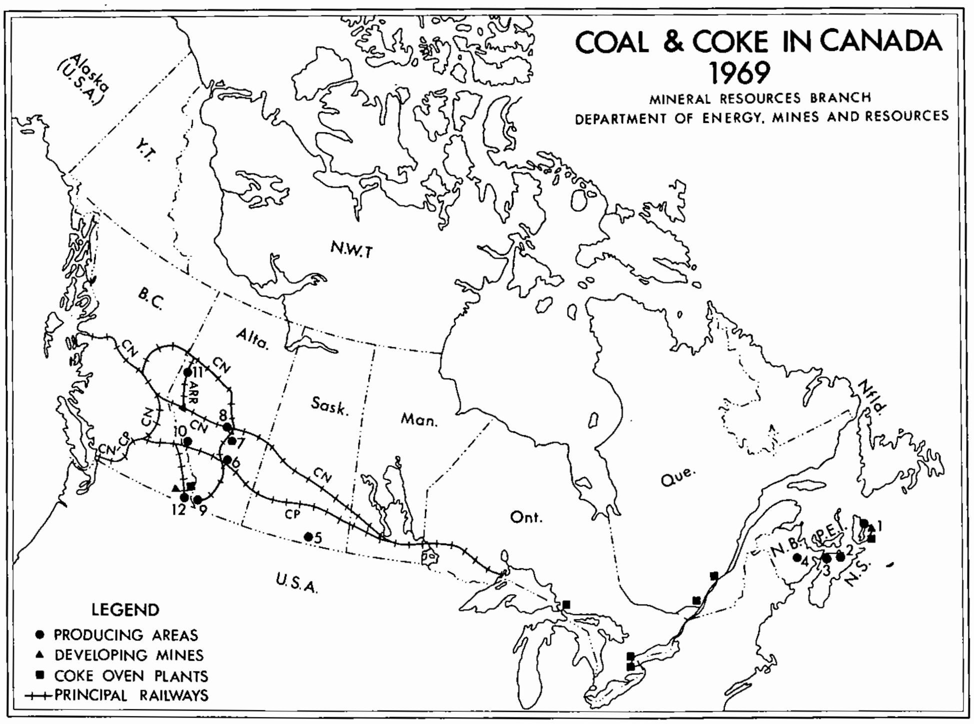


TABLE 4

Principal[1] Coal Mines in Canada–1969

Map Number[2] Company and Location	Rank of Coal[3]	Approximate Output (000 tpy)	Remarks
NOVA SCOTIA			
1. *Sydney and Inverness Area*			
Bras d'Or Coal Company, Limited	Hvb	103	Underground
Cape Breton Development Corporation	Hvb	2,215	Operates four underground collieries and coke oven plant - developing a new mine at Lingan.
Evans Coal Mines Limited	Hvb	37	Underground
2. *Pictou Area*			
Thorburn Mining Limited	Hvb	127	Underground
Drummond Coal Company Limited	Hvb	45	Underground
3. *Springhill and Joggins Area*			
River Hebert Coal Company Limited	Hvb	42	Underground
Springhill Coal Mines Limited	Hvb	52	Underground
NEW BRUNSWICK			
4. Avon Coal Company, Limited	Hvb	161	Operated January through August.
D.W. & R.A. Mills Limited	Hvb	201	" " " "
Midland Mining Co. Ltd.	Hvb	46	" " " "
C. H. Nichols Co. Ltd.	Hvb	36	" " " "
Miramichi Lumber Company (Limited)	Hvb	12	Operated in January only.
N.B. Coal Limited	Hvb	246	Took over existing mines in area on September 1.
SASKATCHEWAN			
5. *Souris Valley Area*			
Battle River Coal	Lig	510	Strip
Manitoba and Saskatchewan Coal Company Limited	Lig	347	Strip
Utility Coals Ltd.	Lig	1,163	Strip
ALBERTA			
6. *Drumheller and Sheerness Areas*			
Alberta Coal Ltd.	Sub	29	Strip
Century Coals Limited	Sub	97	Underground and strip
Fox Coulee Coals Ltd.	Sub	36	Strip
7. *Castor Area*			
Alberta Coal Ltd.	Sub	265	Strip
Forestburg Collieries Limited	Sub	472	Strip
8. *Edmonton and Pembina Areas*			
Alberta Coal Ltd.	Sub	2,118	Strip
Star-Key Mines Ltd.	Sub	29	Underground
9. *Crowsnest Area*			
Coleman Collieries Limited	Mvb	769	Strip and underground
10. *Cascade Area*			
The Canmore Mines, Limited	Lvb & An	267	Strip and underground
11. *Smoky River Area*			
McIntyre Coal Mines Limited	Lvb	194	Underground–Coal produced during preproduction development

TABLE 4 (Cont'd)

Map Number[2]	Company and Location	Rank of Coal[3]	Approximate Output (000 tpy)	Remarks
BRITISH COLUMBIA				
12.	*East Kootenay Area*			
	Kaiser Resources Ltd.	Lvb & Mvb	892	Strip and Underground

[1]Producing 25,000 or more tons per year. [2]See Map for location. [3]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, 1969
(short tons)

	Production		Average Output per Man-day[p]	
	Underground	Surface	Underground	Surface
Nova Scotia	2,621,330	–	2.6	–
New Brunswick	51,965	649,987	1.5	6.6
Saskatchewan	–	2,020,105	–	59.3
Alberta	1,091,559	3,334,501	5.3	49.7
British Columbia	506,830	395,602	4.8	19.6
Canada 1969[p]	4,271,684	6,400,195	3.6	46.5
1968	4,710,210	6,298,067	3.5	45.7
Total, all mines 1969[p]	10,671,879		29.3	
1968	11,008,277		27.6	

Source: Dominion Bureau of Statistics.
[p]Preliminary; – Nil.

At year-end, Cardinal River Coals Ltd. in the Coalspur area at Luscar, had nearly completed the construction of a coal preparation plant (440 tons hourly capacity) and preproduction stripping of overburden from the strip sites. Cardinal, the operating subsidiary of Luscar Ltd. of Edmonton, and Consolidation Coal Company of Pittsburgh, expects to begin shipping coking coal to Japan in April 1970. Because of complex folded coal-seams at Luscar, Cardinal will use an open-pit mining method similar to that used in metal mining for steeply dipping orebodies. The company will use two electric shovels to load eight, 110-ton trucks.

McIntyre Coal Mines Limited is developing in the Smoky River area, the first coal mining venture in recent years to begin in a relatively virgin area. Although high grade coal has been known for a long time in the Smoky River area, there was no rail or adequate road upon which a coal-mine might depend. Also markets were lacking. When construction started on the Alberta Resources Railway, McIntyre began to look to an early utilization of their coal resources and obtained a contract in 1969 for coking coal. The railway was officially opened in May 1969.

A new town, Grand Cache, had to be developed in order to accommodate the anticipated 1,000 employees on a permanent basis. During the year the townsite was surveyed and many of the houses for employees and shopping facilities were completed. In order to meet its labour requirements McIntyre is

TABLE 6

Regional Canadian Coal Shipments, 1969
(short tons)

Destination	Originating Province					Canada
	Nova Scotia	New Brunswick	Saskat-chewan	Alberta	British Columbia	
Railways in Canada	10,562	299	118,462	2,967	275	132,565
Newfoundland	20,872	–	–	–	–	20,872
Prince Edward Island	13,906	–	–	–	–	13,906
Nova Scotia	1,512,569	–	–	–	–	1,512,569
New Brunswick	80,998	392,920	–	–	–	473,918
Quebec	648,834	96,394	–	349	–	745,577
Ontario	365,608	–	129,056	13,430	25,426	533,520
Manitoba	–	–	367,513	67,479	121,810	556,802
Saskatchewan	–	–	1,390,695	71,480	–	1,462,175
Alberta	–	–	–	2,991,312	192	2,991,504
British Columbia	–	–	–	143,783	341,150	484,933
Totals, Canada	2,653,349	489,613	2,005,726	3,290,800	488,853	8,928,341
United States	3,583	163,089	12,381	10,651	34,080	223,784
Japan	–	–	–	891,769	326,184	1,217,953
Other*	–	–	–	–	3,501	3,501
Total shipments	2,656,932	652,702	2,018,107	4,193,220	852,618	10,373,579

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

bringing in coal miners from eastern Canada and Europe. As with many of the coal operations the lack of experienced coal miners is a problem for McIntyre.

McIntyre's mine plan will utilize a retreat, longwall mining system with continuous mining machines and powered roof supports. Shuttle cars together with ancillary conveyors will move the coal from underground to the preparation plant. The plant is designed to wash 3 million tons of coal per year. During 1969, McIntyre produced about 200,000 tons of coal from underground development work all of which went to storage banks near the mine.

In 1969, exploration for coking coal reached a peak in Alberta and British Columbia. All available coal leases in the belt of known bituminous coal in British Columbia and Alberta have been taken up. Some companies by year-end were beginning detailed exploration programs. At present, most companies holding coal leases of bituminous coal are attempting to outline potential strip mine sites. In these areas, surface geology is the initial exploration method for locating suitable coal. The second phase of exploration usually involves trenching followed by diamond drilling and geophysical logging (electric and gamma ray-neutron) of the holes. If down-hole results warrant further work, adits are driven to obtain bulk samples of unoxidized coal for coking tests.

In the plains area of Alberta, the shallow flat lying subbituminous coal is produced primarily to supply thermal electric power plants. Smaller amounts are used for domestic heating and industrial plants in Alberta and as far away as Ontario. In 1970, subbituminous coal shipments outside of Alberta will likely be reduced, because freight subventions, which some of the companies have required to move coal to distant markets, will be discontinued. Alberta Coal Ltd. which mines coal for Calgary Power Ltd. at Wabamun west of Edmonton, has the largest subbituminous coal-mine. Also, Calgary Power is constructing a new 300,000 kw thermal power plant across Lake Wabamun from its other plant and Alberta Coal is preparing a new strip mine adjacent to this plant to supply approximately one million tons of coal annually. The mine is particularly suited to open-pit operation and the major items of strip-mining equipment, including a 30-cubic yard walking dragline, have already been purchased for delivery and erection at the site during the summer of 1970. Alberta Coal also operates mines through subsidiaries at Sheerness and at Halkirk in the Castor area. Forestburg Collieries Limited, a Luscar Ltd. subsidiary, has a large surface mine at Forestburg just north of Halkirk. Both Forestburg Collieries and Alberta Coal supply coal to the Canadian Utilities, Limited power plant at Battle River situated approximately midway between the two mines. Two moderate sized underground mines still produce subbituminous coal in central Alberta. These are Century Coals Limited in Drumheller and Star-Key Mines Ltd. in the Edmonton district.

Elsewhere in the plains area, there was considerable activity during the year as companies evaluated possible sites for strip mines and adjacent power stations by rotary drilling. Limiting factors in construction of thermal electric plants are the scarcity of available cooling water for thermal power plants and the somewhat discontinuous nature of the coal-seams. To be economical, companies consider that coal-seams must have an overburden less than 150 feet. 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.

In British Columbia and Alberta, coal companies with large stripping operations have initiated reclamation programs. Having in mind the unique environment in the west, these companies are now experimenting with reclamation techniques and developing new seeding methods to determine the most suitable programs for reforestation and land preservation.

SASKATCHEWAN

In the Estevan area of southeastern Saskatchewan lignite coal is strip-mined by highly productive mining operations owned by Alberta Coal Ltd., Manitoba and Saskatchewan Coal Company Limited and Utility Coals Ltd. The shallow lignite seams are part of a field extending from southern Saskatchewan into North Dakota, South Dakota and Montana. As indicated in Table 5, output per man day averaged 59.3 tons for Saskatchewan strip mines compared to the Canadian average of 46.5 for surface mines. In part, this reflects the ideal mining conditions experienced in Saskatchewan mines which have shallow overburden and fairly thick coal-seams that are mined by large dragline and shovel operations. Saskatchewan Power Corporation's Estevan Power Station and the Boundary Dam River station, both situated on the lignite field at Estevan, provide the mines with a sound basic market. Due to the decreasing demand for lignite by residential and industrial consumers in the eastern prairies and in western Ontario, Saskatchewan coal production declined slightly in 1969 to about 2.0 million tons compared with about 2.3 million tons in 1968. However, with new thermal power installations planned, lignite requirements are expected to increase 800,000 tons annually by the early 1970's.

YUKON TERRITORY

In the Yukon Territory, the Carmacks coal-mine was reopened by Anvil Mining Corporation Limited. Production from the mine will not be large and will be used at the Anvil zinc-lead-silver mine at Vangorda Creek to supply fuel for a concentrates drying plant.

The original Carmacks mine, which closed three years previously, began production in 1947 to supply river boats on the Yukon River and the heating plants at United Keno Hill Mines Limited.

NEW BRUNSWICK

New Brunswick coal production decreased about 12 per cent to 701,000 tons for 1969 in line with the gradual phasing out of the uneconomic coal industry at Minto. Consistent with this phasing out procedure, a Bill was introduced in the New Brunswick legislature in April outlining the purchase of the four remaining coal mining companies and the establishment of a Crown corporation to operate them. Purchase of the companies was a followup to the Grand Lake Development Act, passed by the provincial legislature in 1968 to rationalize the coal industry and direct new industry to the Minto area. On September 1, the New Brunswick government formally took over all surface and underground coal operations in the Minto Coalfield belonging to Avon Coal Company, Limited; D.W. & R.A. Mills Limited; Midland Mining Co. Ltd., and C.H. Nichols Co. Ltd. Miramichi Lumber Company (Limited) shut down voluntarily at the end of January. A new provincial company, N.B. Coal Limited, a wholly-owned subsidiary of the Grand Lake Development Corporation, was incorporated to take over and manage the Minto coal operations. With the amalgamation of the mining activity at Minto, N.B. Coal Limited is aiming to have as efficient an operation as possible as the industry is phased out with a minimum of dislocation to the region.

Within the Minto coal-field 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 with the latter method producing more than 90 per cent of the coal. New Brunswick coal is used chiefly for thermal power generation by the provincial utility company.

NOVA SCOTIA

High volatile bituminous coal is produced mainly from the Sydney coal-field with some output from the

Inverness area, Pictou area, and Springhill-Joggins area. The coal-fields in Nova Scotia are of Carboniferous age and contain the oldest coal measures in Canada. Some of the Sydney area coal makes satisfactory coke, however the chief markets have been for thermal power generation in Nova Scotia and Ontario. Now that the Ontario market is discontinued, it is planned that more coal will be used for carbonization in the coke-oven plant at Sydney. In 1969, Nova Scotia coal production was 2.6 million tons from 10 operating mines.

Cape Breton Development Corporation (DEVCO), after its take-over of the coal-mines and related interests of the Dominion Steel and Coal Corporation, Limited, in March 1968, had its first full year of operation. DEVCO produced 2.2 million tons in 1969, all by underground methods, from coal-seams located under the sea. Production decreased 18 per cent from the previous year. In line with a plan to reduce the more costly operations and at the same time provide social benefits, the Corporation offered voluntary pre-retirement to about 1,000 older men of the total working force of 5,800 and began reducing its output to an anticipated 2 million tons a year.

In June, marked by an official ceremony, work began on DEVCO's new Lingan mine situated between No. 12 and No. 26 collieries. Initial development work will consist of driving four inclined shafts along the coal-seam which dips below the ocean. The Lingan mine, which will produce relatively low sulphur coal for carbonization at DEVCO's coke-oven plant, should be in full production in 1974. A longwall mining system using shearers and powered roof supports is planned for use.

Bras d'Or Coal Company, Limited, shut down its Four Star Colliery in Broughton in late December and the work force was transferred to the other collieries, or given alternative employment.

On the Nova Scotia mainland, the McBean Colliery continued operating under DEVCO's management in the name of Thorburn Mining Limited. The remaining five independent coal-mines in Nova Scotia have continued to operate without federal financial assistance since March 31, 1968. The provincial government assumed responsibility for these five mines as provided in a federal-provincial agreement.

MARKETS AND TRADE

Within Canada the prime markets for coal now are the thermal electric power industry and the iron and steel industry. Previously the railways had been a prime consumer but by 1958 dieselization of the railways was essentially complete and the important consumers of coal became the mining and manufacturing industries, coke making industry and retail sales for residential consumption. Apparent consumption in Canada in 1969 was 26.6 million tons only slightly higher than the amount consumed a decade ago, in 1959. The low point in consumption was in 1961 when natural gas together with oil were making further inroads in the residential markets and taking over most of the industrial coal markets as well. Since that time there has been a general trend toward increasing consumption of coal in Canada based primarily on the use of coal in thermal electric plants and for metallurgical coke. In the last 10 years the markets for coal within Canada have changed substantially. Thermal power plants, which consumed less than 6 per cent of total coal in 1959 used 45 per cent in 1969. Indeed electric utilities have become Canada's largest domestic users of coal. The coke industry remains a substantial market using roughly 26 per cent of all coal consumed in Canada.

TABLE 7

Supply and Demand of Coal, 1958 and 1968

	1958	1968
SUPPLY		
Production	11,687,110	10,980,850
Landed imports	13,325,905	17,322,968
Total inventory change	-1,631,013	-452,819
Total supply	26,644,028	28,756,637
DEMAND		
Exports	338,544	1,447,012
Domestic sales		
Electric utilities	1,654,936	11,098,800
Mining and manufacturing	9,615,251	5,972,269
Coke making	4,788,958	7,522,715
Sub total	16,059,145	24,593,784
Retail sales	5,908,868	1,062,570
Railways	2,032,979	132,042
Ship's bunker	383,241	179,768
Government and institutional	253,000	173,000
Sub total	8,578,088	1,547,380
Coal-mine and local use	994,280	505,910
Loss	60,754	45,340
Unaccounted for	613,217	617,211
Total domestic consumption	26,305,484	27,309,625
Total demand	26,644,028	28,756,637

Source: Dominion Bureau of Statistics.

TABLE 8

Coal Used by Thermal Electric Generating Stations[1] by Provinces, 1959-1969p
(000's short tons)

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969p
Nova Scotia	426	494	504	515	534	584	698	881	835	712	745
New Brunswick	141	202	168	121	107	245	368	324	303	264	165
Ontario	196	118	272	1,493	2,807	3,081	3,932	3,858	4,889	6,088	7,082
Manitoba	34	56	116	111	66	145	193	87	42	197	56
Saskatchewan	435	770	964	1,129	1,054	1,109	1,196	1,230	1,471	1,492	1,238
Alberta	187	206	229	356	582	1,101	1,335	1,499	1,573	2,346	2,621
Total, Canada	1,419	1,846	2,253	3,725	5,150	6,265	7,722	7,879	9,113	11,099	11,907

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

THERMAL POWER INDUSTRY

Coal for thermal electric power generation has had an average annual growth rate of 23.5 per cent from 1959 to 1969 increasing from 1.4 million tons to nearly 12 million tons in 1969 as shown in Table 8. At the end of 1969 the existing coal-fired electric power plants had a combined total capacity of 7,252 mw. Plans have been announced in several provinces which will result in the addition of thermal facilities totalling about 3,800 mw to be completed within six years. In western Canada, 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 future of coal-fired power plants depends more on availability of coal supply, competition from alternative energy sources, and environmental factors such as air and thermal pollution, although it is expected that a power mix of nuclear and thermal plants necessary for flexibility will continue. In addition, cost of electricity generated from coal-fired stations has been materially improved and the cost advantage, vis-a-vis nuclear plants, is improved above what was anticipated earlier.

During 1969, an estimated 7 million tons of coal were imported from coal-mines in Pennsylvania, Ohio, West Virginia and Kentucky in the United States for thermal power generation in Ontario. Until 1969 The Hydro-Electric Power Commission of Ontario (Ontario Hydro) used about 750,000 tons of coal annually from Sydney, Nova Scotia. However, removal of subvention payments covering shipments of Nova Scotia coal to Ontario has resulted in shipments to Ontario from Nova Scotia being reduced in 366,000 tons in 1969. As to the short term future in Ontario, a 1,000 mw expansion is planned for the Lambton plant near Sarnia and a new 2,000 mw plant (Nanticoke) will be built near Port Dover. For another new plant to be constructed at Lennox, near Kingston, Ontario Hydro originally planned to use coal, but because of coal supply problems decided to use oil.

In both Saskatchewan and Manitoba, Saskatchewan lignitic coal is used for power generation. Lignite consumption was down from the 1968 level due to the availability of larger amounts of hydroelectric power resulting from high water conditions. In Saskatchewan's Estevan area, the Boundary Dam station is being expanded to 600 mw. Upon completion, this station will be one of the largest lignite burning plants in North America, consuming more than 2 million tons per year.

In Alberta, construction began in 1967 at the Sundance coal-fired steam electric plant on the south side of Lake Wabamun, where the first 286,000 kw unit will be available for service late in 1970. A second similar-size unit is planned to be operative early in 1974. A coal-mine with coal reserves in excess of 100 million tons of strippable coal is being developed in the immediate vicinity of the plant. To minimize air pollution, Calgary Power has constructed a 510-foot stack at the new Sundance plant, and installed mechanical precipitations to clean the flue gases. To determine future additional or alternative steps that may be taken to further clean the flue gases, a series of experiments will be conducted when this plant is in operation.

At the minesite of McIntyre Coal Mines in the Smoky River area, Canadian Utilities is building the H.R. Milner station to generate electricity from the coal that is separated from the coking coal in the preparation plant. The Milner station is being designed to accommodate three units, the first will be 145 mw and is scheduled for operation by mid-1972. Up to 500,000 tons a year of coal will be supplied to the plant.

COKE INDUSTRY

Coke production in Canada totalled 5.0 million tons in 1969, down slightly from the 5.3 million tons produced in 1968. Contributing to the reduced output were labour disputes in the Canadian iron and steel industry and in the United States coal industry. In 1969, approximately 6.9 million tons of bituminous coal was carbonized compared to 7.4 million tons of coal used in 1968. In 1969, an average of 1.38 tons of coal was required for each ton of coke produced. Pig iron production in 1969 decreased an estimated 11 per cent from 8.3 million to 7.4 million net tons and accounts partially for the reduction in coke output. Coking coal supplies were inadequate in several major steelmaking countries as well as Canada in 1969 and there is general concern that a shortage of coal may become a serious problem for the world steel industry in the future. Over 90 per cent of coal used to make coke in Canada was imported from the United States primarily because the iron and steel industry in Ontario is in close proximity to high quality coking coals in Pennsylvania, Ohio, West Virginia and Kentucky. Although the three steel companies that operate coke oven plants in Hamilton and Sault Ste. Marie have ownership interests in United States

TABLE 9

Coke Oven and Other Carbonization Plants in Canada

Coke Plant	Battery and No. of Ovens	Oven Type	Year Built	Plant Capacity (000 tpy coal)	Byproducts
The Algoma Steel Corporation, Limited Sault Ste. Marie, Ontario	No. 5 – 86 No. 6 – 57 No. 7 – 57 No. 8 – 60	Koppers-Becker Underjet Koppers-Becker Underjet Wilputt Underjet Wilputt Underjet	1943 1953 1958 1967	2,700	Naphthalene light oil, gas Tar
The Steel Company of Canada, Limited Hamilton, Ontario	No. 3 – 61 No. 4 – 83 No. 5 – 47 No. 6 – 73	Wilputt Underjet Wilputt Underjet Wilputt Underjet Otto Underjet	1947 1952 1953 1967	2,670	Tar, sulphate of ammonia, sodium phenolate, gas, light oil
Dominion Foundries and Steel, Limited Hamilton, Ontario	No. 1 – 25 No. 2 – 35 No. 3 – 45 No. 4 – 53	Koppers-Becker Gun Type Comb Koppers-Becker Gun Type Comb Koppers-Becker Gun Type Comb Koppers-Becker Gun Type Comb	1956 1951 1958 1967	1,400	Tar, light oil, gas ammonium sulphate, sulphur
Cape Breton Development Corporation Sydney, Nova Scotia	No. 5 – 53 No. 6 – 61	Koppers-Becker Underjet Koppers-Becker Underjet	1949 1953	900	Tar, crude oil,gas
Gaz Métropolitain, inc., Ville La Salle, Quebec	No. 1 – 59 No. 2 – 15	Koppers-Becker Koppers-Becker	1928 1947	626	Tar, light oil, gas
Manitoba and Saskatchewan Coal Company Limited	2 units	Lurgi carbonizing retort	1925	110	Creosote, lignite tar, lignite pitch
Char and Briquetting Division Bienfait, Saskatchewan					
Gulf Oil Canada Limited Shawinigan Chemicals Division Shawinigan, Quebec	8 units	Travelling grate coking stoker	1939	200	Low-grade producer gas
Kaiser Resources Ltd. Natal, British Columbia	3 units	Mitchell	1963	2	No byproducts (experimental)
	10 units 10 units 16 units 16 units	Curran-Knowles Curran-Knowles Curran-Knowles Curran-Knowles	1939 1943 1949 1952	243	Crude tar, gas

coal-mines, long term availability is nevertheless of concern. These supply problems including the shortage of low sulphur coal resources have caused Ontario coke producers to show interest in the possibility of receiving quality coking coal from western Canada.

Approximately 3.7 million tons or 75 per cent of the coke produced in Canada is used as blast furnace fuel for ironmaking. The remaining coke was consumed principally in foundries and miscellaneous industrial plants, such as chemical plants and nonferrous smelters. A small amount of coke produced in British Columbia is exported to the United States through Montana for use in nonferrous smelters and about 50,000 tons on a spot basis were shipped from Nova Scotia to European countries.

About 95 per cent of the coke produced in Canada is manufactured in standard slot-type ovens at 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. The steel company coke plants have annual capacities that vary from 1.4 million to 2.7 million tons of coal feed. 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 coke rate, the amount of coke consumed per ton of pig iron produced remained the same as in 1968 at 1,100 pounds. The coke rate has had an average annual decrease of about 4 per cent from 1960 to 1969 decreasing from 1,520 pounds to 1,100 pounds. Based on the coking rate and the amount of coal required for each ton of coke, it is estimated that in 1969 in Canada, about 1,550 pounds (0.78 ton) of coking coal were required per ton of pig iron produced.

A production record was established by the Cape Breton Development Corporation (DEVCO) coke oven plant in its first full year of operation since the plant was purchased from Sydney Steel Corporation. Production rose to 616,548 tons representing a 35 per cent increase over 1968. Also significant was that use of Cape Breton coal for coke making increased 151 per cent. In 1969, 443,150 tons of Cape Breton coal was blended with 481,368 tons of United States coal. Whereas in 1968 the coke oven used 176,104 tons of Cape Breton coal and 564,683 tons of United States coal. Besides supplying Sydney Steel Corporation's blast furnaces, DEVCO sold about 50,000 tons of coke in Europe with plans to sell additional surplus coke to countries in short supply.

TABLE 10

Coke – Production and Trade

	1968		1969[p]	
	Short Tons	$	Short Tons	$
Production*				
Coal Coke				
Ontario	4,369,120		3,915,686	
Other provinces	941,642		1,086,589	
Total	5,310,762		5,002,275	
Petroleum Coke	238,601		227,551[e]	
Total	5,549,363		5,229,826	
Imports (all types)				
United States	755,718	14,933,000	870,152	19,084,000
West Germany	61,094	1,140,000	61,091	1,270,000
Argentina	–	–	53,244	564,000
Total	816,812	16,073,000	984,487	20,918,000
Exports (all types)				
United States	132,047	2,018,000	157,925	2,927,000
Japan	20,160	177,000	–	–
Other countries	–	–	117,678	1,327,000
Total	152,207	2,195,000	275,603	4,254,000

Source: Dominion Bureau of Statistics.
[p]Preliminary; [e]Estimated; – Nil.
*Practically all coke production is used internally in the iron and steel industry and is not given a value.

TABLE 11

Coke – Production and Trade, 1959-69
(short tons)

	Production				Imports			Exports
	Coke	Pitch	Petroleum Coke	Total	Coke	Petroleum Coke	Total	Total
1959	4,094,882	3,463	529,580	4,627,925	382,683	314,732	697,415	176,020
1960	3,872,802	3,414	534,979	4,411,195	297,707	403,391	701,098	161,190
1961	3,899,545	4,466	964,494	4,868,505	288,815	365,744	654,559	226,703
1962	4,021,774	1,899	201,985	4,225,658	247,304	338,068	585,372	157,882
1963	4,280,797	–	199,636	4,480,433	234,610	369,037	603,647	154,332
1964	4,342,982	–	206,815	4,549,797	315,763	440,607	756,370	120,740
1965	4,368,791	–	242,813	4,611,604	569,905	413,047	982,952	88,632
1966	4,426,051	–	230,119	4,656,170	584,965	499,154	1,084,119	87,615
1967	4,430,299	–	227,886	4,658,185	387,049	565,836	952,885	83,933
1968	5,310,762	–	238,601	5,549,363	255,405	561,407	816,812	152,207
1969p	5,002,275	–	227,551	5,229,826	280,905	703,582	984,487	275,603

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

In Montreal, the coke oven plant of Gaz Métropolitain, inc., formerly Quebec Natural Gas Corporation, built primarily to produce manufactured gas for Montreal is now orienting its operations toward 100 per cent foundry coke production.

The small coking operation of Shawinigan Chemicals Limited in Quebec came under the direction of Gulf Oil Canada Limited during the year. This plant produces coke for the manufacture of calcium carbide and with the decreasing demand for this product it is expected that coke production will decline substantially over the next few years.

During the year the char and briquetting plant in Bienfait, Saskatchewan was sold by Husky Oil (Alberta) Ltd. to the Manitoba and Saskatchewan Coal Company, a subsidiary of Luscar Sales Limited, which have a lignite strip mine adjacent to the plant. The new company is modernizing the plant and has instituted a marketing and research program for the plant products.

Of the coal mining companies with associated plants, The Canmore Mines, Limited in 1969 shut down their vertical retort that was used to produce formed coke. Kaiser's coke plant at Natal continues to produce coke both for local consumption at Cominco Ltd's., Trail smelter and for export to western United States. Kaiser is reviewing its coking operations and is preparing a study on the feasibility of expanding its coking facilities.

Production statistics are not available for raw coal chemicals produced as byproducts from coal volatiles during carbonization. This is now a small industry in Canada because of competition from petroleum based products. Coke oven gas is the primary byproduct and is obtained after ammonia, tar and light oil are recovered. Generally, the yield from 1 ton of coal during carbonization is approximately 315 pounds of coke-oven gas, 90 pounds of tar, 20 pounds of light oil and 5 pounds of ammonia. From the tar and light oil the following important primary organic chemicals or chemical mixtures can be obtained through further processing: benzene, toluene, zylene, solvent naphtha, crude chemical oil, creosote oil pitch, and pyridine.

In the coke industry considerable research is being done to lower coking costs, improve coke quality, increase coking rate productivity and reduce pollution. Efforts have been directed toward mechanization of operating equipment in conjunction with larger ovens with highly conductive oven walls. Experiments on preheating of coal before coking was done in an attempt to shorten the coking time and considerable research in the appraisal of coal and coke properties was conducted during the year.

EXPORTS

Exports of bituminous coal in 1969 were 1.37 million tons having a value of $9.4 million (Table 12). The value of exports for 1969 are not comparable with 1968 values due to a new reporting system

TABLE 12

Coal – Production and Trade, 1968-69
(short tons)

	1968		1969P	
	Short Tons	$	Short Tons	$
Production				
Canada, Total	10,989,007	61,131,123	10,671,879	52,538,240
Exports				
Bituminous				
St. Pierre	1,588	20,000	2,519	38,000
United States	172,044	1,545,000	215,821	1,915,000
Japan	1,273,222	14,768,000	1,155,618	7,417,000
Other countries	159	3,000	3,914	81,000
Total	1,447,013	16,336,000	1,377,872	9,451,000*
Briquettes				
United States	25,363	381,000	20,036	299,000
Imports (for consumption)				
Anthracite				
United States	418,621	5,298,000	436,017	5,885,000
USSR	11,576	79,000	–	–
Total	430,197	5,377,000	436,017	5,885,000
Bituminous				
United States	16,616,548	154,740,000	16,911,387	77,650,000*
Briquettes				
United States	6,062	273,000	6,061	292,000

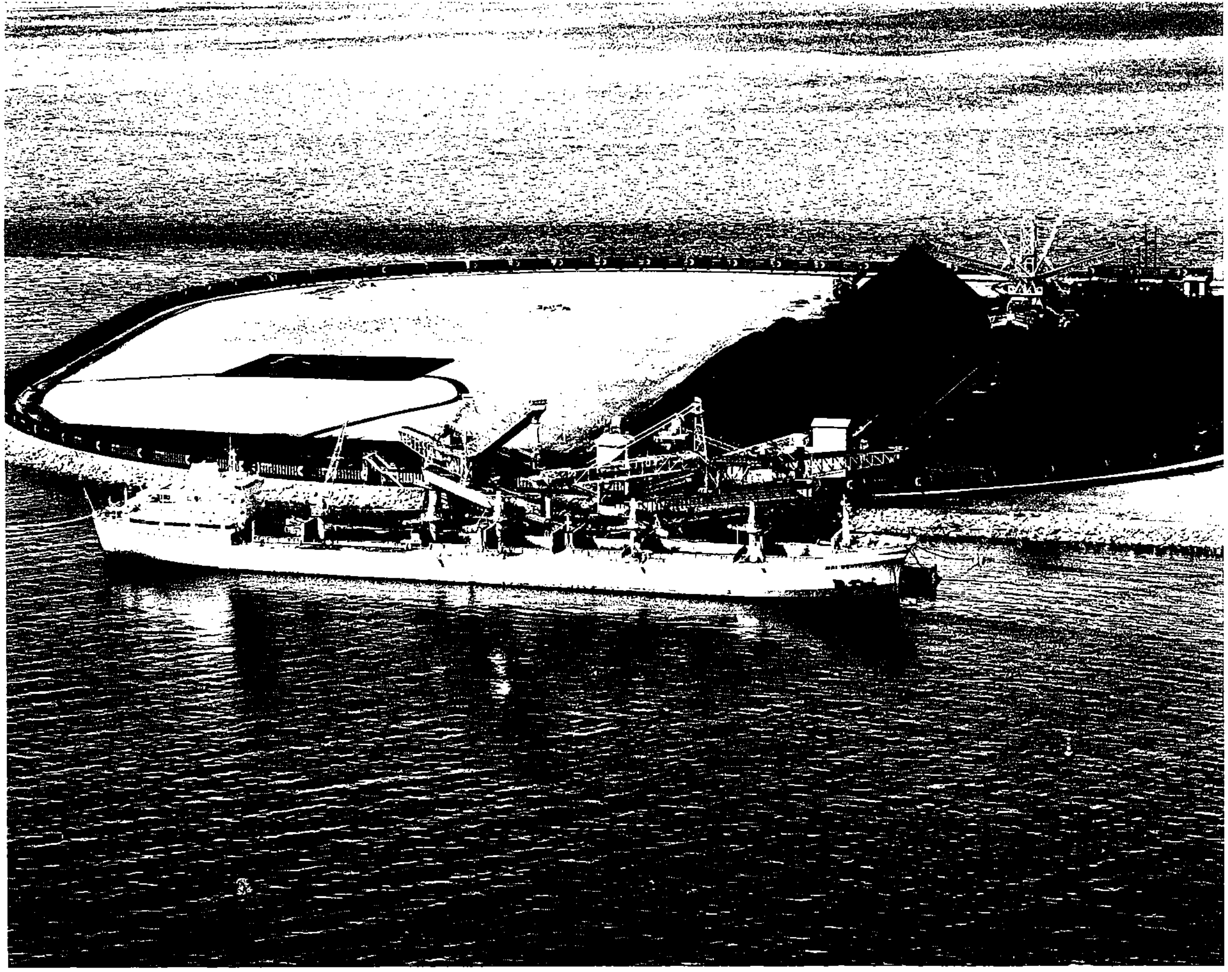
PPreliminary; – Nil; . . Not available.
*Value f.o.b. mine.

TABLE 13

World Coal Production
(thousand short tons)

Continent	1964	1965	1966	1967	1968P
North America	517,884	540,776	560,567	578,944	570,618
South America	10,016	8,318	7,542	8,274	8,395
Europe	1,897,553	1,893,611	1,870,657	1,841,241	1,847,314
Africa	54,527	59,063	58,124	59,154	61,932
Asia	495,884	515,452	552,915	441,024	524,714
Oceania	55,230	61,318	64,640	67,721	73,465
World					
Lignite (estimate)	817,930	812,785	808,386	792,472	812,799
Bituminous and Anthracite (by subtraction)	2,213,164	2,265,753	2,306,059	2,203,886	2,273,639
Total, all types*	3,031,094	3,078,538	3,114,445	2,996,358	3,086,438

Source: United States Bureau of Mines.
PPreliminary.
*Totals are of listed figures only; no undisclosed data included.



ROBERTS BANK BULK-LOADING COAL TERMINAL at Delta area, British Columbia — Loading Kaiser Resources Ltd. coal directly from C. P. Rail unit train into a freighter destined for Japan. (Photo by Hunter)

initiated by the Dominion Bureau of Statistics. The 1968 value of exports represents the value f.o.b. port whereas for 1969 the value is f.o.b. minesite.

Exports were predominately to Japan with lesser volumes being delivered to the United States, the French island of St. Pierre and other countries. Canada's balance of coal trade will improve sharply in 1970 with the growing exports to Japan as discussed previously. Exports to the United States will change in the next year or so due to cessation of coal shipments from New Brunswick to Maine because of oil competition. Exports from Nova Scotia are also expected to be discontinued. In 1969 approximately 12,000 tons of Saskatchewan lignite were exported to the United States. This has remained fairly constant during the last two years and no appreciable change is forecast.

TARIFFS

The 30 cents per ton duty on imported bituminous coal, except for metallurgical coal which was exempt, was eliminated in June 1969 as a result of the acceleration of the Kennedy Round of tariff reductions. The original 50 cents per ton duty, which applied almost entirely to United States coal used for thermal power generation in Ontario, was to be reduced 10 cents per ton per year, effective January 1, 1968.

IMPORTS

In 1969, Canada imported 17.3 million tons of bituminous, anthracite and briquettes all from the

United States as shown in Table 12. Bituminous coal accounts for 95 per cent of the total imports. Ontario markets took about 92 per cent of the imported coal with the remainder going primarily to Quebec and Nova Scotia consumers.

The trend is for decreasing consumption of imported coal in the Atlantic provinces, Quebec and in western Canada but a growing use in Ontario due primarily to growth in demand for the thermal electric and metallurgical industries as discussed elsewhere. The reasons for the decreasing consumption in the Atlantic provinces and Quebec are the easily available and strongly competitive price of foreign oil and the increasing replacement of imported coal by Cape Breton coal for the Sydney coke industry.

GOVERNMENT FINANCIAL ASSISTANCE

Subvention payments by the federal government through the Dominion Coal Board to assist the movement of coal to markets were reduced from $12.8 million in 1968 to $7.5 million in 1969. Of this total $3.2 million was used to assist British Columbia and Alberta mines export coal to Japan and $250,000 was used to move British Columbia, Alberta and Saskatchewan coal to Ontario. A grant of $4 million was made to the Province of New Brunswick to aid the Minto area coal industry. The substantial reduction is related to discontinuation of subvention payments in eastern Canada. However federal aid continued to be given in the form of underwriting annual operating losses of DEVCO's Coal Division amounting to $21 million in 1969. For the smaller mines in Nova Scotia, the province undertook responsibility for the further financial aid required in the marketing of coal. In western Canada present authority for paying subventions expires on March 31, 1970. The exception is a one year extension to March 31, 1971 which respect to aid on two export contracts with Japan. Since inception in 1927, to March 31, 1969, $320,999,665 has been paid by the federal government for subvention aid.

Cobalt

G.P. WIGLE*

Canadian cobalt production in 1969 was 3,203,947 pounds valued at $6.9 million compared with 4,029,549 pounds valued at $8.7 million in 1968. Production was reduced by strikes at the Sudbury, Ontario operations of The International Nickel Company of Canada, Limited, which extended from July 10 to November 17, and at Falconbridge Nickel Mines, Limited from August 21 to November 23. Canada is one of the five major cobalt producing countries and obtains nearly 90 per cent of its cobalt as a byproduct of nickel-copper ores with the balance, also a byproduct, from silver-cobalt ores.

African Metals Corporation which markets the cobalt production of the Congo (Kinshasa) increased its cobalt price to U.S. $2 a pound in October and announced a further increase to U.S. $2.20 a pound in November 1969. Falconbridge Nickel Mines made the same increases in its cobalt prices and Sherritt Gordon Mines, Limited re-established its 15 per cent premium for pure cobalt powder at U.S. $2.35 a pound in December.

The United States General Services Administration sold 8.9 million pounds of cobalt from stockpile surplus in 1969. Prices for this material ranged from U.S. $1.63 a pound of contained cobalt in January to U.S. $2.20 a pound in December. U.S. stockpile sales of cobalt in 1968 were 5.5 million pounds and 6 million pounds in 1967. Increased sales in 1969 resulted from increased demand that developed mainly as a consequence of the shortage of nickel and the substitution of nickel by cobalt to meet part of the requirements of the nickel plating industry. The U.S. stockpile contained nearly 80 million pounds of cobalt at the end of the year; the stockpile objective remained at 38.2 million pounds and further releases of some 40 million pounds were under consideration.

CANADIAN PRODUCTION

The International Nickel Company of Canada, Limited (Inco) delivered 1.87 million pounds of cobalt in 1969 compared with 1.79 million pounds in 1968. Production was reduced, nevertheless, by the 128-day strike at Sudbury.

Falconbridge Nickel Mines also increased its cobalt deliveries in 1969 as a result of increased demand. Falconbridge produces cobalt at its refinery at Kristiansand, Norway, from nickel-copper matte shipped from Canada.

Sherritt Gordon Mines produced 668,000 pounds of cobalt in 1969 compared with 894,000 pounds in 1968. Sherritt's cobalt sales were 725,000 and 985,000 pounds in the respective years. 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 nickel and cobalt-bearing materials on a toll basis.

Cobalt is recovered as a byproduct of the smelting and refining of complex 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, amounting to 290 tons, was shipped to Belgium for treatment and sale.

*Mineral Resources Branch.

TABLE 1

Canada, Cobalt Production, Trade and Consumption, 1968-69

	1968		1969p	
	Pounds	$	Pounds	$
Production[1] (all forms)				
Quebec	33,832	73,077	–	–
Ontario	3,221,025	6,957,851	2,503,400	5,430,540
Manitoba	774,692	1,656,724	700,547	1,491,240
Total	4,029,549	8,687,652	3,203,947	6,921,780
Exports				
Cobalt metal				
United States	811,960	1,655,000	787,698	1,613,000
Belgium and Luxembourg	269,772	510,000	281,029	496,000
Britain	100,797	213,000	60,260	118,000
France	17,600	40,000	22,150	49,000
India	–	–	1,272	3,000
Other countries	10,780	27,000	2,882	4,000
Total	1,210,909	2,445,000	1,155,291	2,283,000
Cobalt oxides and salts[2]				
Britain	1,581,800	2,695,000	1,199,700	2,095,000
Jamaica	–	–	100	...
United States	64,700	128,000	–	–
Total	1,646,500	2,823,000	1,199,800	2,095,000
Consumption[3]				
Cobalt contained in:				
Cobalt metal	274,334	..	294,777	..
Cobalt oxide	53,848	..	58,516	..
Cobalt salts	29,916	..	40,365	..
Total	358,098	..	393,658	..

Source: Dominion Bureau of Statistics.

[1]Production (cobalt content) from domestic ores. Includes cobalt content of concentrates exported. [2]Gross weight. [3]Available data reported by consumers.

pPreliminary; – Nil; . . . less than $1,000; . . Not available.

WORLD PRODUCTION

Non-communist world production of cobalt in 1969, estimated at 18,432 tons (cobalt content), was reduced from about 19,000 tons in 1968 by production problems. United States sales from stockpile provided an additional 4,450 tons of cobalt in 1969; they were 2,763 tons in 1968. Additional production was expected in 1970, with a total of about 1,400 tons from Outokumpu Company's recently completed cobalt refining facilities at Kokkala, Finland, and from new nickel-producing operations in Canada. The Democratic Republic of the Congo (Kinshasa), the world's major producer of cobalt, recovered as a co-product of its copper operations, was expected to increase its production to about 17,500 tons a year in 1971 but it was reported that shipments of Congolese cobalt to Japan were to be reduced in 1970. Morocco was not expected to produce any cobalt in 1970 due to declining grade of ore.

Cobalt is recovered in small amounts in the United States as a byproduct of magnetite ore that contains cobalt-bearing pyrite, and from some zinc plant residues.

TABLE 2

Canada, Cobalt Production, Trade and Consumption, 1960-69
(pounds)

		Exports			Imports		
	Production[1]	Cobalt Metal	Cobalt Alloys[2]	Cobalt Oxide and Salts[2]	Cobalt Ores	Cobalt Oxides	Consumption[3]
1960	3,568,811	844,293	1,938	1,175,206	–	20,227	252,050
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
1969p	3,203,947	1,155,291	. .	1,199,800	. .	. .	. .

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]Total consumption.
pPreliminary; – Nil; . . Not available.

TABLE 3

World Production of Cobalt
(short tons of contained cobalt)

	1967	1968	1969e
Congo (Kinshasa)	10,712	11,000	11,500
Finland	1,984	1,852	910
Morocco	2,125	1,840	1,540
Canada	1,802	2,015r	1,602p
Zambia	1,604	1,319	1,800
West Germany	973	880	880
Australia	164	235r	200
USSRe	1,500	1,500	1,750
Cuba	1,150	1,200	. .
Total	22,014	21,841	20,182

Sources: U.S. Bureau of Mines Minerals Yearbook; Australian Mineral Industry, Quarterly Review; and company reports.
pPreliminary; eEstimated, excluding Cuba; rRevised; . . Not available.

CONSUMPTION AND USES

Consumption of cobalt in Canada in 1969 was 393,658 pounds, 74 per cent of it as cobalt metal, 15 per cent in cobalt oxide, and 11 per cent in cobalt salts.

United States consumption of cobalt in 1969 was 6,946 tons (cobalt content) compared with 6,499 tons in 1968 and it is of interest to note the stockpile sales of 4,550 tons and 2,750 tons of cobalt in the respective years. Cobalt was supplied to users and processors in the form of metal,–79 per cent; salts and driers,–16 per cent; oxide,–4 per cent; and other unspecified forms including scrap,–1 per cent.

The more important uses of cobalt are in high-temperature, high-strength alloys, magnet alloys, high-speed and tool steels, 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, 1967-68
(thousands of pounds cobalt content)

	1967	1968
Steel (ingots and castings):		
High-speed and tool	514	553
Stainless steel	136	145
Alloy (excluding stainless and tool)	516	470
Cutting and wear resistant materials:		
Cemented or sintered carbides	486	516
Other materials	430	191
Welding and hardfacing rods, materials	864	495
Magnetic alloys	2,486	2,700
Nonferrous alloys	3,625	3,061
Electrical materials	759	954
Chemical and ceramic uses:		
Catalysts	626	721
Ground coat frit	286	201
Glass decolorizer	70	67
Pigments	134	211
Other	63	29
Miscellaneous and unspecified	1,390	863
Salts and driers: lacquers, varnishes, paints, inks, pigments, enamels, feeds, electroplating (estimate)	1,592	1,826
Total	13,977	13,003

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 18,000 tons a year while annual production of lead is approximately 2.3 million tons and of copper 4.7 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 of the 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.

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 the market strength was because of a temporary severe shortage of nickel but cobalt gained and will likely retain some new customers due to diversified and growing use of this, and other, alloying metals so evident in recent years.

New and increased production from the Congo, Finland, Canada and other sources, stimulated by improved prices, should more than replace the loss of Moroccan cobalt. Sales from stockpile were expected to continue. Producers should meet with adequate sales volume at current or moderately increased prices over the near future. However, recent substantial growth in demand (e.g. Japan) could exceed new cobalt supplies as they become available and more serious scarcity could redevelop in three to four years.

PRICES

Prices of cobalt in the United States published by *Metals Week*, December 29, 1969, were:

Cobalt metal per lb f.o.b. New York 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	
Regular, 500 lb	2.76
300 mesh	2.78
Briquettes, 10 ton lots, per lb contained	2.38

Cobalt oxide per lb, 250 lb, contained Ceramic, delivered, 3¢ 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

Item No.		British Preferential	Most Favoured Nation	General
CANADA				
33200-1	Cobalt ore	free	free	free
35103-1	Cobalt metal, excluding alloys in lumps, powders, ingots or blocks (effective 4/6/69)	free	free	25%
35110-1	Cobalt metal, in bars	free	10%	25%
92824-2	Cobalt oxides (effective 1/1/69)	free	10%	20%
92824-1	Cobalt hydroxides (effective 1/1/69)	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, 1969		14%	
	" " Jan. 1, 1970		12.5%	
633.00	Cobalt metal, wrought			
	On and after Jan. 1, 1969		14%	
	" " Jan. 1, 1970		12.5%	
418.60	Cobalt oxide, and			
418.62	Cobalt sulphate			
	On and after Jan. 1, 1969		1.2¢ per lb	
	" " Jan. 1, 1970		1¢ per lb	
418.68	Other cobalt compounds			
	On and after Jan. 1, 1969		9.5%	
	" " Jan. 1, 1970		8%	
426.24 } 426.26 }	Cobalt salts			
	On and after Jan. 1, 1969		9.5%	
	" " Jan. 1, 1970		8%	

NOTE: Further tariff reductions on the above U.S. cobalt items will occur on January 1, 1971 and January 1, 1972.

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.

Columbium (Niobium) and Tantalum

G.P. WIGLE*

St. Lawrence Columbium and Metals Corporation produced 3,059,052 pounds of columbium pentoxide (Cb_2O_5) in its fiscal year ended September 30, 1969, compared with 2,005,989 pounds in the 12 months ended September 30, 1968. Production during the 1969 calendar year was 3,495,440 pounds of Cb_2O_5. St. Lawrence Columbium is the only Canadian producer of columbium and operates one of only two mines in the world that produce columbium in pyrochlore concentrates as a primary product; the other, larger operation is near Araxá, Brazil. The demand for columbium continued to increase in 1969 and St. Lawrence planned to produce 4.5 million pounds of Cb_2O_5 in 1970. Published spot prices for Canadian pyrochlore concentrates, f.o.b. mine site, after declining to U.S. 90¢-93¢ a pound of contained Cb_2O_5 in April 1968 and recovering to U.S. 92¢-98¢ in December 1968, increased to U.S. \$1-\$1.05 in the latter part of 1969.

The United States General Services Administration sold in 1969 approximately 2.5 million pounds of combined columbium-tantalum pentoxide in concentrates containing approximately 1.5 million pounds of columbium. The average price for 430,158 pounds sold in December was U.S. \$1.19 a pound of combined pentoxides (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. Annual production was expected to be 500,000, or more, pounds of tantalum pentoxide (Ta_2O_5) with the new plant operating at its rated capacity of 500 tons of ore a day. Concentrates were 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. the mine, for the balance of sales contracted for delivery to the end of 1970.

*Mineral Resources Branch.

TABLE 1

Canada, Columbium (Niobium) and Tantalum Production, Trade and Consumption, 1968-69

	1968		1969p	
	Pounds	$	Pounds	$
Production (Cb_2O_5 content of products shipped)	2,181,304	2,036,315	3,010,356	2,925,698
Imports[1] from United States				
Columbium and columbium alloys, wrought and unwrought, waste and scrap	375	24,128	1,178	21,983
Tantalum and tantalum alloys, wrought and unwrought, waste and scrap	1,972	117,240	1,871	105,095
Tantalum and tantalum alloy powder	1,830	59,443	7,488	158,607
Exports[2] to United States				
Columbium ore and concentrates	295,333	156,970	919,577	472,836
Consumption by the steel industry				
Ferrocolumbium and ferrotantalum-columbium (Cb and Ta-Cb content)	288,000		..	

Source: Dominion Bureau of Statistics, except otherwise noted.

[1]From U.S. Department of Commerce, Exports 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.

p Preliminary; .. Not available.

CANADIAN PRODUCTION AND DEVELOPMENTS

St. Lawrence Columbium and Metals Corporation increased production at its mine near Oka, Quebec in 1969. The mill treated 475,201 tons of ore and recovered 3,059,052 pounds of Cb_2O_5 in the 12 months ended September 30, 1969, compared with 360,194 tons milled and 2,005,989 pounds of Cb_2O_5 recovered in the prior 12-month period. Production revenue in the two periods was $3,105,652 and $1,966,937 respectively. The company planned to produce about 4.5 million pounds of columbium pentoxide in 1970.

Masterloy Products Limited, near Ottawa, Ontario, completed and put into production in late 1969 an enlarged new ferroalloy plant. The new plant is equipped with modern metallurgical facilities for the production of more than 2,000 tons a year of various ferroalloys. Masterloy's production in 1969 included 820,000 pounds of ferrocolumbium, 210,000 pounds of ferromolybdenum and 140,000 pounds of ferrovanadium.

Quebec Mining Exploration Company (SOQUEM) announced, in July, the discovery of a geological complex of carbonate-rich rocks called carbonatite about 8 miles north of Chicoutimi, Quebec. Preliminary estimates based on limited diamond drilling suggest a deposit in the order of 45,000 tons per vertical foot with an average grade of 0.48 per cent columbium pentoxide. St. Lawrence Columbium estimates its Oka ore reserves at 2.5 million tons averaging 0.48 per cent Cb_2O_5.

WORLD PRODUCTION

Non-communist world production of columbium and tantalum concentrates in 1969 was an estimated 17,000 tons consisting of concentrates of columbite, tantalite, and columbium-bearing pyrochlore. Production in 1968 was approximately 10,000 tons.

Brazil has maintained its position as the leading producer of columbium concentrates since 1966. The world's largest producer of columbium is Companhia Brazileira de Metalurgia e Mineração (CBMM) from its mine near Araxá where the ore consists of a large deposit of high-grade columbium-bearing pyrochlore. Production of columbium pentoxide in pyrochlore concentrate increased from 1.4 million pounds in 1965 to 11.3 million pounds in 1969. Milling capacity was increased in 1969 and further expansion is expected in 1970. 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 that it had developed a new process for making high-purity columbium oxide; a plant is being constructed by CBMM in Brazil to produce pure columbium oxide in the latter half of 1970.

Union Carbide Corporation, Belgian interests, and the Congo government were jointly preparing a columbium-pyrochlore mine for production in 1970 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. However, in contrast to the more recent producers of columbium-bearing pyrochlore, its columbite concentrates are a co-product of tin mining where the columbium occurs in the mineral columbite.

Columbium and/or tantalum concentrates are also produced in eight or more countries other than the principal producers listed in Table 2 but their combined annual production is less than 10 per cent of the world total.

TABLE 2

Non-Communist World Production of Columbium and Tantalum Concentrates
(short tons, gross weight)

	1968		1969[e]	
	Columbium	Tantalum	Columbium	Tantalum
Brazil				
pyrochlore	5,510	–	11,300	
columbite-tantalite	69	300	70	325
Canada				
pyrochlore	2,118	–	3,100	–
tantalite	–	–	–	..
Nigeria	1,264	1	1,500	2
Congo (Kinshasa)	103	110	105	112
Mozambique	69	99	70	100
Malaysia	57	–	75	–
Australia	–	119	–	120
Other countries	119	39	120	40
Total	9,309	668	16,340	699

Sources: U.S. Bureau of Mines, annual publications; and company reports.
[e]Estimated; – Nil; .. Not available.

CONSUMPTION AND USE

Canada's consumption of columbium and tantalum in the form of ferroalloys increased sharply to 288,000 pounds in 1968 compared with 78,000 pounds in 1967. The market for this material is growing in such steel applications as the manufacture of oil and gas transmission pipe and in a wide range of alloys.

The United States is the principal consumer of columbium and tantalum with the major part of its wholly-imported supply being used to make ferrocolumbium and ferrotantalum-columbium. The steel industry uses these ferroalloys in the making of alloy and stainless steels, high-temperature alloys, nickel-base alloys, and 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 the use of 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 in 1968 was approximately: steel – 78 per cent, nonferrous alloys – 21 per cent, and of tantalum: electronics – 65 per cent, chemical equipment – 25 per cent, nonferrous alloys – 5 per cent, carbides – 5 per cent.

The principal Canadian suppliers of ferrocolumbium are Union Carbide Canada Limited; Metallurg (Canada) Ltd.; and Masterloy Products Limited. The Macro Division of Kennametal Inc., Port Coquitlam, B.C., makes high-purity tantalum carbides and columbium carbides.

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 Crucible Steel of Canada Ltd.

PRINCIPAL MINERALS AND 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 associated with cassiterite which is mined for tin in placer 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 mineral pyrochlore recovered 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, brought into production of tantalite concentrates in 1969, 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).

OUTLOOK

Columbium, in common with other refractory and reactive ferroalloy metals, such as molybdenum, tungsten, and vanadium, was in growing demand at improved prices during 1969. Brazilian production and sales increased from 6.6 million pounds of columbium pentoxide in 1968 to 11.3 million pounds in 1969. Canada's output increased from 2 million pounds in 1968 to 3 million pounds in 1969. Supply was also supplemented by the sale of columbium concentrates from United States stockpile material that was declared surplus to requirements. Europe, United States, and Japan were the principal market areas in which demand increased.

Increased output planned by present producers could add about 7 million pounds to total production of Cb_2O_5 in Canada and Brazil in 1970. New mine production is expected from the Republic of the Congo (Kinshasa). Columbium should be in adequate supply for some years (possibly 10) with moderate price increases unless annual growth of 7 per cent in consumption, as indicated in the years 1964 to 1968, is exceeded.

The demand for tantalum improved in 1969, initial shipments of Canada's first tantalum production were delivered to customers in the latter part of the year and prices recovered to about $7 a pound of Ta_2O_5. Canada's expected production of about 500,000 pounds of tantalum pentoxide in 1970 would be about 20 per cent of 1968 non-communist world consumption. The indicated adequate supply over the near future should encourage consumption growth and contribute to price stability.

PRICES

The following prices are from *Metals Week* of December 29, 1969:

		U.S. Currency
Columbium ore		
Columbite, per lb Cb_2O_5, 10 to 1 ratio, c.i.f. U.S. ports, spot		$1.12 to 1.17
Pyrochlore, per lb Cb_2O_5		
Canadian, f.o.b. mine or mill		$1 to 1.05
Brazilian, f.o.b. shipping point, spot, six months contracts		95.5¢
Ferrocolumbium		
per lb Cb, ton lots, f.o.b. shipping point		
Low-alloy, standard grades		$2.65 – 3.52
High-purity grades		$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
Tanco, f.o.b. mine, 50% plus	$7
Tantalum metal	
powder, per lb, f.o.b. shipping point, depending on size of lot	$26–36
Mill products, depending on grade	
Sheet	$36–60
Rod	$36–50

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General
CANADA				
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		
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, 1969	8%
	" " Jan. 1, 1970	7%
628.17	Columbium, unwrought alloys	
	On and after Jan. 1, 1969	12%
	" " Jan. 1, 1970	10%
628.20	Columbium metal, wrought	
	On and after Jan. 1, 1969	14%
	" " Jan. 1, 1970	12.5%
629.05	Tantalum metal, unwrought, waste and scrap (Duty on waste and scrap suspended to June 3, 1971)	
	On and after Jan. 1, 1969	8%
	" " Jan. 1, 1970	7%
629.07	Tantalum, unwrought alloys	
	On and after Jan. 1, 1969	12%
	" " Jan. 1, 1970	10%
629.10	Tantalum metal, wrought	
	On and after Jan. 1, 1969	14%
	" " Jan. 1, 1970	12.5%

NOTE: Further tariff reductions on the above United States items will take place Jan. 1, 1971 and Jan. 1, 1972.

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.

Copper

A. F. KILLIN*

Non-communist world copper production in 1969 increased only 8.9 per cent from 1968 whereas consumption increased 10.4 per cent in the same period. Part of the shortfall was made up by increased scrap intake but there was no opportunity in the year to replenish inventories depleted by the United States strikes in 1967 and 1968. Despite production increases in many parts of the world, labour and production difficulties in Canada, Chile and Peru prevented a balance between supply and demand. New copper mines were brought into production in Canada, United States, Philippines and Australia, and mines were being developed to production in many countries including Zambia, Congo (Republic), Chile, Peru, Bougainville, West Irian, Spain, Mauritania, Australia and Turkey.

Strikes at mines in Ontario and Quebec reduced Canada's mine production to 558,228 tons valued at $574,193,275 from the 633,312 tons valued at $607,944,415 produced in 1968. Minor production decreases in Newfoundland, Nova Scotia, New Brunswick, Saskatchewan and the Northwest Territories were almost offset by increases in Manitoba, British Columbia and the Yukon Territory. The output of refined copper was also affected by strikes that closed smelters and one of Canada's two refineries. Production of refined copper in 1969 was 450,655 tons, some 8.6 per cent less than in 1968. The reduced availability of refined copper brought about a decrease in domestic consumption and in exports. Consumption in 1969 was 240,256 tons, about 5 per cent less than in 1968. Imports of refined copper for consumption rose from 5,824 tons in 1968 to 18,137 tons in 1969.

There was no decrease in exploration for new copper deposits in Canada. Major focus of the exploration effort was on British Columbia, Yukon and northwestern Ontario.

CANADIAN DEVELOPMENTS

The Canadian copper industry can be divided structurally into mining and milling; smelting; refining; and fabricating. Mine production in 1969 was obtained in eight provinces and the Yukon and Northwest Territories; smelter production in Quebec, Ontario and Manitoba and refinery production in Quebec and Ontario. The principal fabricating plants were in Quebec, Ontario and British Columbia but satellite plants were operating in other provinces.

The major producing provinces were: Ontario (228,944); Quebec (157,960); British Columbia (81,343); Manitoba (37,042); Newfoundland (19,389); and Saskatchewan (18,011). Lesser production was obtained from the Yukon Territory, New Brunswick, Northwest Territories and Nova Scotia.

Details of individual mine production and development are given in Table 3. The following résumé outlines the production and developments by provinces.

*Mineral Resources Branch.

TABLE 1

Canada, Copper Production, Trade and Consumption, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Production[1]				
Ontario	290,618	278,313,194	228,944	235,491,972
Quebec	167,600	161,231,875	157,960	162,476,885
British Columbia	80,562	77,459,262	81,343	83,670,058
Manitoba	34,583	33,268,918	37,042	38,101,218
Newfoundland	23,299	22,413,551	19,389	19,944,133
Saskatchewan	22,081	21,241,859	18,011	18,525,789
Yukon	5,298	5,097,157	7,860	8,084,127
New Brunswick	8,265	7,950,712	7,062	7,264,127
Northwest Territories	866	833,169	535	550,920
Nova Scotia	140	134,718	82	84,046
Total	633,312	607,944,415	558,228	574,193,275
Refined	524,956		450,655	
Exports				
Copper in ores, concentrates and matte				
Japan	112,610	110,437,000	108,891	128,350,000
Norway	22,944	18,355,000	22,855	18,331,000
United States	9,690	6,784,000	12,508	9,742,000
Sweden	6,730	5,718,000	3,736	4,559,000
West Germany	631	474,000	3,207	2,806,000
Spain	1,910	1,643,000	2,766	2,924,000
Other countries	7,320	5,941,000	3,853	3,869,000
Total	161,835	149,352,000	157,816	170,581,000
Copper in slag, skimmings and sludge				
United States	2,387	344,000	244	235,000
Japan	–	–	6	7,000
Belgium and Luxembourg	50	22,000	–	–
Spain	27	19,000	–	–
Total	2,464	385,000	250	242,000
Copper scrap (gross weight)				
West Germany	15,699	15,247,000	14,349	16,067,000
Spain	10,378	10,675,000	7,834	8,856,000
Belgium and Luxembourg	14,462	13,073,000	5,576	5,004,000
United States	10,812	10,413,000	4,052	3,833,000
Britain	1,480	1,363,000	2,129	2,303,000
Yugoslavia	2,449	2,432,000	1,866	1,962,000
Japan	2,255	2,113,000	1,288	1,264,000
Hungary	2,426	2,379,000	1,054	1,275,000
Other countries	5,222	4,912,000	1,887	2,098,000
Total	65,183	62,607,000	40,035	42,662,000
Brass and bronze scrap (gross weight)				
West Germany	8,422	6,541,000	9,033	8,675,000
United States	3,342	2,314,000	4,711	3,612,000
Japan	6,664	4,545,000	4,204	3,595,000
Belgium and Luxembourg	3,856	3,161,000	1,814	1,483,000

TABLE 1 (Cont'd)

	1968		1969P	
	Short Tons	$	Short Tons	$
Exports (Cont'd)				
Italy	2,592	1,659,000	1,271	936,000
Other countries	2,700	2,101,000	1,557	1,246,000
Total	27,576	20,321,000	22,590	19,547,000
Copper alloy scrap, n.e.s. (gross weight)				
West Germany	67	40,000	178	178,000
Belgium and Luxembourg	436	340,000	123	71,000
United States	140	80,000	117	150,000
Japan	278	165,000	88	68,000
Other countries	95	53,000	208	228,000
Total	1,016	678,000	714	695,000
Copper refinery shapes				
United States	134,248	133,250,000	83,689	86,714,000
Britain	103,395	114,979,000	80,813	90,720,000
France	10,550	10,768,000	15,312	17,315,000
West Germany	10,705	11,983,000	10,861	12,384,000
Japan	5,772	5,689,000	3,651	3,592,000
India	2,286	2,269,000	2,947	3,875,000
Brazil	1,134	1,010,000	2,634	2,903,000
Italy	1,338	1,394,000	2,172	2,323,000
Netherlands	2,953	2,646,000	1,915	2,268,000
Belgium and Luxembourg	963	874,000	1,460	2,025,000
Other countries	3,275	3,736,000	4,580	4,910,000
Total	276,619	288,598,000	210,034	229,029,000
Copper bars, rods and shapes, n.e.s.				
Switzerland	2,846	3,183,000	2,455	3,014,000
United States	5,854	7,588,000	2,269	3,023,000
Norway	4,077	4,568,000	1,433	1,653,000
Denmark	2,538	3,016,000	1,146	1,374,000
Britain	3,978	4,579,000	726	740,000
Iran	56	55,000	447	511,000
Dominican Republic	334	374,000	381	580,000
Pakistan	2,879	3,009,000	347	368,000
West Germany	910	917,000	336	349,000
Belgium and Luxembourg	–	–	329	436,000
Other countries	4,102	4,405,000	1,225	1,424,000
Total	27,574	31,694,000	11,094	13,472,000
Copper plates, sheet, strip and flat products				
United States	10,367	14,202,000	7,359	10,279,000
Britain	254	322,000	631	841,000
Venezuela	403	589,000	279	406,000
New Zealand	93	140,000	156	233,000
Uar-Egypt	–	–	68	105,000
Colombia	50	69,000	59	83,000
Other countries	39	61,000	140	201,000
Total	11,206	15,383,000	8,692	12,148,000
Copper pipe and tubing				
United States	10,021	14,835,000	11,563	13,876,000
New Zealand	670	1,127,000	812	1,364,000
Britain	584	908,000	658	971,000

TABLE 1 (Cont'd)

	1968		1969p	
	Short Tons	$	Short Tons	$
Exports (Cont'd)				
Israel	99	161,000	567	833,000
Philippines	242	379,000	327	448,000
Other countries	2,034	3,183,000	2,026	3,015,000
Total	13,650	20,593,000	15,953	20,507,000
Copper wire and cable, not insulated				
Iran	229	307,000	742	903,000
Iraq	–	–	717	798,000
United States	3,990	4,827,000	678	873,000
Yugoslavia	121	119,000	400	599,000
Other countries	1,234	1,479,000	959	1,158,000
Total	5,574	6,732,000	3,496	4,331,000
Copper alloy refinery, shapes, sections and flat products				
United States	7,573	8,624,000	11,075	13,524,000
Japan	693	566,000	604	601,000
Switzerland	–	–	379	447,000
Britain	301	387,000	210	284,000
Venezuela	192	248,000	130	181,000
Uar-Egypt	–	–	65	87,000
Other countries	582	837,000	253	344,000
Total	9,341	10,662,000	12,716	15,468,000
Copper alloy pipe and tubing				
United States	746	1,189,000	973	1,674,000
Japan	104	228,000	190	419,000
Kuwait	–	–	126	262,000
Taiwan	–	–	86	170,000
New Zealand	73	118,000	67	103,000
India	80	359,000	62	276,000
Other countries	449	736,000	221	404,000
Total	1,452	2,630,000	1,725	3,308,000
Copper alloy wire and cable, not insulated				
United States	245	391,000	526	707,000
Australia	6	12,000	40	81,000
Belgium and Luxembourg	–	–	30	31,000
Other countries	42	154,000	47	85,000
Total	293	557,000	643	904,000
Copper alloy fabricated materials, n.e.s.				
United States	507	1,236,000	702	1,470,000
West Germany	1	10,000	115	146,000
New Zealand	2	4,000	25	40,000
Other countries	376	118,000	39	80,000
Total	886	1,368,000	881	1,736,000
Wire and cable insulated[2]				
United States	7,073	9,529,000	11,771	20,962,000
Turkey	1,268	1,066,000	1,068	979,000
Panama	230	286,000	484	553,000
Philippines	829	1,565,000	479	812,000

TABLE 1 (Cont'd)

	1968		1969p	
	Short Tons	$	Short Tons	$
Exports (Cont'd)				
India	122	160,000	393	213,000
Bahamas	266	354,000	367	465,000
Puerto Rico	874	1,738,000	175	357,000
Netherlands Antilles	13	17,000	170	163,000
Bermuda	187	225,000	166	206,000
Venezuela	119	142,000	143	187,000
Bolivia	79	94,000	132	148,000
Libya	34	48,000	116	169,000
Other countries	2,770	3,647,000	1,227	1,993,000
Total	13,864	18,871,000	16,691	27,207,000
Imports				
Copper in ores, concentrates and scrap	51,151	47,772,000	7,839	7,579,000
Copper refinery shapes	5,824	5,640,000	18,137	20,883,000
Copper bars, rods and shapes (sections) n.e.s.	631	648,000	542	711,000
Copper plates, sheet, strip and flat products	499	723,000	644	1,151,000
Copper pipe and tubing	589	979,000	1,349	2,344,000
Copper wire and cable except insulated	89	204,000	531	1,002,000
Copper alloy scrap (gross weight)	17,547	13,573,000	7,839	2,167,000
Copper powder	339	555,000	399	724,000
Copper alloy refinery shapes, rods and sections	2,379	2,928,000	4,434	6,467,000
Brass plates, sheet and flat products	1,762	2,132,000	4,050	4,939,000
Copper alloy plates, sheet, strip and flat products	393	901,000	813	1,712,000
Copper alloy pipe and tubing	1,263	2,496,000	1,421	2,683,000
Copper alloy wire and cable, except insulated	705	1,317,000	785	1,668,000
Copper alloy castings[3]	202	447,000	239	610,000
Copper and alloy fabricated materials, n.e.s.	582	1,103,000	1,061	1,858,000
Insulated wire and cable	..	10,916,000	..	15,755,000
Copper oxides and hydroxides	160	204,000	168	221,000
Copper sulphate	416	180,000	1,347	535,000
Consumption[3]				
Refined	253,196		240,256	

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.
pPreliminary; – Nil; n.e.s. Not elsewhere specified; .. Not available.

NEWFOUNDLAND

Production in Newfoundland declined with the closure of one of the five producing mines in the province. At 19,389 tons in 1969, output was down 3,910 tons from 1968. The closure of the mine and plant of Atlantic Coast Copper Corporation Limited reduced Newfoundland's total daily mill capacity by 1,200 tons to 6,750 tons. The Newfoundland mines are small to medium sized with mill capacities varying from 1,250 to 2,000 tons of ore a day. With the exception of the Buchans mine, all concentrates were shipped to the Murdochville, Quebec smelter of Gaspé Copper Mines, Limited.

NOVA SCOTIA

All of the copper produced in Nova Scotia in 1969 was contained in the lead-copper concentrates produced at the Walton mine of Dresser Industries, Inc.

NEW BRUNSWICK

Three companies operating four mines in New Brunswick produced concentrates containing 7,062 tons of copper in 1969. Closure of the Wedge mine in late 1968 resulted in a decrease in output in 1969 of

14.5 per cent. Heath Steele Mines Limited revised and expanded its mill circuits from 1,600 tons of ore a day to 3,000 tons a day, and mine capacity was adjusted to suit. Many companies were exploring for copper and copper-zinc deposits in New Brunswick with major emphasis in the Bathurst and St. Stephen-Mount Pleasant areas. A low-grade deposit was under investigation in the vicinity of Woodstock. Anaconda American Brass Limited and Cominco Ltd. announced plans to mine by open pit a copper deposit adjacent to the lead-zinc orebody on the Caribou property. Production was scheduled at 1,000 tons of copper ore a day in 1970. Metallurgical testing of the lead-zinc ore was continued.

QUEBEC

Although production continued to decline, Quebec was Canada's second largest copper-producing province in 1969. Production from the province's 27 mines totalled 157,960 tons, down 9,640 tons from 1968. Production was obtained from five distinct copper districts: Gaspé Peninsula (three producers, one developing); Eastern Townships (two producers, two developing); Chibougamau-Chapais (ten producers, one developing); Mattagami-Joutel (six producers); Noranda-Val d'Or (six producers, one developing). Copper smelters were operated at Noranda and Murdochville, and a copper refinery at Montreal East.

ONTARIO

Despite strikes at the Sudbury operations of The International Nickel Company of Canada, Limited and Falconbridge Nickel Mines, Limited, and the Manitouwadge property of Noranda Mines Limited's Geco Division, Ontario was again Canada's leading copper producing province. Thirty-six mines operated by 15 companies produced concentrates containing 228,944 tons of copper. The decrease in output of 61,674 tons from 1968 was mainly because of the aforementioned strikes. The major Ontario copper producing areas were: Sudbury (20 mines, nine mills, three smelters, one refinery); Timmins (five mines, four mills); and Manitouwadge (four mines, two mills). Minor production was obtained from the Batchawana area north of Sault Ste. Marie (two mines, two mills). Exploration and development of new mines was proceeding near Shebandowan, Uchi Lake and Sturgeon Lake in northwestern Ontario.

MANITOBA

Hudson Bay Mining and Smelting Co., Limited was Manitoba's largest copper producer in 1969. The company operated two mines, a mill and a smelter in the Flin Flon area, three mines in the Snow Lake area and will develop three more mines in the latter area for production. Sherritt Gordon Mines, Limited continued production from its nickel-copper mine and mill at Lynn Lake and began operations at its Fox Lake, copper-zinc mine and mill at mid-year. Sherritt has discovered a copper-zinc deposit at Ruttan Lake in northern Manitoba and has pursued a program of exploration and development at this property.

Production of copper in Manitoba rose to 37,042 tons in 1969 from 34,583 tons in 1968.

TABLE 2

Canada, Copper Production, Trade and Consumption, 1960-69
(short tons)

	Production		Exports			Imports	Consumption[2]
	All Forms[1]	Refined	Ore and Matte	Refined	Total	Refined	Refined
1960	439,262	417,029	47,633	278,066	325,699	25	117,637
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[r]
1968	633,312	524,956	161,835	276,619	438,454	5,824	253,196
1969[p]	558,228	450,655	157,816	210,034	367,850	18,137	240,256

Source: Dominion Bureau of Statistics.
[1] Blister copper plus recoverable copper in matte and concentrate exported. [2] Producers' domestic shipments, refined copper.
[p] Preliminary; [r] Revised.

TABLE 3

Producing Companies, 1969

Company and Location	Mill or Mine Capacity (tons ore/day)	Ore Produced 1969 (1968) (short tons)	Grade (%)			Developments
			Copper	Zinc	Nickel	
NEWFOUNDLAND						
American Smelting and Refining Company (Buchans Unit), Buchans	1,250	371,000 (378,000)	1.12	12.78	–	Routine exploration and development.
Atlantic Coast Copper Corporation Limited, Little Bay	1,200	295,070 (346,289)	0.84	–	–	Mine closed October 30.
British Newfoundland Exploration Limited, Whalesback mine, Springdale	2,000	718,490 (725,867)	0.86	–	–	Routine exploration and development.
Consolidated Rambler Mines Limited, Baie Verte East mine	1,500	404,181 (361,853)	0.99	–	–	Extensive on-property exploration by surface geochemical surveys and diamond drilling. Routine mine development.
First Maritime Mining Corporation Limited, Badger Gullbridge mine	2,000	611,898 (598,429)	0.97	–	–	Preparation of surface ore for open-pit mining. Exploration of new ore zones underground.
NOVA SCOTIA						
Dresser Minerals Division of Dresser Industries, Inc., Walton		49,870 (49,786)	0.28	0.58	–	Exploration of lower levels from shaft deepened in 1968.
NEW BRUNSWICK						
Brunswick Mining and Smelting Corporation Limited, Bathurst						
No. 6 mine	2,500	1,134,224 (948,280)	0.35	5.78	–	Routine open-pit mining. New jaw crusher installed at the mine.
No. 12 mine	5,000	1,696,408 (1,724,465)	0.33	8.05	–	
Heath Steele Mines Limited, Bathurst – Newcastle	3,000	321,403 (391,363)	1.46	4.00	–	Milling capacity increased to 3,000 t.p.d. from 1,600 t.p.d. necessitating 5-month production delay.
Nigadoo River Mines Limited, Robertville	1,000	328,709 (284,867)	0.37	2.66	–	Routine exploration and development.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Ore Produced 1969 (1968) (short tons)	Grade (%) Copper	Grade (%) Zinc	Grade (%) Nickel	Developments
QUEBEC						
Bell Allard Mines Limited, Matagami	370	97,354 (98,037)	0.88	8.50	–	Mining suspended in September. Surface exploration and diamond drilling.
Campbell Chibougamau Mines Ltd., (Main, Cedar Bay and Henderson mines) Chibougamau	3,500	1,196,849 (739,270)	1.56	–	–	New ore zones being explored and developed in Cedar Bay and Henderson mines. Re-evaluation of remaining ore in purchased Merrill Island mine.
Sullivan Mining Group Ltd. (Cupra Division) formerly Cupra Mines Ltd., Stratford Centre	1,500 (mills Solbec ore)	246,009 (225,702)	2.52	3.38	–	Development of ore zone on three new levels from recently deepened shaft.
Delbridge Mines Limited, Noranda	500 (ore trucked to Quemont mill)	57,494 (–)	0.70	10.30	–	Production started October 1st.
Gaspé Copper Mines, Limited, Murdochville	11,000	2,997,800 (3,933,388)	1.01	–	–	Routine exploration and development. Property on strike from May 13 to August 18.
Grandroy Mines Limited, Chibougamau	–	8,931 (117,637)	0.49	–	–	Mine closed in 1968. Clean-up in 1969.
Icon Syndicate, Chibougamau	600 (ore trucked to Merrill Island mill)	225,000 (192,269)	3.20	–	–	Open-pit and underground mining.
Joutel Copper Mines Limited, Joutel	700 (ore trucked to Mines de Poirier mill)	241,899 (242,457)	2.26	–	–	Routine mining and development. New orebody located at depth.
Lake Dufault Mines, Limited, Noranda	1,300	405,790 (415,009)	1.71	2.21	–	Shaft sinking continued on new D-134 zone, 3 miles south of main shaft.
Madeleine Mines Ltd., Gaspé Provincial Park	2,500	402,146 (–)	1.20	–	–	Production started mid-June.
Manitou-Barvue Mines Limited, Val d'Or	1,300	368,675 (466,410)	0.54	2.72	–	Routine mining and exploration. Copper ore reserves will be exhausted in 1970. Preparation for custom milling.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Ore produced 1969 (1968) (short tons)	Grade (%) Copper	Zinc	Nickel	Developments
Mattagami Lake Mines Limited, Matagami	3,850	1,413,651 (1,363,705)	0.62	9.60	–	Routine exploration and development of known ore. Underground exploration of low-grade copper-nickel zone by diamond drilling.
New Hosco Mines Limited, Matagami	900 (ore trucked to Orchan mill)	277,768 (327,715)	0.94	1.79	–	Surface exploration. Exploration for downward extensions of orebody by diamond drilling below the bottom level.
Noranda Mines Limited, Noranda	3,200	754,365 (773,765)	2.25	–	–	Routine mining of remaining ore reserves.
Normetal Mines Limited, Normetal	1,000	355,495 (358,557)	1.67	6.65	–	Routine mining of remaining ore reserves.
Opemiska Copper Mines (Quebec) Limited, Chapais	2,000	792,549 (744,466)	2.61	–	–	Routine mining and exploration of Springer and Perry mines, development and exploration of Beaver Lake orebody from Robitaille shaft. New ore zone discovered south of Campbell Lake fault.
Orchan Mines Limited, Matagami	1,900 (mills ore from New Hosco)	308,732 (269,084)	1.04	11.53	–	Routine mining and development of known ore. Exploration for ore extensions and new orebodies by drifting and diamond drilling.
The Patino Mining Corporation, Copper Rand Mines Division (Machin Point, Portage, Jaculet and Copper Cliff mines), Chibougamau	2,000	731,953 (708,134)	2.06	–	–	Preparation of Copper Cliff mine for production in 1970. Deepening Portage Island shaft. Preparation for mill capacity increase in 1970.
Quemont Mines Limited, Noranda	2,300 (mills ore from Delbridge)	334,432 (429,309)	0.78	1.96	–	Routine mining of remaining ore reserves.
Renzy Mines Limited, Hainault Township	800	88,049 (–)	0.57	–	0.54	Production started from the open pit in July at 500 tons of ore a day and expanded to 800 tons a day. Mill capacity will be expanded to 1,000 tons a day in 1970.
Rio Algom Mines Limited, Mines de Poirier mine, Joutel	2,500 (mills ore from Joutel)	521,886 (567,000)	1.98	–	–	Continued development of lower levels. Exploration of ore zone by diamond drilling.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Ore produced 1969 (1968) (short tons)	Grade (%)			Developments
			Copper	Zinc	Nickel	
Sullivan Mining Group Ltd., Solbec mine, Stratford Centre	400 (ore milled at Cupra)	185,288 (262,076)	1.07	4.21	–	Routine mining of remaining ore reserves.
ONTARIO						
Canadian Jamieson Mines Limited, Timmins	450	196,140 (165,526)	2.50	4.40	–	Routine development of remaining ore reserves. Continued exploration of the ore zone by underground diamond drilling.
Consolidated Canadian Faraday Limited, Werner Lake Division, Gordon Lake	1,200 (mills ore from Dumbarton)	177,726 (207,417)	0.39	–	0.82	Routine development. Mill capacity increased to treat ore from Dumbarton mine in Manitoba.
Copperfields Mining Corporation Limited, Temagami	200	40,936 (50,321)	3.45	–	–	Shaft deepened two levels. Continued exploration and development.
Ecstall Mining Limited (Texas Gulf Sulphur Company), Kidd Creek mine, Timmins	9,000	3,617,226 (3,614,860)	..	..	–	Continued open-pit mining. Start of ramp to develop orebody underground. Clearing of site for zinc refinery.
Falconbridge Nickel Mines, Limited, (Falconbridge, East, Strathcona, Hardy, Fecunis Lake, Onaping, North and Longvac South mines), Falconbridge	3,000 (Falconbridge) 1,500 (Hardy) 2,400 (Fecunis) 6,000 (Strathcona)	3,118,000 (3,208,000)	..	–	..	Operations closed by labour dispute for three months. Development of Lockerby mine continued.
The International Nickel Company of Canada, Limited, (Frood, Stobie, Creighton, Garson, Levack, Copper Cliff North, Crean Hill, Totten, Murray and Maclennan mines, Clarabelle and Crean Hill open pits), Copper Cliff	30,000 (Copper Cliff) 12,000 (Creighton) 6,000 (Levack) 22,500 (Frood-Stobie)	14,578,700 (20,808,500)	..	–	..	Operations hampered by a strike from July 10 to November 17. Development of four new mines in the Sudbury area delayed. Announcement of construction of new mill and refinery at Copper Cliff.
Jameland Mines Limited, Timmins	700 (milled at Kam-Kotia)	26,931 (–)	1.38	0.25	–	Production started in November. Exploration and development of lower levels underway.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Ore Produced 1969 (1968) (short tons)	Grade (%)			Developments
			Copper	Zinc	Nickel	
Kam-Kotia Mines Limited, Timmins	2,500 (mills Jameland ore)	817,716 (669,400)	1.21	3.22	–	Expanding mill to 2,700 tons a day to handle Jameland ore. Underground exploration including adjoining property.
McIntyre Porcupine Mines Limited, Schumacher	2,000	741,440 (635,000)	0.78	–	–	Exploration and development to maintain ore reserves. Changeover from slushers to load-haul-dump equipment.
Noranda Mines Limited, Geco Division, Manitouwadge	4,000	1,320,000 (1,495,369)	2.48	4.90	–	Operations hampered by strike that started November 22. Mill capacity to be expanded.
North Canadian Enterprises Limited, Coppercorp mine, Point Mamainse	500	161,488 (142,986)	1.46	–	–	Development of known ore. Exploration for ore extensions by surface and underground diamond drilling.
Rio Algom Mines Limited, Pronto Division, Spragge	750	241,622 (258,823)	1.90	–	–	Routine mining of remaining ore reserves. Mine expected to close in early 1970.
Spanish River Mines Limited, Sudbury	500 (ore milled at Kidd Copper mill)	80,000 (–)	1.30	–	–	Operations started in June. Decline started to open new level for development.
Tribag Mining Co., Limited, Batchawana Bay	400	177,339 (157,787)	1.93	–	–	Routine mining and exploration in the Breton zone. Development and mining started in the West Breccia zone.
Upper Beaver Mines Limited, Dobie	150 (ore trucked to Upper Canada Mines Limited)	62,297 (62,085)	1.29	–	–	Shaft deepening and installation of new loading pocket. Production increase and installation of new ball mill in Upper Canada plant.
Willecho Mines Limited, Manitouwadge	1,000 (ore trucked to Willroy mill)	318,149 (346,444)	0.44	4.06	–	New incline being driven to permit mining below the 1,350-foot level.
Willroy Mines Limited, Manitouwadge	1,700 (mills ore from Willecho)	127,300 (174,336)	0.91	2.38	–	Routine mining and exploration.

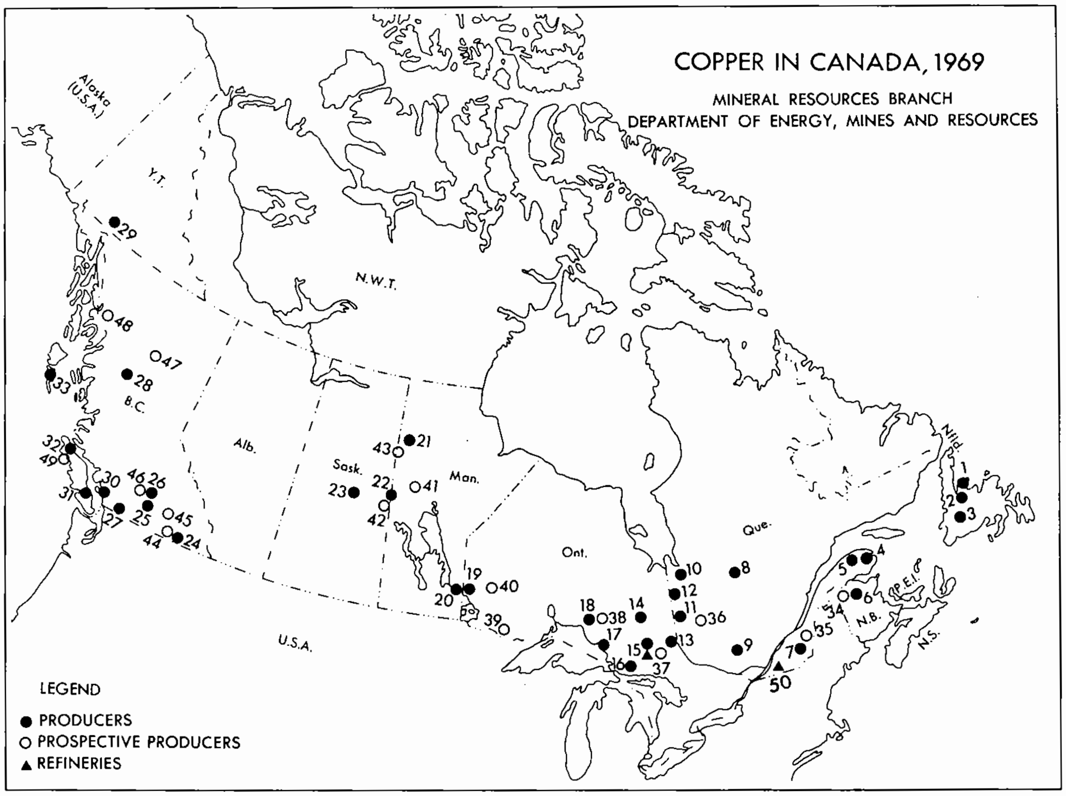
TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Ore produced 1969 (1968) (short tons)	Grade (%)			Developments
			Copper	Zinc	Nickel	
MANITOBA						
Dumbarton Mines Limited, Bird River	700 (ore trucked to Consolidated Canadian Faraday mill)	66,395 (–)	0.26	–	0.77	Mine started production in September. Routine development.
Hudson Bay Mining and Smelting Co., Limited, Flin Flon	6,000	1,702,000 (1,610,000)	2.70	4.30	–	Routine mining and exploration at developing properties. Anderson Lake mine being developed for production in 1970.
Sherritt Gordon Mines, Limited, Lynn Lake	3,500	1,258,193 (1,276,517)	..	–	..	Continued underground exploration by drifting and diamond drilling. Ore reserves maintained.
SASKATCHEWAN						
Hudson Bay Mining and Smelting Co., Limited, (Flin Flon and Flexar mines), Flin Flon, Man.		See Manitoba				Flexar mine started production in April. Ore is trucked to Flin Flon.
Rio Algom Mines Limited, Anglo-Rouyn mine, Waden Bay	900	274,523 (279,797)	1.79	–	–	Exploration and development of A and B zones. Open-pit mining of new ore zone started.
Western Nuclear Mines, Ltd., Hanson Lake	350	59,718 (60,789)	0.57	10.42	–	Routine mining of remaining ore reserves. Mine expected to close in 1970 when ore reserves are exhausted.
BRITISH COLUMBIA						
Anaconda Britannia Mines Ltd., (Formerly The Anaconda Company (Canada) Ltd., Britannia Division) Britannia Beach	3,000	605,273 (604,676)	1.18	0.17	–	Shaft sinking below the 4,100-level to develop the 040 zone. Continued surface and underground exploration.
Bethlehem Copper Corporation Ltd., Highland Valley	14,000	5,236,914 (5,080,664)	0.53	–	–	Continued open-pit mining of Jersey orebody. Stripping of overburden from Heustis orebody in preparation for mining.
Cominco Ltd., Coast Copper mine, Benson Lake	750	281,000 (241,500)	..	–	–	Decline being driven below 5,100 level to develop new mining levels.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Ore Produced 1969 (1968) (short tons)	Grade (%)			Developments
			Copper	Zinc	Nickel	
Craigmont Mines Limited, Merritt	5,000	1,810,855 (1,763,123)	1.02	–	–	Continued development and underground mining. Exploration for ore extensions by diamond drilling. Installation of magnetic separation circuit to mill to recover magnetite concentrate.
Falconbridge Nickel Mines, Limited, Wesfrob mine, Tasu Harbour, Q.C.I.	10,000	871,809 (1,570,626)	0.90	–	–	Copper concentrate produced as a by-product of iron mining and beneficiation. Exploration planned to west of open pit.
Giant Mascot Mines Limited, Hope	1,300	337,056 (338,340)	0.40	–	0.83	Continued exploration and development. Ore reserves increased by discovery of 4,600 ore zone. Mill capacity will be increased.
The Granby Mining Company Limited, Granisle mine, Babine Lake	5,000	2,329,957 (2,230,210)	0.60	–	–	Open-pit mining. Further delimitation of orebody by diamond drilling.
The Granby Mining Company Limited, Phoenix Copper Division, Greenwood	2,400	759,299 (698,796)	0.75	–	–	Mill capacity expanded from 1,900 t.p.d. to 2,400 t.p.d.
Texada Mines Ltd., Vananda	4,000	1,414,925 (. .)	0.22	–	–	Byproduct production from iron mining. Routine mining and development.
Western Mines Limited, Buttle Lake, V.I.	1,000	383,931 (330,223)	1.83	7.67	–	Extensive surface and underground exploration.
YUKON TERRITORY						
New Imperial Mines Ltd., Whitehorse	2,500	805,519 (732,095)	1.09	–	–	Open-pit mining at Warl Eagle orebody. Driving of decline to provide drilling stations to explore deep ore under the Little Chief open pit.

Source: Company Reports.
. . Not available; – Nil.



PRODUCERS

(Numbers refer to numbers on map)

1. Atlantic Coast Copper Corp. Ltd.
   British Newfoundland Expl. Ltd. (Whalesback Pond)
   Consolidated Rambler Mines Ltd.
2. First Maritime Mining Corp. Ltd. (Gullbridge)
3. American Smelting and Refining Co. (Buchans unit)
4. Gaspé Copper Mines, Ltd.
5. Madeleine Mines Ltd.
6. Brunswick Mining and Smelting Corp. Ltd. (No. 6 and No. 12 mines)
   Heath Steele Mines Ltd.
   Nigadoo River Mines Ltd.
7. Sullivan Mining Group Ltd. (Solbec mine and Cupra mine)
8. Campbell Chibougamau Mines Ltd. (3 mines)
   Opemiska Copper Mines (Quebec) Ltd.
   The Patino Mining Corp., Copper Rand Mines Division (4 mines)
   Grandroy Mines Ltd.
   Icon Syndicate
9. Renzy Mines Ltd.
10. Bell Allard Mines Ltd.
    Joutel Copper Mines Ltd.
    Mattagami Lake Mines Ltd.
    New Hosco Mines Ltd.
    Orchan Mines Ltd.
    Rio Algom Mines Ltd. (Mines de Poirier mine)
11. Delbridge Mines Ltd.
    Lake Dufault Mines Ltd.
    Manitou-Barvue Mines Ltd.
    Noranda Mines Ltd.
    Quemont Mines Ltd.
12. Normetal Mines Ltd.
13. Copperfields Mining Corp. Ltd. (Temagami mine)
14. Canadian Jamieson Mines Ltd.
    Ecstall Mining Ltd.
    Jameland Mines Ltd.
    Kam-Kotia Mines Ltd.
    McIntyre Porcupine Mines Ltd.
    Upper Beaver Mines Ltd.
15. Falconbridge Nickel Mines, Ltd. (8 mines, 1 smelter)

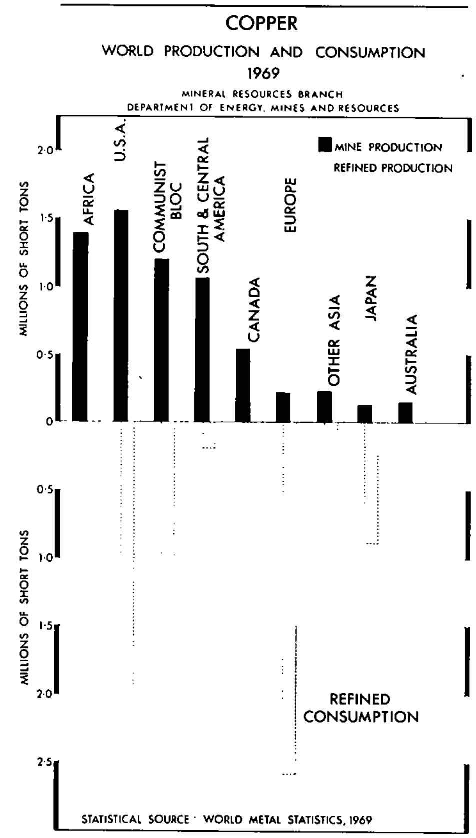
The International Nickel Company of Canada, Ltd. (12 mines, 2 smelters, 1 refinery)
Spanish River Mines Ltd.
16. Rio Algom Mines Ltd. (Pronto Division)
17. North Canadian Enterprises Ltd.
(Coppercorp mine) Tribag Mining Co., Ltd.
18. Noranda Mines Ltd. (Geco Division)
Willecho Mines Ltd.
Willroy Mines Ltd.
19. Consolidated Canadian Faraday Ltd.
20. Dumbarton Mines Ltd.
21. Sherritt Gordon Mines, Ltd.
22. Hudson Bay Mining and Smelting Co., Ltd. (5 mines, 1 smelter)
23. Rio Algom Mines Ltd. (Anglo-Rouyn mine)
Western Nuclear Mines, Ltd.
24. The Granby Mining Co., Ltd. (Phoenix Division)
25. Craigmont Mines Ltd.
26. Bethlehem Copper Corp. Ltd.
27. Giant Mascot Mines Ltd.
28. The Granby Mining Co. Ltd. (Granisle mine)
29. New Imperial Mines Ltd.
30. Anaconda Britannia Mines Ltd.
31. Western Mines Ltd.
32. Cominco Ltd. (Coast Copper mine)
33. Falconbridge Nickel Mines, Ltd. (Wesfrob mine)

PROSPECTIVE PRODUCERS

34. The Anaconda Company (Canada) Ltd., (Caribou mine)
35. D'Estrie Mining Company Ltd.
Weedon Mines Ltd.
36. Louvem Mining Company Inc.
37. Falconbridge Nickel Mines, Ltd. (1 mine)
The International Nickel Company of Canada, Ltd. (5 mines, 1 mill, 1 refinery)
38. Big Nama Creek Mines Ltd.
39. The International Nickel Company of Canada, Ltd. (Shebandowan mine)
40. Selco Exploration Company Ltd. (South Bay mine)
41. Falconbridge Nickel Mines, Ltd.
Hudson Bay Mining and Smelting Co., Ltd. (2 mines)
42. Hudson Bay Mining and Smelting Co., Ltd. (1 mine)
43. Sherritt Gordon Mines Ltd. (Fox Lake mine)
44. Aabro Mining & Oils Ltd.
45. Brenda Mines Ltd.
46. Lornex Mining Corp. Ltd.
47. Churchill Copper Corp. Ltd.
48. Granduc Mines, Ltd.
49. Utah Construction and Mining Co.

REFINERIES

15. The International Nickel Company of Canada, Ltd.
50. Canadian Copper Refineries Ltd.



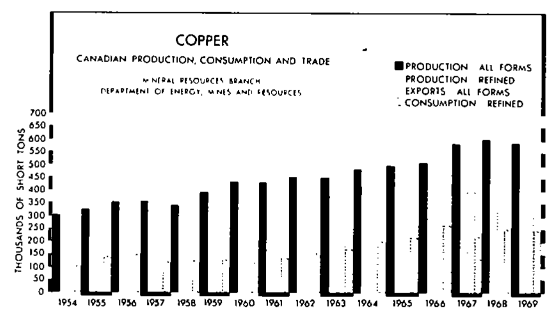


TABLE 4

Prospective Producing Companies* 1969

Company and Location	Type of Ore	Mill or Mine Capacity (tons ore/day)	Production to Start	Destination of Concentrates
NEW BRUNSWICK				
The Anaconda Co., (Canada) Ltd., Caribou mine, Bathurst	Cu	1,000	1970	..
QUEBEC				
D'Estrie Mining Company Ltd., Stratford Centre	Cu, Zn	.. (will be milled at Cupra)	1970	Export market
Louvem Mining Company Inc., Louvicourt Township	Cu	800	1970	Ore will be trucked to Manitou-Barvue mill
Weedon Mines Ltd., Disraeli	Cu	.. (ore will be trucked to Cupra mill)	1970	Export market
ONTARIO				
Big Nama Creek Mines Limited, Manitouwadge	Zn,Cu	.. (will be milled at Willroy)	1970	Noranda
The International Nickel Company of Canada, Limited, Copper Cliff				
Copper Cliff North	Ni, Cu	8,000 (will be treated at Copper Cliff)	1970	Own smelter
Kirkwood	Ni, Cu	1,500 (will be treated at Copper Cliff)	1970	Own smelter
Little Stobie	Ni, Cu	8,000 (will be milled at Stobie)	1971	Own smelter
Copper Cliff South	Ni, Cu	6,000 (will be milled at new Clara-belle mill)	1972	Own smelter
Coleman	Ni, Cu	4,000 (will be milled at new Clara-belle mill)	1972	Own smelter
The International Nickel Company of Canada, Limited, Shebandowan	Ni, Cu	3,000	1972	Own smelter at Copper Cliff
Falconbridge Nickel Mines, Limited, Lockerby mine, Falconbridge	Ni, Cu	..	..	Own smelter

TABLE 4 (Cont'd)

Company and Location	Type of Ore	Mill or Mine Capacity (tons ore/day)	Production to Start	Destination of Concentrates
Selco Exploration Company Limited, South Bay mine, Uchi Lake	Cu, Zn	500	1971	..
MANITOBA				
Falconbridge Nickel Mines, Limited, Manibridge mine, Bowden Lake	Ni, Cu	750	1971	Own smelter
Hudson Bay Mining and Smelting Co., Limited, Snow Lake				
Anderson Lake mine	Cu, Zn	1,000	1970	Own smelter
Dickstone mine	Cu, Zn	..	1970	Own smelter
Sherritt Gordon Mines Limited, Lynn Lake				
Fox Lake mine	Cu, Zn	3,000	1970	Japan
BRITISH COLUMBIA				
Aabro Mining & Oils Ltd., Greenwood	Cu	2,000	1970	Tacoma, Wash.
Brenda Mines Ltd., Peachland	Cu, Mo	24,000	1970	Japan
Churchill Copper Corporation Ltd., Magnum Creek	Cu	750	1970	..
Granduc Mines, Limited, Unuk River	Cu	7,000	1970	Tacoma, Wash.
Lornex Mining Corporation Ltd., Highland Valley	Cu, Mo	38,000	1972	Japan
Utah Construction and Mining Co., Coal Harbour, V.I.	Cu, Mo	33,000	1971	Japan

Source: Company reports.
*Only mines with announced production plants.
. .Not available.

SASKATCHEWAN

Hudson Bay operated its Saskatchewan portion of the Flin Flon deposit and started production in April at the Flexar mine. Rio Algom Mines Limited continued production from the Anglo-Rouyn mine and mill at Waden Bay. In the same area the Hanson Lake mine of Western Nuclear Mines, Ltd. was closed in July when ore reserves were exhausted.

BRITISH COLUMBIA

Copper output in British Columbia was stable throughout 1969. Production at 81,343 tons was only 781 tons more than in 1968. It is expected that production from the Brenda mine will bring about a sharp increase in output in 1970. Several large, low-grade bulk copper deposits are being developed for production or are being explored to the feasibility stage. The Highland Valley-Merritt district of south central British Columbia continued as one of the major producing areas and one of the most active areas of exploration. Bethlehem Copper Corporation Ltd. in the Highland Valley and Craigmont Mines Limited near Merritt together accounted for 50 per cent of the province's total output of copper. Lornex Mining Corporation Ltd. completed financing to bring its property in the Highland Valley into production in 1972. Valley Copper Mines Limited continued exploration of a multi-million ton copper deposit adjacent to Lornex. A production feasibility study should be completed in May, 1970. On northern Vancouver Island, Utah Construction & Mining Co. was preparing an open-pit mine and a 33,000-ton-a-day mill for production in 1971. The start-up at Granduc Mines, Limited north of Stewart was delayed by labour problems.

TABLE 5

Canadian Copper and Copper-Nickel Smelters

Operator and Location	Product	Rated Annual Capacity (short tons)	Remarks	Ore and Concentrate Treated 1969 (short tons)	Blister or Anode Copper Produced 1969 (short tons)
Falconbridge Nickel Mines, Limited, Falconbridge, Ont.	Copper-nickel matte	650,000 (ores and concentrates)	Copper-nickel ore and prepared 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	300,000 (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.	269,000 (of which 84,000 were custom concentrates)	49,400
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.	400,500 (of which 32,100 were custom concentrates)	42,302
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 concentrates; 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.	..	..

TABLE 5 (Cont'd)

Operator and Location	Product	Rated Annual Capacity (short tons)	Remarks	Ore and Concentrates Treated 1969 (short tons)	Blister or Anode Copper Produced 1969 (short tons)
			Electric-furnace melting of copper sulphide and conversion to blister copper.		
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.	1,588,500 (of which 776,500 were custom material)	220,700

Source: Company reports.
.. Not available.

TABLE 6

Copper Refineries in Canada, 1969

Refinery	Products
Canadian Copper Refiners Limited, Montreal East, Quebec. (subsidiary of Noranda Mines Limited)	Rated annual capacity: 342,000 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: 168,000 tons (will be expanded). 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.

WORLD MINE PRODUCTION AND OUTLOOK

The accompanying graph on copper production and consumption illustrates much about the world structure of the copper industry. The communist bloc countries have a virtual balance in supply and consumption. The excess refined output can probably be explained by re-processed scrap.

In the non-communist world, mine production is concentrated in Africa, United States, South America and Canada. United States, Japan and Europe have excess refinery capacity indicating that, in addition to scrap, these areas must import ores, concentrates and blister copper to maintain full production.

Ninety-three per cent of the copper consumed in the non-communist world is used in United States, Europe, Japan and Canada. These areas produce 76 per cent of the refined copper and only 46 per cent of mine output, outside of the centrally planned countries. From this it can be seen that about 51 per cent of the non-communist world's copper is produced from the mines in lesser developed areas that consume about 8 per cent of the total output. Most of the lesser developed producing countries derive a major portion of their national revenue from the copper mining industry and these countries are moving rapidly to increase production and to increase the national participation in the mining industry. This increased participation has taken the form of government financial participation in the mining-refining complexes, i.e., Chile and Congo (Kinshasa), or of increased taxation and/or retention of part or all of the profits within the country for reinvestment, i.e., Zambia and Peru.

The major African and South American producing countries have formed an association to study the interrelationship of markets, supply and prices. It is expected that this organization will make recommendations to their respective government organizations on actions that might be taken to ensure a stable and reasonably profitable price level.

New copper production is scheduled in many countries including Canada, United States, Chile, Peru, Philippines, Yugoslavia, Australia and Bougainville. World estimates of production expansions in non-communist areas vary, but a check of published information indicates the following increases in mine production by 1973: Canada, 256,000 tons; United States, 250,000 tons; Chile, 580,000 tons; Peru, 155,000 tons; Zambia, 75,000 tons; other 500,000 tons; a total of 1,816,000 tons. There is a good possibility that this rate of production expansion will continue to 1975. Non-communist world production of refined copper by 1973 should approximate 8,000,000 tons, allowing for 19 per cent of supply from scrap. If consumption to 1973 rises at an average 4.5 per cent a year there will be an indicated surplus of about 500,000 tons of copper in 1973. If a surplus of this magnitude develops it will have a depressing effect on copper prices and will probably slow the rate of mine development.

TABLE 7

Canada, Consumption of Primary Copper in Manufacture of Semi-fabricated Products, 1967-68 (short tons)

	1967	1968
Copper mill products, sheet, strip, bars, rolls, pipe, tube, etc.	50,338	60,707
Brass mill products–plate, sheet, strip, rods, bars, rolls, pipe, tubes, etc.	12,942	12,287
Wire and rod mill products	83,908	92,695
Miscellaneous	1,534	1,372
Total	148,722	167,061

USES

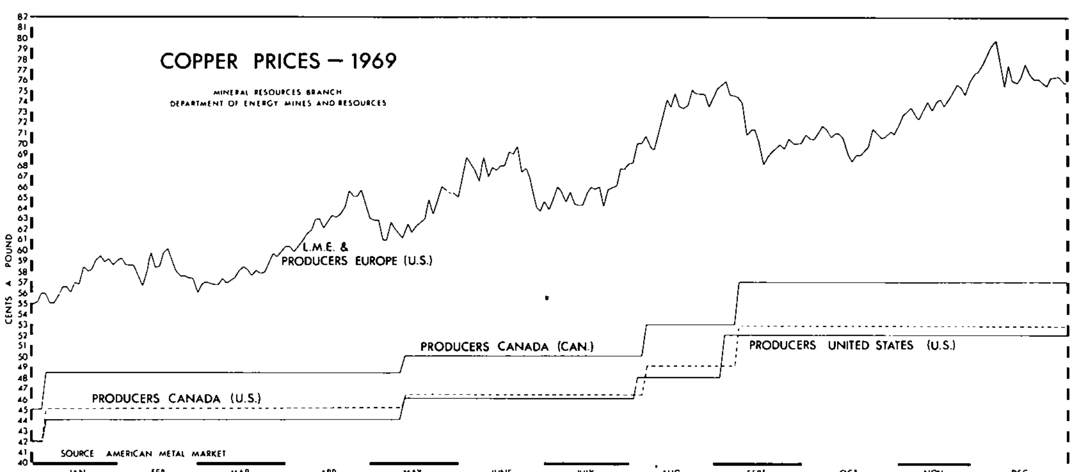
Copper's properties of malleability, ductility, conductivity, corrosion resistance, alloying qualities and pleasing appearance make its use universal in the electrical, construction, plumbing and automotive industries. Approximately half of all copper consumed is for electrical applications, including power transmission, electronics and electrical equipment, and transportation. Generation and utilization of electrical energy requires very large quantities of copper for heat exchangers, bus bars, magnet wire, and windings in motors, generators and transformers.

The 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 for radiators, wires, bearings, bushings, switches and oil lines.

The principal copper and brass fabricators in Canada are: in British Columbia–Noranda Copper Mills Ltd., Western Division, Vancouver; in Ontario–Anaconda American Brass Limited, Toronto, Phillips Cables Limited, Brockville, Ratcliffs (Canada) Limited, Richmond Hill, Wolverine Tube Division of Calumet & Hecla (Canadian) Limited, London; in Quebec–Noranda Copper Mills Ltd., Eastern Division, Montreal East, Pirelli Canada Ltd. (Pirelli Cables Limited), St. John's and Northern Electric Company, Limited, Montreal.

PRICES

Copper pricing varies with the area in which the metal is produced and sold. In 1969 there were two major pricing areas, North America and non-North America. In the North American market, the major producers in Canada and the United States sold their copper at equivalent producer-quoted prices in their respective domestic markets. Outside of North America the producer price for copper in the non-communist world was based on the spot price on the London Metal Exchange (LME). World consumption and supply was in virtual balance in the year and the continued high level of industrial activity plus sporadic supply interruptions owing to labour stoppages and equipment breakdowns prevented replenishment of inventories. Continued demand for consumption and inventory building maintained steady pressure on available supplies and prices rose during the year in all markets. The Canadian producers price rose in four steps by 26.7 per cent from 45 cents to 57 cents a pound; the United States producers price, in four steps, 24 per cent from 42 cents (U.S.) to 52 cents (U.S.) a pound; and the LME price, 38 per cent from 55 cents (U.S.) to 76 cents (U.S.) a pound. The LME price fluctuated daily in response to various market developments.



TARIFFS

Copper entering Canada in ores and concentrates is not subject to tariff. Various tariff rates are in effect for the copper content in bars, rod, wire, semi-fabricated forms and fully processed products entering the country.

The United States tariff on copper entering the country in ores, concentrates and primary shapes remains suspended. The duty prior to January 1, 1968 was 1.7 cents a pound of contained copper. This has subsequently reduced under GATT provisions to 1.1 cents a pound effective January 1, 1970. On fabricated products an ad valorem duty that varies with the type of product is added to the basic tariff on copper content.

TABLE 8

World Copper Mine Production, 1968-69
(short tons)

	1968	1969p
United States	1,204,621	1,558,000
Communist Countries	1,074,776	1,100,000
Chile	729,348	730,000
Zambia	732,910	750,000
Canada	633,312	558,228
Congo (Kinshasa)	353,311	350,000
Peru	235,356	250,000
Republic of South Africa	141,351	..
Japan	131,934	..
Australia	117,680	..
Other countries	564,195	850,000
Total	5,918,794	6,146,228

Source: U.S. Bureau of Mines Minerals Yearbook Preprint 1968; 1969 U.S. Bureau of Mines Commodity Data Summaries, January 1970.
pPreliminary; .. Not available.

TABLE 9

Canadian Tariffs*

	Most Favoured Nation
Ores, concentrates, pigs, blocks or ingots and anodes	free
Bars and rods for manufacture of wire and cable	5%
Oxides	15%
Electrolytic copper powder (expires 31 Jan. 1970)	free
Electrolytic copper wire bars	free

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1969) TC Publication 272.
*Effective Jan. 1, 1970

Diatomite

D. H. STONEHOUSE*

Diatomite is a siliceous, sedimentary accumulation, composed of opaline silica from the fossil remains of planktonic plant organisms–diatoms. Synonyms include "diatomateous earth", "kieselguhr", "infusorial earth" and "tripolite". Diatoms, of either fresh or salt water origin, extracted silica from the water and secreted it as a micro-porous, intricate, complex fossil arrangement, often symmetrical in design, which accumulated to form deposits, some of which are hundreds of feet thick. Diatomite's usefulness stems from its physical characteristics and chemical inertness. The porous structure provides unusual filtering properties, low bulk-density, large surface area and low thermal conductivity. Although diatomite deposits occur in many parts of the world, the industry is dominated by a few producers operating in the United States and western Europe.

CANADIAN INDUSTRY AND DEVELOPMENTS

Diatomite has been produced each year in Canada since 1896 but total production to date does not equal Canadian consumption during one year. Up to 1941 essentially all Canadian diatomite production was from lake deposits in Nova Scotia, the highest output for a single year being 1,789 tons in 1933. Since 1955 all production has come from the Quesnel area in central British Columbia.

Fairey & Company, Limited removed small quantities of diatomite from a property at Moose Heights on the east bank of the Fraser River about 5 miles north of Quesnel. The material was shipped by rail to the company's processing plant in Vancouver, where it was used in the manufacture of insulating brick.

In 1967 Dome Petroleum Limited, Calgary, acquired the mining rights of Crownite Diatoms Ltd. and through a name change formed the wholly-owned subsidiary–Crownite Industrial Minerals Ltd.–to mine and process diatomite and pozzolanic shales from deposits just west of Quesnel. Crownite Diatoms Ltd. had operated for about six years on a very limited basis, producing mainly a burnt shale pozzolan which was used as a construction material. During 1968 the new company reportedly began construction of a drying and crushing plant capable of handling 80,000 tons of product a year. Crude diatomite from an open-pit mine was to be trucked 5 miles to the plant from where various products would be shipped by rail or truck, in bags or bulk, principally to western Canadian markets. Export markets were being considered as well by Canadian Industries Limited through whom all marketing was to be done. During 1968 the company reported some trenching, sampling and removal of overburden.

In 1967 Pacific Diatomite Ltd. announced its intention to invest $1.4 million in a mine and processing plant at Quesnel; $120,000 was for the installation of a 4½-inch pipeline across the Fraser River to Barlow Station to be constructed by Carrol Oilfield Enterprises Ltd. The pipeline would carry a slurry of pulverized diatomite 7½ miles and eliminate a 44½-mile round trip by truck. To date the company has not produced diatomite from its leased areas.

Beginning in 1960, Cariboo Diatomite Ltd. has been engaged in developing a diatomite property near Quesnel. Having begun by studying new methods of upgrading crude ore, the company went public in 1965 to finance the installation of plant facilities. No production has been reported.

Other deposits of diatomite have been recorded in British Columbia–in the Kamloops and Ashcroft mining divisions and along the coastal areas–but they are usually small and contain deleterious organic material. Occurrences in the Muskoka district of Ontario were mined on a small scale in the 1930's.

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*Mineral Resources Branch.

TABLE 1

Canada – Diatomite Production, Imports and Consumption

	1964		1965		1966		1967		1968		1969p	
	sh. tons	$	sh. tons	$	sh. tons	$	sh. tons	$	sh. tons	$	sh. tons	$
Production (shipments)												
British Columbia	1,143	64,555	82	4,420	70	3,755	2,819*	14,096*	856*	17,159*	487	11,340
Imports, diatomaceous earth, crude and ground												
United States	25,089	1,349,330	25,089	1,386,209	29,220	1,579,000	33,309	1,790,000	30,679	1,674,000	30,463	1,757,000
West Germany							20	2,000				
Consumption												
Filtration	14,000e		15,000e		15,500e		18,641e		19,000e			
Fertilizer dusting	5,703		5,082		5,224		7,438		7,802			
Paper	976		960		1,803		1,608		785			
Paint and varnish	910		1,081		923		910		915			
Pesticides	173		178		143		105		68			
Foundry	722		355		482		507		536			
Insulation	852		1,032		1,467		1,218		954			
Other products	412		1,894		4,195		3,232		3,417			
Total	23,748		25,582		29,737		33,659		33,477			

Source: D.B.S. Consumption data estimated by Mineral Resources Branch.
*British Columbia Annual Mines Report 1968.
pPreliminary; eEstimated.

TABLE 2
World Production of Diatomite, by Countries[1]
(short tons)

Country	1964	1965	1966	1967	1968p
North America:					
Canada	1,143	82	70	2,819	856
Costa Rica e	3,968	3,307	3,307	11,023	11,023
Mexico	2,260	987	9,327	7,921	10,961
United States[2]	580,275	580,275	627,292r	627,292	627,292
South America:					
Argentina	8,567	6,774	12,063r	8,979	NA
Colombia	255	220		NA	NA
Peru	2,858	2,724	1,742	4,118	NA
Europe:					
Austria	4,224	4,447	4,138	4,031	3,284
Denmark					
Diatomite e	20,393	13,779	11,023	11,023	11,023
Moler e3	210,761	234,461	223,989	220,462	220,462
Finland	2,392	1,047	1,323	1,785	2,182
France[4]	146,699	166,046	155,710r	176,370	NA
Germany, West (marketable) e4	116,845	126,766	98,106	98,106	117,947
Iceland					2,750
Italy	76,445	69,739r	69,131r	66,088	66,139e
Portugal[4]	2,207	2,896	3,845r	4,308	3,307
Spain[4]	12,507e	13,131	17,637e	17,637e	17,637e
Sweden[5]	955	1,342	3,617	2,205	3,307
USSR e	352,739	363,762	385,808	396,832	396,832
Britain	15,363	16,888	16,460r	16,424e	NA
Africa:					
Algeria	22,163	18,092	17,637er	20,128	19,842
Kenya	3,368	2,445	1,953	2,079	2,265
Rhodesia, Southern[4]	347	529e	529e	NA	NA
South Africa, Republic of	546	1,076	240	645	688
Asia: Korea, South	620r	638	303r	2,467	2,441
Oceania:					
Australia	9,780	7,793	8,006r	9,313	2,205e
New Zealand	1,881	1,937	5,219	1,577	NA
Total[6]	1,599,561r	1,641,183r	1,678,475r	1,713,632	1,522,443

Source: U.S. Bureau of Mines Minerals Yearbook 1968.
[1] Diatomaceous earth is produced in Brazil, Bulgaria, Hungary, Japan, Mozambique, Rumania, United Arab Republic, and Yugoslavia but outputs are insignificant or not available. [2] Average annual production from the appropriate 3-year totals, 1963-65 and 1966-68. [3] Moler earth used as a raw material in making refractory bricks plus exports in bulk form. [4] Includes Tripolite. [5] Includes calcined. [6] Totals are of listed figures only.
e Estimated; p Preliminary; r Revised; NA Not available.

MARKETS, TRADE AND OUTLOOK

Diatomite is marketed in three grades—natural, calcined or pink, and flux-calcined or white. Although mining is by open-pit methods and normally uncomplicated, present processing techniques are not simple and require costly plant equipment such as dryers, kilns, cyclones and air classifiers, to produce a product of high purity and of consistent uniformity, often tailor-made for a specific application. Research and sales facilities are essential to maintain markets and to develop new product uses, making it difficult for small producers to get established. Most diatomite is produced by long-established companies familiar with the processing and marketing of industrial minerals, and which market their products under trade names, one or more of which the customer recognizes as best serving his requirements.

The principal use for diatomite is as an industrial filtration medium. The porous structure of the individual diatoms and of their arrangement within the bedded deposit, results in a material with about 90 per cent voids, capable of removing solid particles as small as 0.1 micron in size, while not impeding the flow of liquid through the filter. Flux-calcined grades, which are calcined at up to 2200°F with alkali salts, although more expensive, are favored as filtration aids.

Diatomite is one of the principal extender minerals or fillers. It is used as a flatting agent in paints, a bulking agent in paper, a pozzolanic agent in concrete, and a shrinkage-control agent in plastics. These applications usually require calcined material which would average over 90 per cent silica content and have a near-white appearance.

As a powder, an aggregate or in the form of bricks, blocks or slabs, diatomite is used as an insulation material, its cellular structure providing sound-proofing qualities and low thermal conductivity. In the natural form (uncalcined) diatomite in the minus 325-mesh size range is used as a fertilizer coating and insecticide carrier.

Canada's output is used mainly in the production of insulating brick. Any large-scale new undertaking in Canada would probably look towards the fertilizer industry and the refractory industry as major consumers. Filter-aid diatomite products require sophisticated processing at high costs and established markets are difficult to penetrate. It is also recognized that some deposits contain broken and poorly-shaped diatoms which do not provide good filtering characteristics.

Despite the low bulk-density of diatomite and diatomite products, they are shipped great distances because of relatively high unit prices compared with most industrial minerals. High-quality filter aids are regularly shipped from western United States to western European markets. Canadian requirements are imported from western United States producers and although accurate consumption data are not available it is estimated that over 50 per cent of imports is consumed as a filter medium.

The prospects for the world diatomite industry are good. It is, however, unlikely that companies other than the current major producers will develop and obtain markets other than local ones. Continued research by large companies will develop new markets and new processing techniques. The industry structure will remain unchanged over the next few years at least.

WORLD REVIEW

The world diatomite industry is dominated by a few large producers in the United States and in Europe. The leading producer is Johns-Manville Corporation operating at Lompoc, California and marketing a range of products under the trade name "Celite". Grefco Inc. a subsidiary of General Refractories Co. also operates at Lompoc and produces high-quality diatomite under the trade name "Dicalite". From dry lake deposits in Nevada, the Fibres and Minerals Division of Eagle-Picher Industries Inc. produces under the trade name "Celatom".

In Europe, the USSR accounts for 26 per cent of world production and Denmark, a country with little other mineral production, produces 15 per cent, marketed for many years as "Molar" and used principally as a fertilizer coating or an insulation medium. Diatomite of filter-aid quality is produced in France by CECA (Carbonization et Charbons Actifs) at Riom-es-Montagne and at Saint-Bauzile, and in West Germany at Tagebau and at Unterluss by Kieselguhr-Industrie GmbH.

A white diatomite is quarried near Monte Amiata in Italy by three companies and a medium grade material is mined near Tombolina in northern Italy. Diatomite for filler applications is quarried in Spain by an affiliate of a French company. Deposits of diatomite at the bottom of Lake Myvatn in Iceland are being exploited by The Icelandic Diatomite Co., a joint venture by Johns-Manville Corporation and the Icelandic government. A flux-calcined filter-aid is manufactured for shipment to European markets.

PRICES

Prices vary in accordance with the purity of the diatomite, its particle size range, the degree of processing performed–uncalcined, calcined or flux-calcined–and whether the product is packaged or is shipped in bulk. Transportation costs are high per unit of weight. Depending on the quality and quantity, shipments landed at Ontario or Quebec warehouses could cost from $100 to $300 a ton. A U.S. Bureau of Mines survey of the industry provided the following average values a ton by use–

TABLE 3
Average Annual Value per ton of
Diatomite, by Use, f.o.b. Mine

Use	U.S. value per ton, 1968
Filtration	$ 67.74
Insulation	44.50
Abrasives	128.70
Fillers	57.20
Miscellaneous	35.34

TARIFFS

There is no tariff on diatomite imported into Canada or into the United States.

Fluorspar

P.R. COTE*

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.

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; 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 3.5 million long tons and, based on forecast increased demands by the major consuming industries, consumption will double by 1974. 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 4 pounds per ton of steel produced, the former approximately 12.5 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. Larger demand 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.

*Mineral Resources Branch.

PRODUCTION AND DEVELOPMENTS IN CANADA

All fluorspar produced in Canada is mined from the Burin Peninsula area in Newfoundland.

Value of production increased 17 per cent from \$2,603,347 in 1968 to \$3,036,470 in 1969. For the second year in a row, Canada was a net importer of fluorspar.

Newfoundland Fluorspar Limited, a wholly owned subsidiary of the Aluminum Company of Canada, Limited (Alcan), 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 production from the Director mine, to Alcan's aluminum smelter at Arvida. The concentrate is upgraded and then converted to artificial cryolite which is an essential requirement for the reduction of alumina to aluminum. A third mine in the same area may be developed by the mid-1970's. The deposits on the Burin Peninsula constitute a major domestic fluorspar reserve.

Allied Chemical Canada, Ltd. imports acid-grade fluorspar for the production of hydrofluoric acid at the company's plant located at Valleyfield, Quebec. A portion of the acid is utilized in the manufacture of various fluorine chemicals. Allied Chemical operates mines in Mexico and the United States in order to ensure an uninterrupted supply of fluorspar. The company intends to establish a hydrofluoric acid plant at Amherstburg, Ontario. Completion date for this facility is scheduled for mid-1971.

Huntingdon Fluorspar Mines Limited with a plant at North Brook, Ontario, imports metallurgical-grade fluorspar to make 5-pound briquettes for foundry use.

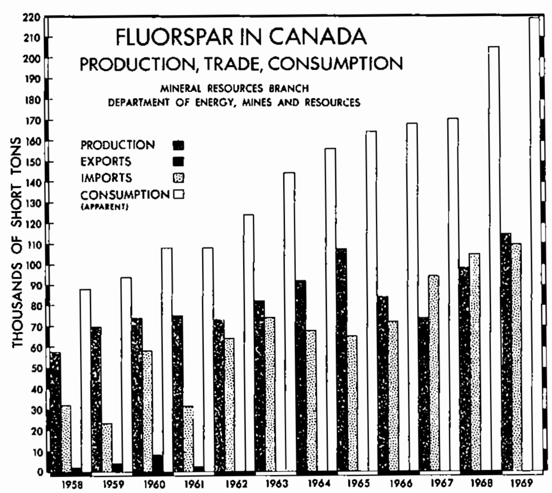
TABLE 1

Canada, Fluorspar, Production, Trade and Consumption

	1968		1969p	
	Short tons	$	Short tons	$
Production (shipments)				
Newfoundland	..	2,602,230	..	3,036,470
British Columbia	..	1,117	–	–
Total	..	2,603,347	..	3,036,470
Imports				
Mexico	97,619	2,556,000	85,135	2,624,000
Britain	7,908	316,000	16,010	676,000
United States	9,938	405,000	3,237	156,000
Total	115,465	3,277,000	104,382	3,456,000
Consumption[1] (available data)	1967		1968	
Metallurgical flux[2]	32,854		35,027	
Glass	1,120		1,257	
Enamels	260		254	
Others[3]	121,115		142,363	
Total	155,349		178,901	

Source: Dominion Bureau of Statistics.
[1]As reported by consumers. Breakdown by Mineral Resources Branch.
[2]Consumption as flux in the production of steel, magnesium and use in foundries.
[3]Includes consumption in the production of aluminum and chemicals and other miscellaneous uses.
pPreliminary; .. Not available;–Nil.

Some fluorine is being recovered as fluosilicic acid from the processing of phosphate rock by Electric Reduction Company of Canada, Ltd., at Port Maitland, Ontario and by Cominco Ltd., at Trail, British Columbia.



International Mogul Mines Limited continued assessing 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 1,000,000 tons of marginal ore has been outlined and pilot plant tests have been initiated to determine the most economically attractive milling process. From 1940 to 1949, approximately 1,400 tons of fluorspar, along with some barite was recovered from this deposit.

OTHER DOMESTIC SOURCES

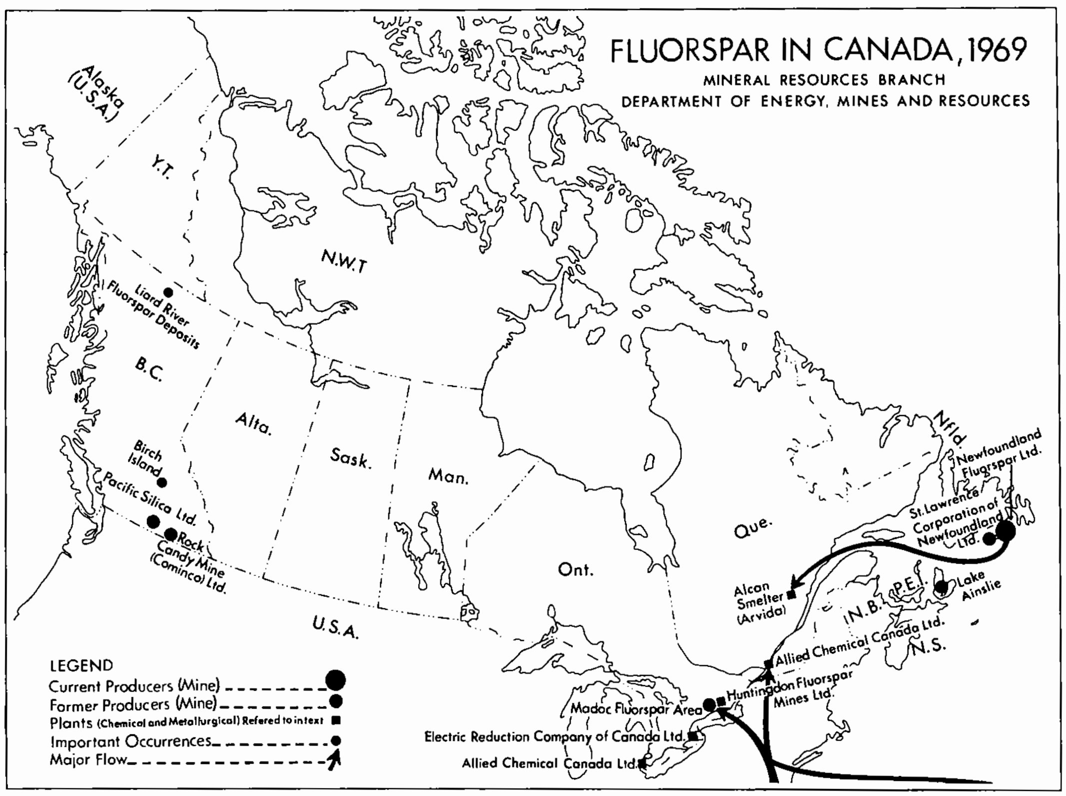
Fluorite is known to occur as fracture fillings within pink granites and rhyolite porphyry in the St. Lawrence area of the Burin Peninsula, Newfoundland. Altogether some forty veins have been outlined in this area and the granite complex forming the peninsula must be considered as a prime exploration target for additional discoveries.

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 costs 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. 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.

MARKETS AND TRADE

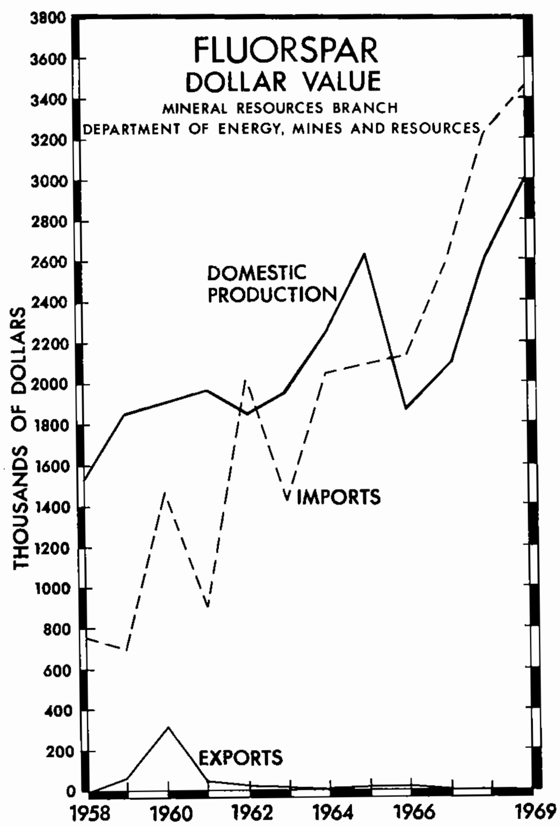
The most important uses of fluorspar are: as a fluxing material in metallurgical and related industries; in the chemical industry for the manufacture of hydrofluoric acid and other fluorine compounds; in the glass and ceramic industries; in the refining of uranium ores and concentrates; and in the manufacture 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, these are: acid grade containing a minimum of 97 per cent CaF_2 and a maximum of 1 per cent SiO_2; metallurgical grade containing 75 to 80 per cent CaF_2 with a maximum of 5 per cent SiO_2; ceramic grade containing 93 to 95 per cent CaF_2, and not more than 3 per cent SiO_2, 1 to 3 per cent $CaCO_3$ and less than 0.1 per cent Fe_2O_3.

Currently, slightly less than one half of all fluorspar consumed in Canada, and almost all domestic production, is used in the manufacture of artificial cryolite (Na_3AlF_6). Acid-grade fluorspar is first converted to hydrofluoric acid prior to the manufacture of cryolite which along with aluminum fluoride (AlF_3) forms the electrolyte flux in the Hall process for converting alumina to aluminum. A small amount of fluorspar is added to the electrolyte for make-up purposes.

Hydrofluoric acid, used in the chemical industry, is manufactured by reacting sulphuric acid with acid-grade fluorspar according to the reaction: $H_2SO_4 + CaF_2 \rightarrow CaSO_4 + 2HF$. Much of the acid produced from imported fluorspar is utilized in the manufacture of aerosol propellants, refrigerants, plastics and various solvents. Slightly over one quarter of fluorspar consumed in Canada is used in the chemical industry.



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. Approximately 19 per cent of fluorspar consumed in Canada is utilized in the manufacture of steel which requires 3 to 7 lb of fluorite per ton of steel produced by open hearth furnaces, 12 to 16 lb by the basic oxygen process and 8 to 10 lb by electric furnaces. For fluxing purposes, fluorspar is purchased in lump or gravel form and should contain a minimum of 60 per cent CaF_2. Silica is an objectionable impurity as well as barite, both of which decrease the fluidity of the melt. The use of pelletized flotation concentrates is now receiving attention in the United States and this may become the preferred form for adding fluorspar to oxygen steel furnaces. Metallurgical-grade fluorspar is also used as a flux in foundries and in the reduction of dolomite to magnesium.

Ceramic-grade fluorspar is used as an opacifer in enamels and opal glass. It is also used, to a limited extent, in the manufacture of clear glass as an active flux, a contributor to the gloss and as a decolourizer.

TABLE 2

Canada, Fluorspar, Production, Trade and Consumption, 1960-69
(short tons)

	Production	Exports	Imports	Consumption
1960	77,000[1]	10,312	59,690	111,835
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	94,000[1]	..	94,244	155,349
1968	98,000[1]	..	115,465	178,901
1969	115,000[1]	..	104,382	..

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.
.. Not available.

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.

Virtually all fluorspar consumed in Canada outside of the aluminum industry is imported. Preliminary figures for 1969 indicate that imports declined 9.5 per cent from 1968 and amounted to 104,382 tons valued at $3,465,000. This decrease is probably due in large part to a loss of steel production resulting from strikes at two of the largest integrated steel facilities. In 1969, imports accounted for 48 per cent of apparent domestic consumption. Shipments from Mexico where some major Canadian consumers operate mines, amounted to 82 per cent of total imports, the United States accounted for 15 per cent and Britain 3 per cent.

Prior to 1957 Canada exported a large portion of production to the United States and Europe. In 1958 exports declined abruptly owing to the development of alternative low-cost deposits in Mexico by large consumers in the United States. Competition from these deposits in Mexico forced the closure of a number of producers in Canada who had formerly relied upon exports to the United States.

WORLD REVIEW

The increasing demand for fluorspar because of growing consumption in the steel, aluminum and chemicals industries is world-wide and has led to many new and enlarged producing facilities.

Mexico continued to rank as the world's largest supplier with production in 1969 amounting to an estimated 1.11 million tons, up from 1.02 million tons in 1968. Currently in operation in Mexico are nine flotation plants, and three ore dressing plants served by some thirty producing mines. Mining and chemical companies operating in Canada that have deposits in Mexico include: Noranda Mines Limited, Allied Chemical Corporation and Alcan. By far the largest producing mine in Mexico and probably in the world is the Las Cuevas, operated by Empress Fluorspar Mines Limited, a subsidiary of Noranda Mines Limited. This operation currently accounts for some 40 per cent of total Mexico production; at current production rates the mine has a life expectancy of some ten years.

The rapid growth of fluorspar production in Mexico has paralleled consumption increases in the United States which currently relies upon Mexico for some 95 per cent of imports.

In the United States, consumption of fluorspar of all grades reached an estimated 1.3 million tons, up some 70,000 tons from 1968. Producers' shipments dropped 72,000 tons from 1968 to 180,000 tons in 1969 because of the closing of some mining operations and strikes affecting the two major merchant producers. In France, there has been a great increase in fluorspar mining activity with new deposits being worked in the middle of France, the Massif central and in the Alpine region. Reserves in France are estimated at 10 million tons grading 50 per cent CaF_2.

Significant new reserves have been found in the Caravia district in Oviedo Province of Spain. These new reserves are reported to be the largest yet found in the country but mining may prove difficult as the deposit extends under the village of Caravia. The fastest developing new source of fluorspar in the world is Thailand where production has risen from 3,400 tons in 1960 to some 270,000 tons in 1968. Thailand's reserves have yet to be accurately assessed but are believed to total several million tons of high-grade ore. Production is virtually all metallurgical grade with the greatest portion of output being exported to Japan. Freight rates from Thailand to the Japanese market average $7.50 a ton.

TABLE 3

World Production of Fluorspar
(short tons)

	1967	1968	1969^e
Mexico	865,439	1,021,000	1,110,000
USSR	420,000	420,000	..
United States	295,643	252,411	180,000
China, Mainland	280,000	280,000	..
Spain	268,000	282,000	..
France	269,000	..	..
Britain	156,700	159,800	..
Italy	226,190	249,000	270,000
Thailand	146,775	270,173	..
Republic of South Africa	105,058	119,667	..
Other countries	469,289	463,394	2,550,000[1]
Total	3,502,094	3,517,445	4,110,000

Source: For 1967 and 1968 U.S. Bureau of Mines, Minerals Yearbook Preprint 1968, for 1969 U.S. Bureau of Mines, Commodity Data, Summaries, January 1970.
[1] Other countries in this instance includes all countries listed separately for 1967 and 1968.
^{e}Estimated; .. Not available.

OUTLOOK

Both steel and primary aluminum production are increasing throughout the world. In 1975 steel production may reach 750 million metric tons, up 176 million metric tons from a current production level of approximately 574 million metric tons. Based on this

TABLE 4

The U.S. Metallurgical Grade Fluorspar Market Supply

Year	Total Demand	Natural Imported	Gravel Domestic	Processed Imported	Concentrate Domestic	Total Supply	Surplus (+) Shortage (−)
1964	322,900	292,100	38,100	–	22,300	352,500	29,600 (+)
1965	375,600	312,300	20,700	11,200	33,200	377,400	1,800 (+)
1966	427,800	347,700	28,900	4,800	52,300	433,700	5,900 (+)
1967	442,800	318,200	38,100	9,500	68,900	434,700	8,100 (−)
1968	475,500	389,000	29,000	8,000	63,600	489,600	14,100 (+)
1969	507,500	370,000	24,000	10,000	98,000	502,000	5,500 (−)
1970	555,900	370,000	15,000	33,000	108,000	526,000	29,900 (−)
1971	591,300	365,000	15,000	55,000	111,000	546,000	45,300 (−)
1972	627,700	360,000	15,000	45,000	121,000	541,000	86,700 (−)
1973	664,400	360,000	15,000	46,000	125,000	546,000	118,400 (−)

Source: Industrial Minerals August 1969.
–Nil.

forecast and on anticipated changes in methods of steel production, fluorspar consumption in this industry alone is forecast to reach 3 million metric tons in 1975, up some 1.65 million metric tons from 1968. Consumption in the aluminum industry is expected to reach 1 million metric tons by 1975. Even though it is anticipated that the largest growth in consumption will be related to increased steel production, significant growth is expected in some sectors of the chemicals industry. By 1975, world requirements for fluorspar could easily reach 5 million metric tons and could possibly be as high as 6.5 million metric tons, requiring the mining of some 15 million tons of ore a year. Estimates of world reserves vary widely from 70 to 150 million tons. In any case, these reserves must be considered marginal for future requirements and considerable efforts will be made in the near term to expand both production and reserves to meet these ever-growing consumer demands. As a measure of growing concern; in late 1969, the National Research Council in the United States formed a special panel to study available reserves of world fluorspar and fluorine as well as U.S. consumer needs for the next ten years. There is much concern among major consumers in the United States over long range supplies as reserves in Mexico have not been growing at a rate commensurate with forecast consumption rates.

Table 4, indicates a potential shortage of fluorspar supplies for the steel industry in the United States beginning in 1970 and reaching some 118,000 short tons by 1973. This forecast assumes that the trend to convert to basic oxygen furnaces from open hearth furnaces will continue.

The insatiable appetite of world steel furnaces, aluminum smelters and chemical complexes may provide sufficient incentive for industry to re-assess known fluorspar occurrences in Canada and may eventually lead to further domestic mine production.

PRICES

United States fluorspar prices quoted in the *Engineering and Mining Journal* of December 1969 were as follows:

per short ton, f.o.b. mill, Illinois and Kentucky, CaF_2 content, bulk

Metallurgical	
72½	\$47.50 - \$48.50
70%	45.50 - 46.50
60%	42.50 - 43.00
Pellets	
70%, effective	\$50.00 - \$57.00
Acid, dry basis, 97%	
Carloads	\$57.50
Less than carloads	59.50
Bags, extra	5.00
Pellets, 90% effective	56.00 - 60.00
Wet filter cake, 8-10% moisture, sold dry content – subtract approx.	2.50

PRICES (Cont'd)

Ceramic, calcite and silica variable	
88-90%	$51.50
93-94%	54.50
95-96%	55.50
97%	57.50
in 10 lb paper bags, extra	5.00
European	
c.i.f. U.S. ports, duty paid, per short ton	
Acid, wet filter cake, 8-10% moisture, sold dry content	$47.50 - 50.00
Mexican	
Metallurgical 70% f.o.b. cars, Mexican border	– $30.15
Tampico, f.o.b. vessel	– $31.15
Acid, 97% + Eagle Pass, bulk	– $47.00 - 51.00

TARIFFS

Item No.		
CANADA		
29600–1	Fluorspar	free
	Source: The Custom Tariff and Amendments, March 1969.	
UNITED STATES		
522.21	Fluorspar, containing over 97% calcium fluoride	$2.10/lt
522.24	Fluorspar, containing not over 97% calcium fluoride	$8.40/lt
	Source: Tariff Schedules of the United States Annotated, 1969.	

Note: There are no United States fluorspar tariff reductions under the Kennedy Round of GATT.

Gold

J.J. HOGAN*

Gold production in Canada declined in 1969 for the ninth successive year and the decline is expected to continue in 1970.

Production in 1969 is estimated at 2,502,169 troy ounces valued at $94,331,773, based on the average Royal Canadian Mint price for the year. In comparison, 1968 production was 2,743,021 ounces worth $103,439,321. The record Canadian gold production was attained in 1941 when 5,345,179 ounces valued at $205,789,392 was produced. The highest production since World War II was attained in 1960 when 4,628,911 ounces, worth $157,151,527, was produced.

The 1969 decrease in production, a drop of about 8.8 per cent from 1968, is mainly attributable to the closure of auriferous-quartz (lode) gold mines and to production declines at those lode mines still operating. In 1969 the lode gold mines produced 2,027,030 ounces compared with 2,208,184 in 1968. Three lode gold mines closed in 1969.

Ontario continued as the leading gold-producing province in 1969 with 48.2 per cent of the national total. Quebec was in second place with 29.5 per cent followed by the Northwest Territories with 13.7 per cent and British Columbia 4.5 per cent.

World production in 1968 was estimated at 46.24 million troy ounces by the U.S. Bureau of Mines. In 1967 world production was 45.73 million ounces. About 67.2 per cent of the 1968 total, or 31.09 million ounces, was produced by the Republic of South Africa. The USSR produced an estimated 6.04 million troy ounces in 1968.

Canada has long been one of the world's leading producers of gold. Since production was first officially recorded in 1858 Canada has produced over 189.0 million ounces worth approximately $6,146 million to the end of 1969. 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. In December, 1967 the Act was extended for three years to the end of 1970.

In 1969 a total of 33 lode gold mines were eligible for assistance. One lode gold mine was not eligible and sold its production on the free market. Six other lode gold mines, although eligible for assistance, sold part of their production on the free market during periods of high free-market prices.

Three gold mines closed in 1969 due to the exhaustion of ore reserves. Most of the mines continue to experience difficulty in maintaining operations due to ever-increasing costs and dwindling economic ore reserves.

A minor amount of gold was recovered in 1969 from placer operations, mainly in the Yukon Territory.

*Mineral Resources Branch.

TABLE 1

Canada, Production of Gold, 1968-69
(troy ounces)

	1968	1969P
NEWFOUNDLAND		
Base-metal mines	7,803	7,440
NOVA SCOTIA		
Auriferous quartz	3	13
NEW BRUNSWICK		
Base-metal mines	2,202	1,567
QUEBEC		
Auriferous quartz mines		
Bourlamaque-Louvicourt	198,038	182,697
Malartic	226,572	221,640
Chibougamau	24,929	19,500
Noranda	58,709	61,764
Total	508,248	485,601
Base-metal mines	259,820	251,953
Total Quebec	768,068	737,554
ONTARIO		
Auriferous quartz mines		
Kirkland Lake	109,017	80,440
Larder Lake	178,244	151,380
Porcupine	572,523	509,625
Red Lake and Patricia	335,328	335,950
Sudbury	35,860	27,000
Thunder Bay	52,455	43,300
Sault Ste. Marie	1,687	1,700
Total	1,285,114	1,149,395
Base-metal mines	94,665	56,715
Total Ontario	1,379,779	1,206,110
MANITOBA-SASKATCHEWAN		
Auriferous quartz mines	10,270	–
Base-metal mines	73,855	67,143
Total Manitoba and Saskatchewan	84,125	67,143
ALBERTA		
Placer operations	146	100
BRITISH COLUMBIA		
Auriferous quartz mines	52,324	45,000
Base-metal mines	71,577	67,481
Placer operations	521	340
Total British Columbia	124,422	112,821
YUKON		
Auriferous quartz mines	–	3,905
Base-metal mines	15,270	14,900
Placer operations	8,897	7,500
Total Yukon	24,167	26,305

TABLE 1 (Cont'd)

	1968	1969p
NORTHWEST TERRITORIES		
Auriferous quartz mines	352,225	343,116
Base-metal mines	81	-
Total Northwest Territories	352,306	343,116
CANADA		
Auriferous quartz mines	2,208,184	2,027,030
Base-metal mines	525,273	467,199
Placer operations	9,564	7,940
Total	2,743,021	2,502,169
Total value	$103,439,321	$94,331,773
Average value per oz	$37.71	$37.70

Source: Dominion Bureau of Statistics, basic data; breakdown by types of operations by Mineral Resources Branch.
pPreliminary

OPERATIONS AT PRODUCING MINES

ATLANTIC PROVINCES

Gold production in Newfoundland, Nova Scotia and New Brunswick totalled 9,020 troy ounces in 1969 compared with 10,008 ounces in 1968.

Virtually all production is derived as a byproduct of base-metal mining in Newfoundland. America Smelting and Refining Company (Buchans Unit) was the largest producer. Some gold is recovered from base-metal ores in New Brunswick. A very minor amount of gold is occasionally recovered from the auriferous-quartz deposits in Nova Scotia.

QUEBEC

Gold production in Quebec amounted to 737,554 troy ounces, a decrease of 4 per cent compared with 1968. Ten lode gold mines operated in 1969.

Two gold mines exhausted their ore and suspended operations in 1969. Production decreased from both lode gold mines and byproduct, base-metal mines. The base-metal mines accounted for about 34.2 per cent of the provincial gold total as against 33.8 per cent in 1968. The principal producers of byproduct gold are the base-metal mines of the Chibougamau and Noranda districts.

Auriferous Quartz Mines

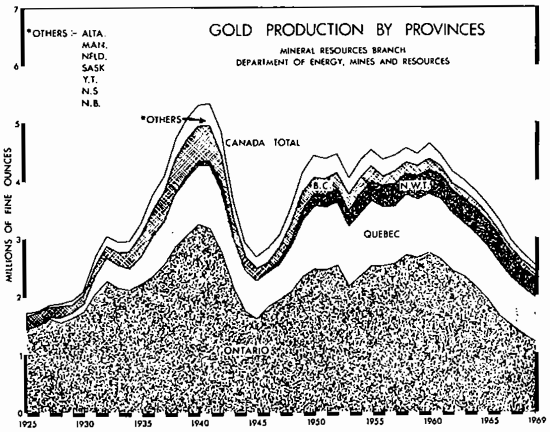
Bourlamaque-Louvicourt District. Two lode gold mines operated in the district in 1969. Production at Lamaque Mining Company Limited (Lamaque Division), the largest gold producer in the province, decreased about 10.6 per cent in 1969 compared with 1968. Production at Sigma Mines (Quebec) Limited increased by approximately 2.8 per cent.

Malartic District. Five lode gold mines operated in the area in 1969, the same number as in 1968. Production for the district decreased slightly. Malartic Gold Fields (Quebec) Limited operated its custom mill in 1969 treating ore from Barnat Mines Ltd., Marban Gold Mines Limited, The Little Long Lac Gold Mines Limited and Camflo Mines Limited.

Production at Barnat decreased by approximately 15 per cent as compared with 1968. Ore reserves are near depletion and Barnat is scheduled to suspend operations early in 1970. Camflo completed the construction of a 1,000-ton-a-day cyanide plant in March and began to treat the ore from its property on July 1, 1969. The milling agreement between Camflo and Malartic Gold Fields terminated on June 30, 1969. Production decreased at Camflo by approximately 6 per cent. Additions to the mill enabled East Malartic Mines, Limited to increase tonnage milled and to increase ounces of gold produced by about 6 per cent. Marban increased production in 1969 by about 4.7 per cent compared with 1968. The Little Long Lac mine produced a small amount from its property adjoining Marban and exhausted ore reserves.

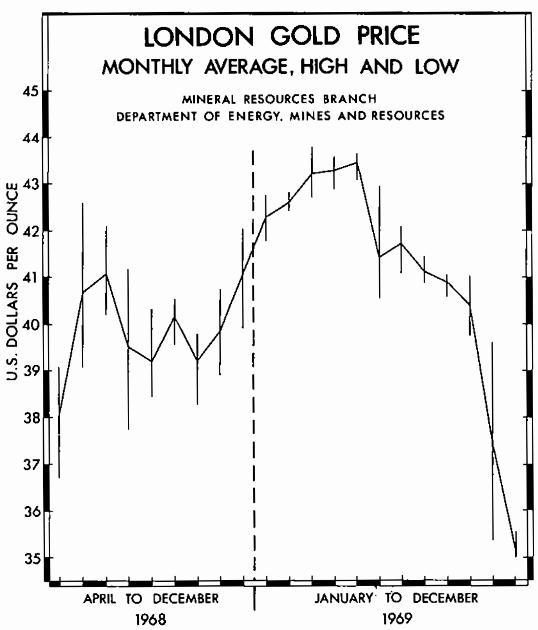
Chibougamau District. Norbeau Mines (Quebec) Limited, the only lode gold producer in the area, depleted its ore reserves and closed at the end of 1969. Production declined in 1969.

Noranda District. At the end of 1968 Wright-Hargreaves Mines, Limited acquired the assets of Wasamac Mines Limited. The combined production of the Wasamac Shafts No. 1 and No. 2 increased slightly in 1969 compared with 1968. Wasamac Shaft No. 2 recorded its first full year of production. The ore is trucked about five miles for treatment at the mill at Shaft No. 1.



ONTARIO

Seventeen lode gold mines operated in the province in 1969 compared with twenty in 1968. Gold produced from the lode mines accounted for 95.3 per cent of the province's total gold output. Production declined by 10.6 per cent in 1969 compared with 1968.



Auriferous-Quartz Mines

Kirkland Lake District. Two lode gold mines operated in this district in 1969. Production at both Macassa Gold Mines Limited and Upper Canada Mines, Limited was down substantially in comparison with 1968.

Larder Lake District. Production at Kerr Addison Mines Limited declined by approximately 15 per cent.

Porcupine District. Production at Aunor Gold Mines Limited decreased significantly in 1969 due to grade-control problems caused by adverse ground conditions in the mining area. Production at the Ross mine of Hollinger Mines Limited and at McIntyre Porcupine Mines Limited were approximately the same as in 1968. Dome Mines Limited and Hallnor Mines, Limited reported small declines in output.

Sudbury Mining Division. Production at Renabie Mines Limited, near Missinabie, declined. Towards the end of the year, development work was stopped and the mine began salvage operations. The mine is scheduled to close in 1970.

Sault Ste. Marie Mining Division. Surluga Gold Mines Limited, near Wawa, produced a small amount of gold. Production was below expectations and the mill closed in February. Surface and underground exploration work was continued for the remainder of the year.

Thunder Bay Mining Division. Production at the MacLeod Mosher mine was down sharply. The mine near Geraldton, which is owned by Lake Shore Mines, Limited, is scheduled to close in 1970.

Red Lake Mining Division. Six lode mines operated in the district in 1969, the same as 1968, and total production was approximately the same. Annco Mines Limited and Cochenour Willans Gold Mines, Limited suffered sharp declines in production while closely-related Wilmar Mines Limited more than doubled its output. Production at Campbell Red Lake Mines Limited decreased about 4.4 per cent, while Dickenson Mines Limited and Madsen Red Lake Gold Mines Limited managed to increase production slightly. Some gold was recovered by Dickenson from an underground development program on the adjoining property of Robin Red Lake Mines Limited.

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 Timmins and Upper Beaver Mines Limited near Kirkland Lake produce 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. Hudson Bay Mining and Smelting Co., Limited recovered byproduct gold from its operations in the Flin Flon and Snow Lake areas. 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, recovers byproduct gold from its copper ore.

A small amount of gold is recovered by gravel-washing operations on the North Saskatchewan River near Edmondon, Alberta.

BRITISH COLUMBIA

Bralorne Pioneer Mines Limited acquired the assets of Can-Fer Mines Limited and the name of the company was changed to Bralorne Can-Fer Resources Limited. It is the only lode gold producer operating in the province. Production decreased by about 14 per cent in 1969.

A small amount of placer gold was produced, chiefly in the Cariboo district.

Byproduct gold recovered from base-metal ores declined slightly in 1969. Byproduct gold accounted for 59.8 per cent of the total gold produced in the province. The Phoenix Copper Division of The Granby Mining Company Limited, Granisle Copper Limited and Coast Copper Company, Limited were the three largest contributors to gold production in 1969. Byproduct gold production at Western Mines Limited and Wesfrob Mines Limited increased slightly.

NORTHWEST TERRITORIES

Six lode gold mines operated in the Territories in 1969. Production for the year decreased as compared with 1968. Discovery Mines Limited mined known ore and suspended operations in April. The Con mine of Cominco Ltd. began sinking a new internal shaft to a depth of 750 feet below the 4,900-foot level to establish three levels. Production at the Con mine increased while Rycon Mines Limited recorded a small decline. Giant Yellowknife Mines Limited, the largest lode gold producer in Canada in 1969, increased production by about 3.2 per cent. Lolor Mines Limited and Supercrest Mines Limited, both contiguous to and controlled by Giant, mined larger tonnages and recorded substantial increases in production. Ore from these mines is custom treated at the Giant mill.

YUKON TERRITORIES

Gold production in the Yukon in 1969 increased by a small margin over the previous year. The silver-gold mine of Arctic Gold and Silver Mines Limited accounted for about 15 per cent of the total gold produced before suspending operations. The copper mine of New Imperial Mines Ltd. accounted for about 56.6 per cent of the total production.

Placer gold was produced by operators in the Dawson, Mayo and Kluane Lake districts.

TABLE 2

World Gold Production, 1967-68
(troy ounces)

	1967	1968p
NORTH AMERICA		
Canada	2,986,268	2,743,021
United States	1,584,187	1,478,292
Nicaragua	177,702	193,008
Mexico	165,287	176,952
Other countries	12,424	9,750
Total	4,925,868	4,601,023
SOUTH AMERICA		
Colombia	257,668	237,480
Brazil	171,700	170,070
Peru	95,559	82,502
Bolivia	55,069	68,266
Chile	58,135	53,145
Other countries	41,236	43,546
Total	679,367	655,009
EUROPE		
USSRe	5,700,000	6,040,000
Sweden	60,668	49,737
Yugoslavia	68,064	70,000
Other countries	111,003	93,059
Total	5,939,735	6,252,796
ASIA		
Philippines	490,557	527,355
Japan	252,993	238,301
Korea	223,337	222,405
India	101,628	115,357
Other countries	101,326	85,334
Total	1,169,841	1,188,752
AFRICA		
Republic of South Africa	30,532,880	31,094,466
Ghana	762,609	727,122
Southern Rhodesia	500,000	500,000
Congo (Kinshasa)	153,520	169,975
Other countries	118,230	115,790
Total	32,067,239	32,607,353
OCEANIA		
Australia	801,009	796,635
Fiji	111,028	106,784
New Guinea	27,671	26,144
Other countries	10,903	8,826
Total	950,611	938,389
WORLD TOTAL	45,732,661	46,243,322

Source: U.S. Bureau of Mines Minerals Yearbook and for Canada, Dominion Bureau of Statistics.
pPreliminary; eEstimated.

TABLE 3

Canada – Gold Production, 1960-69

	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
1960	3,930,366	84.9	80,804	1.7	617,741	13.4	4,628,911	100.0
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
1969p	2,027,030	81.0	7,940	0.3	467,199	18.7	2,502,169	100.0

Source: Dominion Bureau of Statistics. Breakdown classification by Mineral Resources Branch.
pPreliminary.

TABLE 4

Canada – Gold Production, Average Value per Ounce
and Relationship to Total Value
All Mineral Production, 1960-69

	Total Production (troy ounces)	Total Value ($ Cdn.)	Average Value per Ounce ($ Cdn.)	Gold as a % of Total Value of Mineral Production
1960	4,628,911	157,151,527	33.95	6.3
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	3.6
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
1969p	2,502,169	94,331,773	37.70	2.0

Source: Dominion Bureau of Statistics.
pPreliminary.

NEW PROPERTY DEVELOPMENTS

QUEBEC

Kerr Addison Mines Limited began preparations to bring the mine owned by Donalda Mines Limited, near Rouyn, into production in 1970 at a minimum rate of 500 tons a day. Two headings have been advanced from the underground workings of Quemont Mines Limited into the Donalda ground, one on the 1,260-foot level and the other on the 2,340-foot level. Ore will be mined through Quemont and treated in the Quemont mill.

Eagle Gold Mines Limited in Joutel Township, Northwestern Quebec, suspended construction of a 1,000-ton-a-day cyanide plant in 1969. The economic outlook for gold mining was not deemed favourable for further development of the operation at this time.

ONTARIO

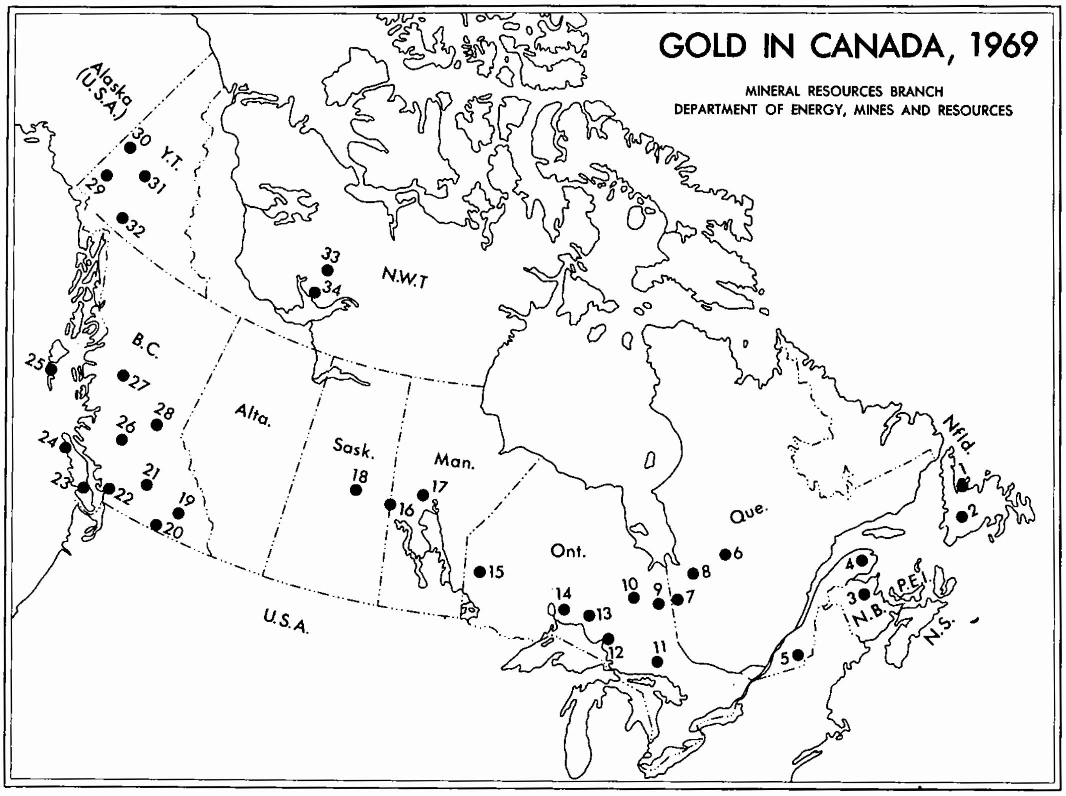
The underground program of exploration and development by Robin Red Lake Mines Limited on its property in the Red Lake area continued in 1969. The work is being carried out by Dickenson Mines Limited through extension of the workings from its adjoining gold mine. Plans to bring the mine into production are being considered.

MANITOBA

Agassiz Mines Limited was reorganized and the name changed to Royal Agassiz Mines Ltd. A program of crosscutting, drifting and diamond drilling was done in 1969 on the 320-foot and 450-foot levels of its property near Lynn Lake. Work was suspended during the year pending an improvement in the gold outlook.

NORTHWEST TERRITORIES

In the Yellowknife area, Cominco Ltd. under an agreement with Yellorex Mines Limited, began an exploration program on the Yellorex property adjoining the Con mine to the south. On the 2,300-foot level, a drift was advanced from the Con into the Yellorex ground.



GOLD PRODUCERS, 1969

(numbers refer to numbers on the map)

NEWFOUNDLAND

1 Atlantic Coast Copper Corporation Limited (a)
  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)
  Merrill Island Mining Corporation, Ltd. (a)
  Norbeau Mines (Quebec) Limited (b)
  Opemiska Copper Mines (Quebec) Limited (a)
  The Patino Mining Corporation (Copper Rand Mines Division) (a)

7 Noranda-Rouyn District
Delbridge Mines Limited (a)
Lake Dufault Mines, Limited (a)
Noranda Mines Limited (a)
Kerr Addison Mines Limited (Quemont) (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)
Little Long Lac Gold Mines Limited, The (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)
New Hosco 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)
Sault Ste. Marie Mining Division
Surluga Gold 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)
The International Nickel Company of Canada, Limited (Thompson Mine) (a)

SASKATCHEWAN
16 Hudson Bay Mining and Smelting Co., Limited (a)
18 Anglo-Rouyn Mines Limited (a)

BRITISH COLUMBIA
19 Cominco Ltd. (a)
20 The Granby Mining Company Limited (Phoenix Copper Division) (a)
21 Bethlehem Copper Corporation Ltd. (a)
22 The Anaconda Company (Canada) Ltd., (Britannia Mine) (a)
Texada Mines Ltd. (a)
23 Western Mines Limited (a)
24 Coast Copper Company, Limited (a)
25 Wesfrob Mines Limited (a)
26 Bralorne Can-Fer Resources Limited (b)
27 Granisle Copper Company Limited (a)
28 Small placer operations (c)

YUKON TERRITORY
29 Small placer operations (c)
30 Small placer operations (c)
31 Small placer operations (c)
32 New Imperial Mines Ltd. (a) Arctic Gold and Silver Mines Limited (d)

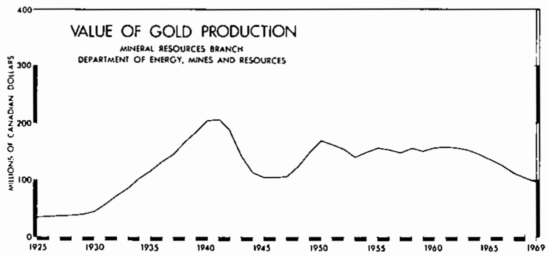
NORTHWEST TERRITORIES
33 Discovery Mines Limited (b)
34 Cominco Ltd. (Con and Rycon Mines) (b)
Giant Yellowknife Mines Limited (b)
Lolor Mines Limited (b)
Supercrest Mines Limited (b)

(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 trade differences and it is still an important commodity for this purpose. However, in recent years the commercial demand for gold from industry and the decorative arts has greatly increased. The International Monetary Fund recently estimated that gold consumed in the world for industrial and artistic purposes had increased in value from $725 million US funds in 1966 to $930 million in 1968. Estimated consumption for the first quarter of 1969 is $275 million.

Over 70 per cent of industrial gold is consumed by manufacturers of jewellery and objects of art. Dentistry is a major user and increasing amounts are being demanded by the electric, electronic, computer and aerospace industries.



PRICES

The average price paid for gold by the Royal Canadian Mint in 1969 was $37.70 per fine ounce. This compares with $37.71 in 1968 and $37.75 in 1967. During 1969 the price fluctuated between a low of $37.54 and a high of $37.85. The fixed value of the Canadian dollar is $0.925 in terms of United States funds but a variation of one per cent either way is permitted. As a result of this tolerance, the Mint gold price could range from $37.46 to $38.22 per fine ounce.

The price on the London gold market varied from a high of $43.825 US a troy ounce in March to a low of $35.00 US a troy ounce in December.

The establishment of a two-tier price system for gold in March, 1968 by leading world monetary authorities was the start of a new era for gold marketing. Under the same agreement, it was agreed that no additions or deletions would be made from total world monetary gold stocks by the main central banks. This included newly-mined gold and, as a result, Canada, along with all other countries which support the agreement, can sell newly-mined gold only on the open market.

The agreement not to add to world gold stocks affected South Africa, which relies heavily on gold sales to meet balance of payments deficits. For a time South Africa reduced its sales of gold, and the price on the open market climbed, due mainly to speculative demand.

In October, 1969 the International Monetary Fund ratified a plan to issue a new international monetary currency known as Special Drawing Rights. The Special Drawing Rights (SDR), which will be used to supplement gold in the settlement of international trade balances, are allocated to members of the International Monetary Fund based on each member's existing Fund quota. The first allocation of $3.5 billion of SDR's was made on January 1, 1970. Additional allocations of $3 billion each will be made at the first of 1971 and 1972.

At about the same time as the SDR announcement was made, South Africa was compelled to sell increasing amounts of gold on the open market in order to meet trade deficits. These factors, together with a devaluation of the French franc, a revaluation of the West German deutsche mark and an improved economic position in Britain, relieved speculative pressures in the international monetary system. Thus, the gold market was vulnerable to selling pressure and, as producers continued to sell newly-mined gold, speculators reduced their holdings. This combination caused a sharp decline in the open market gold price in the period from October to December, 1969.

On December 30, 1969 some stability returned to the open market when South Africa reached an agreement with the International Monetary Fund on the marketing of its newly-mined gold. The Fund agreed to buy South African gold whenever the open market price dropped to $35 US funds an ounce or whenever South Africa needed funds to pay its international debts. In return, South Africa agreed to sell on the open market whenever the price was above $35 US funds.

Gypsum and Anhydrite

D. H. STONEHOUSE*

Gypsum is a hydrous calcium sulphate ($CaSO_4 . 2H_2O$) which, when calcined at temperatures ranging from 250° to 400°F, forms plaster of paris, the main constituent in gypsum wallboard, lath and plasters. 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 1969 was estimated at $13 billion, about 30 per cent of which was credited to residential building construction. This represented an increase of over 10 per cent from the value of residential building construction in 1968. Despite high interest rates and serious work stoppages in the construction industry in 1969, dwelling starts were 210,415, up 7 per cent from the previous year.

In 1969 gypsum production increased to 6,871,971 tons, exports increased to 4,871,184 tons and imports rose to 81,799 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 to manufacture gypsum building products.

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 is formed into a continuous sheet 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 increased by over 160-million square feet in 1969 and plaster production remained about the same as for 1968.

Crude gypsum is also used in the manufacture of 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.

CANADIAN INDUSTRY AND DEVELOPMENTS

ATLANTIC PROVINCES

During 1969 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 and Ontario plants to produce gypsum products for the construction industry in those provinces.

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.

*Mineral Resources Branch.

TABLE 1

Canada – Gypsum – Production and Trade, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Production (shipments)				
Crude gypsum				
Nova Scotia	4,441,080	7,872,101	5,211,548	9,214,892
Ontario	570,715	1,461,189	630,000	1,539,000
Newfoundland	435,231	1,194,794	490,000	1,176,000
British Columbia	243,374	681,447	278,000	778,400
Manitoba	151,872	442,760	180,000	487,500
New Brunswick	84,668	173,091	82,423	237,310
Total	5,926,940	11,825,382	6,871,971	13,433,102
Imports				
Crude gypsum				
Mexico	67,966	264,000	78,808	256,000
United States	1,092	17,000	2,959	34,000
Britain	4	...	31	1,000
West Germany	–	–	1	1,000
Total	69,062	281,000	81,799	292,000
Plaster of paris and wall plaster				
United States	7,678	507,000	8,579	589,000
Britain	380	16,000	278	12,000
Total	8,058	523,000	8,857	601,000
Gypsum lath, wallboard and basic products				
United States	396	36,000	3,412	201,000
Britain	12	1,000	73	7,000
Total	408	37,000	3,485	208,000
Total imports gypsum and gypsum products	77,528	841,000	94,141	1,101,000
Exports				
Crude gypsum				
United States	4,463,605	8,332,000	4,871,164	9,107,000
France	–	–	20	1,000
Total	4,463,605	8,332,000	4,871,184	9,108,000

Source: Dominion Bureau of Statistics.
pPreliminary; – Nil; ... Less than $1,000.

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 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.

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 1969. 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 Company, Limited 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 1969 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 1969. Gypsum products plants, situated in areas exhibiting major development trends were supplied from Canadian producers of gypsum rock or by imports, mostly from Mexico. The value of building permits rose by 4 per cent in 1969 for the whole western region although Saskatchewan recorded a decrease over the period. Three companies signified their intentions to construct gypsum wallboard manufacturing plants in or near Edmonton during the year; BACM Industries Limited began construction of a plant at Clover Bar destined to go 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 was used at the company's gypsum products plant at Saskatoon and will probably be used at the company's new plant under construction near Edmonton, Alberta. BACM Industries is controlled by Genstar Limited.

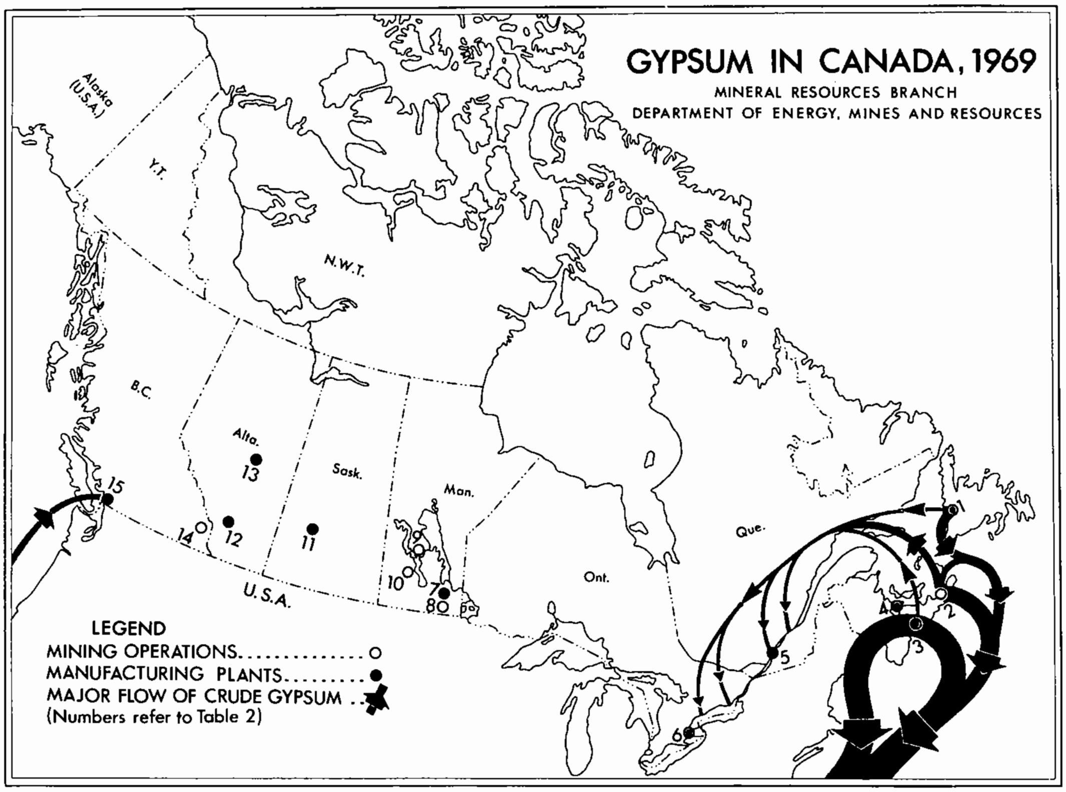
Western Gypsum Mines Ltd., a subsidiary of Western Gypsum Limited, operated an open-pit mine near Windermere in the southeastern part of British Columbia, supplying raw gypsum to its products plants at Calgary and Vancouver and to the Calgary plant of Domtar Construction Materials Ltd. Domtar's Vancouver based gypsum products plant uses raw gypsum imported from Mexico.

TABLE 2

Canada – Summary of Gypsum and Gypsum Products Operations, 1969
(numbers refer to map)

Company	Location	Remarks
Newfoundland		
1. The Flintkote Company of Canada Limited	Flat Bay	Open-pit mining of gypsum.
Atlantic Gypsum Limited	Corner Brook	Gypsum products manufacture.
Nova Scotia		
2. Little Narrows Gypsum Company Limited	Little Narrows	Open-pit mining of gypsum and anhydrite.
Georgia-Pacific Corporation, Bestwall Gypsum Division	River Denys	Open-pit mining of gypsum.
3. Fundy Gypsum Company Limited	Wentworth and Miller Creek	Open-pit mining of gypsum and anhydrite.
National Gypsum (Canada) Ltd.	Milford	Open-pit mining of gypsum.
	Walton	Open-pit mining of gypsum and anhydrite.
Domtar Construction Materials Ltd.	Mackay Settlement	Open-pit mining of gypsum.
	Windsor	Gypsum plaster manufacture.
New Brunswick		
4. Canadian Gypsum Company, Limited	Hillsborough	Open-pit mining of gypsum. Gypsum products manufacture.
Canada Cement Company, Limited	Havelock	Open-pit mining of gypsum used in cement manufacture.
Quebec		
5. Canadian Gypsum Company, Limited	Montreal	Gypsum products manufacture.
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 under construction.
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.



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.

WORLD REVIEW

World production of gypsum for 1969 was estimated to be over 54 million tons. European countries accounted for approximately 53 per cent of the total, the major producers in order of output being: France, USSR, Britain, Spain, Italy and West Germany. North American production of gypsum amounted to about 30 per cent of world total, the United States, Canada and Mexico, in that order, being the major producers. In the United States, Republic Gypsum Co. (Dallas) announced discovery of a 20-million ton deposit of gypsum in northern Indiana during 1969. In support of increased construction activity, wallboard manufacturing plants were expanded, new plants were put on stream during 1969, and some companies diversified their activities to include production of other construction materials. Approximately 11 per cent of world gypsum production came from Asian countries, in particular Iran, India and Japan. The remaining 6 per cent was produced in Africa, Oceania and South America.

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. Imperial Chemical Industries Ltd., which produced 15 per cent of Britain's gypsum-based products, was to phase out its plaster and wallboard production plants at Severnside and at Billingham during 1969 and 1970. Both plants were based on byproduct gypsum.

TABLE 3

World Production of Gypsum, 1968-69
(thousand short tons)

	1968	1969e
United States	10,018	9,700
France	5,512	5,500
Canada	5,927	6,872
Britain	5,126	5,100
Communist countries (except Yugoslavia)	7,712	7,700
Spain	. .	. .
Italy	3,638	3,600
Other countries	15,780	15,900
Total	53,713	54,372

Source: U.S. Bureau of Mines, Commodity Data Summaries, January 1970.
eEstimated; . . Not available.

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 the Marchon Division of Albright & Wilson Ltd. with a plant in England capable of producing 440,000 short tons of each product yearly. A feasibility study was conducted during 1969 on the possibility of producing cement and sulphuric acid from gypsum and anhydrite from the southeastern part of British Columbia. The proposed process involved calcining a pelletized mixture of calcium sulphate, sand, coke and shale at high temperature.

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. In South Africa, a plant was planned to use byproduct gypsum as a source of sulphur. 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 full capacity of 1,000 tpd was not anticipated until mid-1970.

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.

TABLE 4

Canada, Gypsum Production, Trade and Consumption, 1960-69
(short tons)

	Production[1]	Imports[2]	Exports[2]	Apparent Consumption[3]
1960	5,205,731	60,011	4,273,668	992,074
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
1969p	6,871,971	81,799	4,871,184	2,082,586

Source: Dominion Bureau of Statistics.
[1] Producers' shipments, crude gypsum. [2] Includes crude and ground, but not calcined. [3] Production plus imports minus exports.
pPreliminary.

TABLE 5

Canada – Production of Gypsum Products 1968, 1969

Item		1968	1969
Wallboard (square feet)		711,237,181	880,150,068
Lath	"	182,172,494	172,324,542
Sheathing	"	18,751,082	20,981,533
Plaster	(tons)	203,905	202,660

Source: Dominion Bureau of Statistics.

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, for gypsum products manufacture. Raw gypsum is imported on the west coast from Mexico.

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 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.

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 1968 was 269,961 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.

TARIFFS

Tariff No.		British Preferential	Most Favoured Nation	General
CANADA				
29200-1	Gypsum, crude	free	free	free
29300-1	Plaster of paris, or gypsum, calcined, and prepared wall plaster, the weight of the package to be included in the weight for duty			
	Jan. 1 to June 3, 1969 – per 100 lbs	free	9¢	12½¢
	effective June 4, 1969 " " "	"	6¢	"
29400-1	Gypsum, ground, not calcined			
	Jan. 1 to June 3, 1969	6%	7½%	15%
	effective June 4, 1969	free	free	15%
UNITED STATES				
512.21	Gypsum, crude		free	
512.24	Gypsum, ground, calcined			
	On and after Jan. 1, 1969		95¢ per long ton	
	" " " Jan. 1, 1970		83¢ " " "	
245.70	Gypsum or plaster building boards and lath			
	On and after Jan. 1, 1969		10%	
	" " " Jan. 1, 1970		8.5%	

Note: further tariff reductions on the above United States gypsum items will be in effect Jan. 1, 1971 and Jan. 1, 1972.

Indium

ROBERT J. SHANK*

Indium occurs widely in nature, usually in minute quantities and never in the native state. It is found principally in the ores of zinc with lesser amounts found in lead, iron and copper ores. Being most commonly associated with sphalerite, the predominant zinc mineral, indium becomes concentrated in certain residues and slags formed during zinc and lead smelting operations. Painstaking metallurgical procedures are followed in recovering high-purity indium suitable for industrial needs from these residues and slags. Only a few of the world's zinc and lead smelters recover indium.

Statistics on the production of indium are not available. Cominco Ltd., the only producer in Canada, recovers indium from zinc and lead metallurgical operations at Trail, British Columbia, and is one of the world's largest producers. The total potential annual capacity in the non-communist world is estimated to be from 2 million to 3 million ounces and could be readily expanded.

Present annual non-communist world production is about 1 million ounces, three quarters of which comes from Canada and the remainder from United States, Japan, Europe, and Peru.

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

*Mineral Resources Branch.

point and high boiling point. It is easily scratched with the fingernail and can be made to adhere to other metals by hand-rubbing. It has a melting point of 156°C. Like tin, a rod of indium will emit a high-pitched sound if bent quickly. The metal has an atomic weight of 114.8; its specific gravity at room temperature is 7.31, which is about the same as that for iron.

Indium forms alloys with silver, gold, platinum and many of the base-metals, improving their performance in certain special applications. Its first major use, still an important outlet, was in high-speed silver-lead bearings in which the addition of indium increases the strength, wettability and corrosion resistance of the bearing surface. Such bearings are used in aircraft piston engines, diesel engines and several types of automobile engines; the standard grade (99.97 per cent) is satisfactory for this purpose. 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 disks 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. It is also used in neutron monitoring badges. Indium compounds added to lubricants have been found to have a beneficial anticorrosive effect. Indium is used in certain very small lightweight batteries.

TRADE AND CONSUMPTION

No statistics are available on export, import or domestic consumption of indium. Much of Canada's output is exported to the United States and Britain, and smaller amounts go to a number of countries in Europe.

PRICES

Prices of indium as quoted in *Metals Week*, remained unchanged during 1969 from those established September 19, 1968.

Prices were as follows:

	September 19, 1968 to Year-end 1969
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 were 35.7 million tons** valued at $432 million in 1969 compared with 42.4 million tons valued at $533 million in 1968. Both exports, at 27.9 million tons, and domestic shipments, at 7.8 million tons, were down sharply from 1968. The inability to produce and deliver as a result of widespread iron-ore industry strikes were mainly responsible for the losses. Strikes at Canada's two largest integrated steelworks resulted in a production loss of about 1.3 million net tons. Some of this tonnage was made up in the last few months of the year and total steel production was therefore 10.3 million net tons, down 1.0 million net tons from 1968. Domestic consumption of iron ore at iron and steel plants was 9.3 million tons of which 7.4 million tons came from Canadian mines and 1.9 million tons from imports. Total receipts at iron and steel plants, comprised of 7.4 million tons of domestic iron ore and 2.3 million tons of imported iron ore, exceeded consumption by 0.4 million tons and iron ore stocks at the plants went up accordingly.

The Canadian iron ore industry began a period of slow growth in 1969; no new capacity was added, only 0.42 million tons is likely to be added in 1970 and none is expected in 1971. The anticipated 1970 increase will include 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. The International Nickel Company of Canada, Limited's expansion of 0.25 million tons has been deferred to 1972. No other new capacity can be expected before 1972 since it takes at least two years from the date of announcement to construct facilities and begin production. Only one of the several projects that have been planned but not yet committed for Labrador-Quebec, that of the 5-million-ton expansion of Iron Ore Company of Canada's Carol Lake plant, could be ready by 1973. Annual iron ore production capacity in Canada at the end of 1969 was 47 million tons, including 24.8 million tons of pellet capacity.

Production in 1969 came from mines of 17 companies of which eight had mines in Ontario, five in British Columbia, two in Quebec, two in Newfoundland (Labrador) and one in Quebec-Labrador (Table 2). The pellet plants of Steep Rock Iron Mines Limited and the Sherman Mine reached capacity production for the first time in 1969.

In 1970, Canada's iron ore shipments are expected to recover from the 1969 drop and probably will exceed the 1968 peak of 42.4 million tons by about 2.8 million tons. Domestic shipments are expected to be 8.2 million tons and exports about 37 million tons. Shipments in 1975 are expected to be about 60 million tons with Japan becoming a new major importer of Canadian ore. The long-term prospects for the Canadian iron ore industry appear excellent.

* Mineral Resources Branch.
**The long or gross ton (2,240 pounds) is used throughout unless otherwise noted.

TABLE 1

Canada, Iron Ore Production and Trade, 1968-69

	1968		1969p	
	Long Tons	$	Long Tons	$
Production (shipments)				
Newfoundland	17,594,032	246,508,466	13,154,830	178,992,960
Quebec	13,157,183	137,417,718	11,495,893	109,405,064
Ontario	9,738,569	127,137,824	9,345,304	126,081,382
British Columbia	1,870,308	21,630,102	1,718,830	17,450,904
Total	42,360,092	532,694,110	35,714,857	431,930,310
Byproduct iron ore*	860,108	..	968,000	..
Imports				
Iron ore				
United States	2,297,800	30,465,000	1,999,058	27,038,000
Brazil	373,100	3,536,000	174,615	1,533,000
Chile	–	–	40,168	341,000
Mauritania	–	–	27,162	291,000
Venezuela	–	–	19,353	247,000
Australia	1,752	17,000	–	–
Liberia	76,936	593,000	–	–
Total	2,749,588	34,611,000	2,260,356	29,450,000
Exports				
Iron ore, direct shipping				
United States	5,623,769	55,757,000	3,078,121	29,674,000
Britain	301,268	2,878,000	718,766	6,863,000
Italy	457,060	2,907,000	394,162	2,507,000
Belgium and Luxembourg	69,419	677,000	77,547	753,000
Netherlands	–	–	44,560	670,000
Total	6,451,516	62,219,000	4,313,156	40,467,000
Iron ore concentrates				
United States	8,558,296	92,571,000	5,565,815	56,175,000
Japan	1,862,169	19,045,000	2,084,315	20,354,000
Britain	1,843,978	16,331,000	1,149,650	7,958,000
Netherlands	702,460	5,112,000	1,090,660	7,297,000
West Germany	481,012	3,210,000	742,014	5,228,000
Finland	18,328	127,000	90,629	648,000
Italy	68,974	480,000	65,549	459,000
Bahamas	–	–	4,999	48,000
Total	13,535,217	136,876,000	10,793,631	98,167,000
Iron ore, agglomerated				
United States	11,992,246	182,540,000	8,917,644	135,466,000
Netherlands	529,741	7,978,000	1,013,658	15,247,000
Britain	1,205,920	18,377,000	991,097	15,045,000
Italy	820,092	12,664,000	581,786	8,417,000
West Germany	809,730	12,195,000	478,249	7,195,000
Japan	28,810	434,000	106,561	1,602,000
Belgium and Luxembourg	89,972	1,380,000	83,100	1,248,000
France	–	–	29,670	446,000
Total	15,476,511	235,568,000	12,201,765	184,666,000

TABLE 1 (Cont'd)

	1968		1969p	
	Long Tons	$	Long Tons	$
Exports (Cont'd)				
Iron ore, not elswhere specified including byproduct iron, ore				
United States	512,355	8,466,000	596,556	9,830,000
West Germany	35,119	72,000	–	–
Total	547,474	8,538,000	596,556	9,830,000
Total export all classes				
United States	26,686,666	339,334,000	18,159,136	231,145,000
Britain	3,351,166	37,586,000	2,859,513	29,866,000
Japan	1,890,979	19,479,000	2,190,876	21,956,000
Netherlands	1,232,201	13,090,000	2,148,878	23,214,000
West Germany	1,325,861	15,477,000	1,220,263	12,423,000
Italy	1,346,126	16,051,000	1,041,497	11,383,000
Belgium and Luxembourg	159,391	2,057,000	160,647	2,001,000
Finland	18,328	127,000	90,629	648,000
France	–	–	29,670	446,000
Bahamas	–	–	4,999	48,000
Total	36,010,718	443,201,000	27,906,108	333,130,000

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.

PRODUCTION, TRADE AND CONSUMPTION

Renegotiation of some major labour contracts in the iron ore industry resulted in a series of strikes during late spring and summer and consequent large output losses in 1969. As a result of the inability to produce and ship, both exports and domestic shipments suffered large losses.

PRODUCTION

Newfoundland and Quebec were the most seriously affected by the labour strikes with shipments from Newfoundland being down from 17.6 million tons in 1968 to 13.2 million tons and those from Quebec down 1.7 million to 11.5 million tons.

Ontario shipments, at 9.3 million tons in 1969, were down only slightly from 1968 despite labour strikes at four mines. Decreased shipments from these mines were largely offset by increased shipments from two of Ontario's new pellet producers, Steep Rock Iron Mines Limited and the Sherman Mine, both of which operated at about rated capacity for the first time. The Griffith Mine, which also increased shipments, is not expected to attain rated production until 1970. Another stabilizing factor was capacity production at the other Ontario mines.

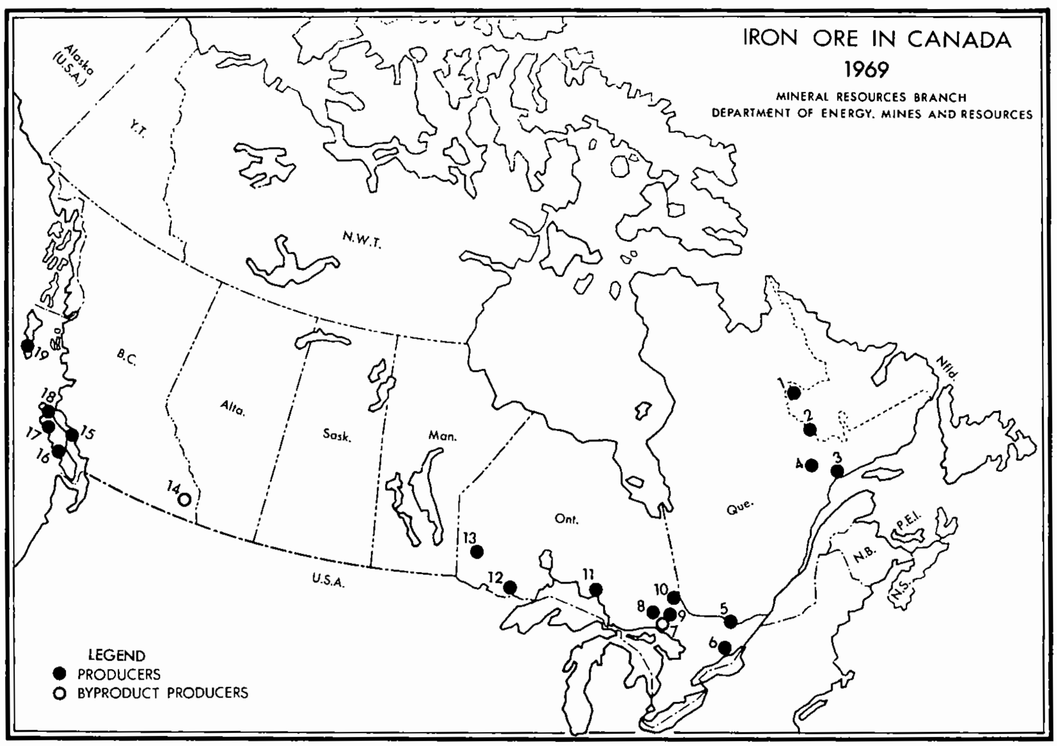
British Columbia shipments at 1.7 million tons were down slightly from the 1968 total of 1.9 million tons. While shipments increased from Wesfrob Mines Limited, Texada Mines Ltd. and Coast Copper Company, Limited, shipments decreased from Zeballos Iron Mines Limited, which was closed in mid-year, and from Brynnor Mines Limited, which continued to ship from stockpile but at a reduced rate. No shipments were made from Jedway Iron Ore Limited whose mine was closed in 1968. All British Columbia shipments were consigned to Japan.

TRADE: EXPORTS

Exports of iron ore fell from a record 36.0 million tons in 1968 to 27.9 million tons in 1969. The weakness of exports was because of the inability to produce and deliver iron ore brought on by strikes during the spring and summer when operations reach their highest production rates. Despite the absence of a strike hedge in the United States that had brought Canadian exports to record levels in 1968, export demand was higher in 1969 because of the more buoyant state of the world steel industry. In the first four months of the year, iron ore exports were 1.6 million tons or 35.7 per cent ahead of those in 1968 but from then to September exports declined sharply from the same period of the previous year. At the end of September 1969, exports totalled 17.5 million tons compared with 26.3 million tons the year before; only a small portion of the loss was recovered in the fourth quarter and the net loss from 1968 was 8.1 million tons.

Exports to the United States, Britain, Italy, West Germany, Belgium and Luxembourg were all lower than in 1968 while those to the Netherlands and Finland were higher. Exports to Japan totalled 2.2 million tons of which 1.8 million tons were from British Columbia and 0.4 million tons were from Quebec-Labrador.

Quebec-Labrador may become an important source of iron ore for Japan by 1975. Shipments from that region, a mere 28,000 tons in 1968, increased to 0.4 million tons in 1969 and consisted of 282,000 tons of



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 (Marmora)
8. National Steel Corporation of Canada, Limited (Capreol)
9. Sherman Mine (Timagami)
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. Brynnor Mines Limited (Ucluelet)
17. Zeballos Iron Mines Limited (Zeballos)
18. Coast Copper Company, Limited (Benson Lake)
19. 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)

Quebec Cartier Mining Company concentrate, 107,000 tons of Carol Pellet Company pellets and 11,000 tons of Carol concentrate. Iron Ore Company of Canada (IOC) signed a contract in 1969 to supply Japan with 800,000 to 1.2 million tons of Carol concentrate during a two-year agreement with shipments beginning in 1970. Also in 1969, Quebec Cartier Mining (QCM) signed a contract to supply Japan with 1.2 million tons a year over a period of five years with shipments beginning in 1971. Two very large Quebec-Labrador projects to supply Japan with significant tonnages are pending. QCM has offered a total of 50 million tons of concentrate over 10 years, starting in 1975, from a new mine it plans to develop at Mt. Wright 75 miles northeast of its present facilities at Gagnon. IOC plans to expand its Carol Lake concentrator to supply Japan with 5 million tons of concentrate annually over 15 years, beginning in 1973.

TRADE: IMPORTS

The trend towards lower imports continued in 1969 as they declined 0.4 million tons from 1968 to 2.3 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 Canada's reliance on foreign sources. Imports will continue because some Canadian steel companies have interests in United States mines. With the anticipated increase in shipments from The Griffith Mine and Sherman Mine and normal shipments from other domestic sources, imports should decline further to about 2.0 million tons in 1970.

United States provided the bulk of imports in 1969 with 2.0 million tons, or 87 per cent, followed by Brazil with 0.2 million tons. Chile, Venezuela and Mauritania shipped small tonnages to Canada with the latter being a supplier for the first time. All the United States ore was consigned to Ontario steel plants, while the African and South American ore went to Sydney Steel Corporation, on Canada's east coast.

CONSUMPTION

Consumption of iron ore in Canadian iron and steel plants declined in 1969, roughly in proportion to lower iron and steel production. Labour strikes at Canada's two largest steelworks – The Steel Company of Canada, Limited and The Algoma Steel Corporation, Limited – were responsible for the lower steel output and consequent lower iron ore requirements. Iron ore consumption, excluding ilmenite, was 9.3 million tons in 1969 compared with 10.7 million tons in 1968; crude steel production was 10.3 million net tons compared with 11.3 million net tons.

TABLE 2

Production and Capacity of Pig Iron and Crude Steel at Canadian Iron and Steel Plants, 1968-69
(short tons)

	1968	1969p
Pig iron		
Production	8,382,601	7,461,219
Capacity at Dec. 31	9,580,000	9,580,000
Steel ingots and castings		
Production	11,250,996	10,306,552
Capacity at Dec. 31	13,114,375	13,241,375

Source: Dominion Bureau of Statistics.
p Preliminary.

TABLE 3

Receipts, Consumption and Stocks of Iron Ore at Canadian Iron and Steel Plants, 1968-69
(long tons)

	1968	1969
Receipts imported	2,595,761r	2,193,270
Receipts from domestic sources	8,025,525	7,402,291
Total receipts at iron and steel plants	10,621,286r	9,595,561
Consumption of iron ore	10,720,331	9,302,792
Stocks of ore at iron and steel plants, December 31	3,673,269r	4,060,747
Change from previous year	−77,059	+387,478

Source: American Iron Ore Association, compiled from company submissions.
r Revised.

WORLD REVIEW

World production of iron ore was an estimated 690 million tons in 1969, up 32 million tons from 1968. This parallels the rise in world steel production, which was up some 47 million net tons from 1968 to 632 million net tons. The USSR ranked first among world iron ore producers with 183 million tons (compared to 174 million tons in 1968), followed by United States with 86 million tons (86 million tons), France with 55 million tons (55 million tons), Australia with 39 million tons (23 million tons) and Canada with 36 million tons (42 million tons). Australia displaced Canada in fourth position because of a tremendous rise in shipments by Australia to supply burgeoning Japanese demand against lower shipments to major

TABLE 4

Canada, Iron Ore Producers, 1968 and 1969

Company and Property Location	Material Mined and/or treated (% Fe natural)	Product Shipped (% Fe dry)	Shipments (000 tons) 1968	1969	Developments in 1969
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)	1,788	1,109	Operations at Wawa closed because of labour strikes at parent steelworks lasting 13 weeks. Work conducted on The Little Long Lac Gold Mines Limited iron property; will continue in 1970. Testing of sized sinter for blast furnace feed continued.
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)	200	39	Ceased mine operations Dec. 1967; continued to mill 1967-68; ceased all production June 1968; shipments continued from stockpile in 1969; stockpiled ore exhausted Jan. 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 to 60)	1,039 1,203	896 886	Strikebound 7 weeks.
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)	9,071 875	8,096 328	Strikebound 13 weeks. 5-million-ton expansion to concentrator pending.
Coast Copper Co., Ltd.; Benson L. northern Vancouver Is., B.C.	Chalcopyrite and magnetite from underground mine (31)	Byproduct magnetite concentrate (65)	67	75	Crude ore from Coast Copper mine supplemented by crude ore from newly-developed Benson Lake mine.
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)	501	921	Capacity production of 1.5 million tons anticipated for 1970.
Hilton Mines, The[2]; near Shawville, Que., 40 miles NW of Ottawa.	Magnetite from open-pit mine (31)	Pellets (66)	636	1,020	Increased shipments came from stockpile with production at rated capacity of 900,000 tons.

Iron Ore Company of Canada (IOC)[3]; Schefferville, Que.	Hematite-goethite-limonite from open-pit mines (54)	Direct shipping (60)	6,514	4,231	Strikebound 13 weeks. Pellet plant at Sept-Iles to pelletize Schefferville ores pending. $15-million dock to handle 200,000-ton vessels completed early 1970.
Jedway Iron Ore Ltd.[1]; Moresby Island, Queen Charlotte Is., B.C.	Magnetite from open-pit mines (37e)	Magnetite concentrate (63)	101	–	Ceased operations Feb. 1968; no shipments made in 1969.
Jones & Laughlin Mining Co., Ltd. (Adams Mine); near Kirkland Lake, Ont.	Magnetite from open-pit mines (20)	Pellets (65)	1,104	1,083	Northeast orebodies being readied for production in 1970.
Marmoraton Mining Company, Division of Bethlehem Chile Iron Mines Company; near Marmora, Ont.	Magnetite from open-pit mine (21e)	Pellets (65)	454	513	Operations at normal capacity rate. Shipments exceeded production by drawing on stockpiled ore.
National Steel Corporation of Canada, Ltd. (Moose Mountain Mine); Sudbury area, 20 miles north of Capreol, Ont.	Magnetite from open-pit mine (34)	Pellets (64)	680	664	Operations normal.
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)	8,601	7,736	Strikebound 7 weeks. Approach channel at Port Cartier deepened to 55 ft. and turning basin enlarged to 1,200 ft. to accommodate vessels of up to 150,000 tons.
Sherman Mine[4]; near Timagami ,Ont.	Magnetite from open-pit mines (24)	Pellets (65)	762	1,058	Capacity production reached in 1969. Modifications to raise capacity 120,000 tons to 1.12 million tons to start 1970. Silica content of pellets reduced with new flotation system.
Steep Rock Iron Mines Ltd.; Steep Rock Lake, north of Atikokan, Ont.	Hematite-goethite from open-pit (51e)	Concentrate (58) Pellets (63)	242 1,058	159 1,413	Pellet plant reached capacity production. Extensive modifications to pellet plant; bentonite now used as a binder. Review of ore reserves in 1969 to be continued in 1970.
Texada Mines Ltd.[5]; Texada Island, B.C.	Magnetite and chalcopyrite from underground mines (34)	Magnetite concentrate (65)	529	581	New contract with Japanese calling for price of U.S. $9.12 f.o.b. and U.S. $11.62 c.i.f. a metric ton. Transition to trackless mining completed at year-end.
Wabush Mines[6]; Scully Mine Division includes Scully 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)	5,483	3,321	Strikebound for 17 weeks. Modifications of entire grinding circuit from wet to dry at Pointe Noire plant, started in 1968, continued in 1969. Modifications expected to be completed in 1970. Program includes installation of 9th mill to achieve necessary grinding capacity.

TABLE 4 – (Cont'd)

Company and Property Location	Material Mined and/or treated (% Fe natural)	Product Shipped (% Fe dry)	Shipments (000 tons) 1968	1969	Developments in 1969
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 (69) and sinter-feed concentrate (62)	781	928	Near-capacity production reached.
Zeballos Iron Mines Ltd.[1]; near Zeballos, Vancouver Is., B.C.	Magnetite from underground mine (48)	Magnetite concentrate (63)	133	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	132	149	Operations normal.
Falconbridge Nickel Mines, Ltd.; Falconbridge, Ont.	Pyrrhotite flotation concentrates treated	Iron oxide calcine (67)	67	44	Strikebound 13 weeks. Nickel-Iron Refinery for production of 300,000 tons of iron-nickel, reduced pellets annually to be completed mid-1970.
International Nickel Co. of Canada, Ltd., The; Copper Cliff, Ont.	Pyrrhotite flotation concentrates treated	Pellets (67)	654	775[e]	Strikebound 18 weeks. Expansion of iron ore recovery plant deferred; will be completed in 1972 to raise capacity by 250,000 tons to 1.1 million tons.
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 electric smelted to TiO_2 slag and various grades of desulphurized pig iron or remelt iron	1,232[7]	1,381[7]	

Sources: Company reports, personal communication and others for shipments and detail.

[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 The Youngstown Sheet and Tube Co. [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.; The Youngstown Sheet and Tube Co.; Inland Steel Co.; Interlake Steel Corp.; Wheeling-Pittsburgh Steel Corp.; Finsider of Italy; and Pickands Mather & Co. (managing agent). [7]Ilmenite smelted; 525,402 net tons of pig iron and 749,234 net tons of titania slag (70-72% TiO_2) were produced in 1969.

[e]Estimated; – Nil.

markets by Canada as a result of labour disputes. Record shipments were made from most iron ore producing countries, including Brazil, Liberia, Peru and Mauritania. Sweden's production was down from 1968 by 2 million tons to 30 million tons as a result of a labour strike at its LKAB mines late in the year.

One of the outstanding events of the industry in 1969 was the startup of Australia's Mt. Newman Mining Co. facilities with first shipments being made to Japan. The world pelletizing industry experienced a pause in its surging growth in 1969 when only 8.3 million tons were added to capacity compared with 15.8 million tons the year before. New pellet plants included those of CVRD in Brazil (2.0 million tons), Inland Steel Company in the United States (0.75 million tons) and A/S Sydvaranger in Norway (1.20 million tons). World iron ore pellet capacity at the end of 1969 was 105.6 million tons of which 77.4 million tons was in North America (52.6 million tons in the United States and 24.8 million tons in Canada). The remaining capacity was in Australia (5.8 million tons), Sweden (3.1), Peru (3.5), Liberia (2.0), Brazil (2.0), Russia (2.0) and other countries. Renewed growth in world pelletizing capacity is indicated in 1970 as 13.0 million tons additional capacity is expected. An expansion of the Minntac pellet plant in the United States from 6.0 million tons to 12 million tons a year was announced in 1969.

The trend towards increasing international trade in ore continued in 1969 and was attributable to the fact that many large steel-producing countries that regularly record gains in steel production are also major importers of ore. Japan was the major contributor to the increase when its imports rose from 67.5 million tons in fiscal 1968 to 84.8 million tons in fiscal 1969 (ending March 31, 1970). Import requirements for fiscal 1970 are estimated at 99 million tons. However, world trade as a percentage of output may not rise appreciably from the 1968 figure of 39 per cent, including intra-ECSC trade, because a greater proportion of world ores entering trade channels are higher grade.

OUTLOOK AND FORECAST

In 1970, Canadian iron ore shipments are expected to recover from the 1969 decline and will probably exceed the 1968 peak of 42.4 million tons by about 2.8 million tons. This is based mainly on the two underlying assumptions that world steel demand, at a record in 1969, will probably be maintained or increase slightly and that Canadian steel production will increase considerably from 1969 to slightly more than the 1968 record. Stabilized production from mines as a result of settlement of major labour contracts in 1969, capacity production for the first time at several mines, and ample stocks at the mines will enable the iron ore industry to meet any increased export and domestic demand in 1970. It is reasonable to anticipate exports at 37 million tons and domestic shipments at 8.2 million tons. Imports will likely be down from 1969 by 0.3 million tons to 2.0 million tons in 1970.

Canadian iron ore shipments in 1975 are expected to be about 60 million tons comprised of 13 million tons of domestic shipments and 47 million tons of exports. A recent steel company estimate placed Canadian steel consumption in 1975 at 16 million net tons, up 4.7 million net tons from 1968 and 5.7 million net tons from 1969. This is equivalent to iron ore requirements of about 15 million tons of which 2 million tons will probably still come from imports. New requirements for domestic consumption by 1975 could well be met by developments in several areas of which one of the most important might be expansion of Wabush Mines, which is 42 per cent owned by Stelco and Dofasco. Dofasco could also expand its Sherman Mine and Stelco its Griffith Mine. Additional requirements by Algoma will probably be met by new construction on one or more of the properties in northern Ontario in which it has interests.

It is reasonable to anticipate exports at 47 million tons in 1975 if Canada maintains its current markets and if negotiations to supply iron ore to Japan from new or expanded facilities in Quebec and Labrador are finalized.

The long-range outlook for iron ore markets and much higher Canadian production are excellent. As in the past, the domestic iron ore industry will continue to rely on export markets for the bulk of its iron ore sales. Factors influencing the growth in Canadian iron ore exports are many and include the expanding demand for iron ore in consuming countries; the inability of some traditional sources to meet the increase in demand; the increasing demand for beneficiated high-grade ore; the proximity of beneficiating-grade ores to the United States and Europe; the existence of deep-water ports in Quebec to make sales of concentrates competitive in the Japanese market; and Canada's traditionally favourable political and fiscal policies. Domestic requirements will parallel the demand to meet the growth in crude steel production that averaged nearly 9 per cent a year from 1960 to 1968.

PRICES

The downward trend in international iron ore prices was arrested in 1969 when the improved situation of the steel market tended to stabilize iron ore prices at about the 1968 level. The buoyant state of the world steel industry will probably result in higher prices on the European market for 1970. The Lake Erie base price will also be higher in 1970 as a result of increased transportation and labour costs. Large contracts with Australian producers during 1969 will stabilize prices of ore entering the Japanese market in 1970.

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 delivered at rail of vessel at Lake Erie ports. The Lake Erie base price for selected ores in 1969 and posted prices for 1970 shipments are listed in Table 5.

TABLE 5

Lake Erie Base Price* of Selected Ores, 1969-70

	$U.S.	
	1969	1970
Mesabi Non-Bessemer	10.55	10.80
Mesabi Bessemer (+ phos. premium)	10.70	10.95
Old Range Non-Bessemer	10.80	11.05
Old Range Bessemer	10.95	11.20
High Phosphorus	10.55	10.80
Pellets (per iron nat. unit**)	0.252	0.266

* Per gross ton, 51.5% of iron natural, at rail of vessel, lower lake port.

**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.

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 is the first change in the base price since 1963 when pellet prices were first quoted and when the price of natural ore had declined 10¢ in a buyer's market to cover an increase in the lake freight rate.

Although price revisions to higher levels were being considered for most of 1969, they were not settled and announced until mid-January 1970. The price of natural ore was increased by 25 cents to cover the rise in transportation charges. Increased labour costs resulting from industry-wide labour agreements during 1969 and higher transportation charges account for the rise in the price of pellets. The increased labour cost for making pellets was passed on to the consumer, that for natural ore was absorbed by the producer who is seeing a declining demand for this type of ore. Some listed prices for offshore iron ore pertinent to the United States market are:

Swedish iron ore pellets, Atlantic shipping ports, 68% Fe min.-Nom. U.S. $14.25 a ton*

Brazilian iron ore, Atlantic port, 68-69% Fe-Nom. U.S. $10.00 a ton*

Venezuelan iron ore, Orinoco No. 1, 58% Fe f.o.b. Puerto Ordaz-U.S. $7.88 a ton*

Brazilian lump, 68.5% Fe, f.o.b. Brazil – U.S. $9.10 – 9.60**

Sources: *American Metal Market 3/12/70.
**Metals Week 3/9/70.

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 metric ton, equivalent to about 18¢ a unit, and the f.o.b. price by 5¢ to U.S. $9.12 a metric ton.

EUROPE

The price for Kiruna D ore (60 per cent Fe, 1.8 per cent p), 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. Prices for Swedish pellets were reported to be 5 per cent lower on 1969 contracts than in 1968. Overall, the statistical mean price for Swedish iron ore products declined by 0.8 per cent from the previous year. This was in spite of a continued shift towards increased production of higher grade products.

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 on a spot basis from other sources and 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 upwards to account for some of the price rise.

From Dominion Bureau of Statistics data and estimated shipping costs, prices for Canadian ore c.i.f. Rotterdam in U.S. cents a long ton unit are calculated to be 24.6 for pellets, 19 for concentrate and 13 for run-of-mine. It was reported that the price for Canadian pellets in Europe will be raised 5 per cent in 1970 to maintain parity with the North American price.

Iron ore prices will rise in Europe in 1970. Generally, Europe's steel producers, unlike those in the United States and Japan, have relatively unprotected forward positions in that most 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, in either country, ore prices are not affected by strong short-term demand. The LKAB strike may have helped to strengthen the bargaining position of the mines who were reported to be seeking substantial price increases ranging from 10 to 15 per cent. Some of the suppliers, especially those who 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.

JAPAN

The downward trend in the f.o.b. price of iron ores contracted to Japan levelled off in 1969 although Japan's c.i.f. prices will probably continue to decline gradually because of ever-decreasing transportation costs. The Australian price sets the pattern for prices of other ores entering the Japanese market because its ores are high-grade, high-quality and comparatively close to Japan. C.i.f. prices for fines, lump and pellets contracted in 1969, are calculated to be 15, 18 and 21.5 U.S. cents a unit.

The contract concluded in 1969 for 0.8 to 1.2 million tons of Carol concentrate calls for a price of U.S. 16.4¢ a metric unit, all on a special c & f basis. The price of concentrate for the 6-million-ton-a-year contract being sought by Quebec Cartier Mining in 1969 is not known. Freight rates were reported to be U.S. $3.60 a ton with ore to be carried in Oil-Bulk-Oil Carriers (OBO) some 15,200 miles around the Cape of Good Hope. From this data, QCM and Carol concentrate would be selling for an estimated U.S. $7.14 a ton f.o.b. Sept-Iles. However, the proposed 5-million-ton-a-year contract by IOC for Carol concentrate is at an announced price of U.S. $7.50 a ton, which could mean that the shipping cost may be reduced to U.S. $3.14 a ton by shipping in larger vessels. 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).

Iron and Steel

G.E. WITTUR* and V.B. SCHNEIDER*

Demand for steel in Canada, as measured by apparent consumption, rose in 1969. Two separate factors, however, had a major influence on domestic iron and steel production and trade. One of these was expiry of labour contracts at several iron and steel plants about mid-year with consequent lengthy strikes. The other was a rather remarkable, almost worldwide increase in steel demand that taxed production capacity and led to sharply higher steel prices in nearly all countries and to long lead-times for steel ordered from offshore sources.

Crude[1] steel production in Canada was 10.3 million tons[2] in 1969, compared with 11.25 million tons in 1968 and 9.7 million tons in 1967. Production lost because of strikes is estimated at 1.3 million tons although some of this tonnage was made up in the last two months of the year and by production at plants not closed. Apparent consumption, at 11.8 million tons, on a crude steel basis, was moderately higher than the 1968 level of 11.1 million tons. Since it is believed that steel inventories were reduced during the year, it follows that real consumption probably exceeded apparent consumption in 1969. The difference between domestic production and apparent consumption was covered partly by reduced exports, which fell by 32 per cent in 1969, and partly by higher imports, which rose by 56 per cent. Restricted supply from most countries normally exporting steel to Canada, combined with sharply higher international export prices, undoubtedly discouraged an even larger increase in imports.

Although 1969 capital expenditures at iron and steel mills were expected to total about $150 million, based on a survey of intentions conducted late in 1968, actual expenditures reached only $102.4 million. Major reasons for failure to reach the planned level included delays due to construction and steel industry strikes, and to high costs of borrowed capital. Investment totalled $85.8 million in 1968 compared with a record $210.6 million in 1966. Nevertheless, corporate announcements between late 1968 and early 1970 indicate that major investment expenditures in the Canadian iron and steel industry may be expected during the 1970's.

During 1969 there were three price changes for steel products. Prices of semi-finished shapes, bar products, plate and structurals were raised in the spring although tin-plate and bar prices were fractionally reduced. Prices on hot rolled, cold rolled and galvanized sheet and strip were raised in October. In November a further series of price increases was announced for those products whose price had been increased in the spring. Price changes on individual products varied and ranged as high as 11 per cent on semi-finished carbon shapes. The net effect of 1969 price movements was an increase averaging slightly over 6 per cent on all rolling mill products.

Corporation profits varied from company to company, but in general the year was a good one. 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 7.8 per cent

* Mineral Resources Branch.

[1] Crude steel includes steel ingots, continuous-cast sections and castings; the term 'raw steel' used with increasing frequency is crude steel less castings.

[2] The short or net ton of 2,000 pounds is used throughout.

in 1969. This was a decline from 11.6 per cent in 1968.

WORLD PRODUCTION

Canada and Italy were the only major exceptions in an otherwise worldwide increase in steel production in 1969. Output rose by nearly 8 per cent to 629 million tons. This rate of increase is remarkable because during the last 20 years the annual rise has seldom exceeded 5 per cent and has averaged about 3.6 per cent compounded. As shown in Table 2, Japan alone accounted for more than one third of the absolute rise in 1969 with an increase of 16.8 million tons. Substantially higher production was also recorded by many European countries, especially West Germany and France, and by the United States. Canada remained in 12th place among world producers. High levels of production are expected to be maintained in most countries well into 1970. Japan expects to produce 130 million tons a year by 1972 and some have projected production there at 178 million tons in 1975. One result of recent international demand trends will probably be a major expansion of steelmaking capacity in many countries.

TABLE 1

Canada – General Statistics
of the Domestic Primary Iron and Steel Industry, 1967-69

	Unit	1967	1968[r]	1969[p]
Production				
Volume Indexes				
Total Industrial Production	1961 = 100	151.7	159.8	167.9
Iron and Steel Mills[1]	"	148.1	169.7	166.6
Value of Shipments, Iron and Steel Mills[1]	$ millions	1,211.0	1,333.8	1,366.5
Value of unfilled orders, year-end, Iron and Steel Mills[1]	"	158.0	156.2	220.6
Value of Inventory owned, year-end, Iron and Steel Mills	"	262.2	270.7	286.1
Employment – Iron and Steel Mills[1]				
Administrative	number	8,125	8,678	8,784
Hourly rated	"	36,078	36,414	34,309
Total	"	44,203	45,092	43,093
Employment index, all employees	1961 = 100	129.5[r]	130.7	126.2
Average hours per week, hourly rated	hours	39.9[r]	40.3	40.0
Average earnings per week, hourly rate	$	124.17[r]	132.11	140.04
Average salaries and wages per week, all employees	$	130.91[r]	139.08	148.17
Expenditures – Iron and Steel Mills[1]				
Capital: on construction	$000	19,128	11,658	17,511
on machinery	"	103,740	53,673	84,868
Total	"	122,868	65,331	102,379
Repair: on construction	"	7,225	9,116	8,940
on machinery	"	132,764	144,429	129,186
Total	"	139,989	153,545	138,126
Total Capital and Repair	"	262,857	218,876	240,505
Trade – Primary Iron and Steel[2]				
Exports	$ millions	223.2	310.9	267.8
Imports	"	310.7	284.9	410.4

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.

[p]Preliminary; [r]Revised.

TABLE 2

World Production of Steel, 1967-69
(thousands of net tons)

	1967	1968r	1969p
North America, total	140,265	146,304	155,102
Canada	9,701	11,251	10,307
Mexico	3,351	3,591	3,726
United States	127,213	131,462	141,069
South America, total	7,377	8,593	9,288
Western Europe, total	145,505	159,250	168,642
Belgium and Luxembourg	15,645	18,079	20,225
France	21,670	22,491	24,805
West Germany	40,502	45,366	49,938
Italy	17,516	18,694	18,092
Netherlands	3,753	4,081	5,194
Total ECSC	99,086	108,711	118,254
Britain	26,763	28,965	29,594
Other	19,656	21,574	20,794
Eastern Europe, total	149,254	155,463	164,298
Czechoslovakia	11,024	11,676	11,880
Poland	11,476	12,133	12,298
USSR	112,655	117,064	121,220
Other	14,099	14,590	18,900
Africa and Middle East, total	5,061	5,095	5,698
Far East, total	92,929	98,347	118,023
China	14,880	15,000	17,700
India	7,099	6,953	7,383
Japan	68,512	73,730	90,523
Other	2,438	2,664	2,417
Oceania, total	7,137	7,330	7,716
Australia	6,967	7,160	7,716
Other	170	170	..
World total	547,528	580,382	628,767

Sources: Dominion Bureau of Statistics; Annual Statistical Report, American Iron and Steel Institute; Metal Bulletin, March 26, 1970; Monthly Report of the Iron & Steel Statistics, Feb. 1970, Vol. 13, No. 2, The Japan Iron & Steel Federation.

pPreliminary; rRevised; . . Not available.

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 1969.

PIG IRON

Production of pig iron fell 10.7 per cent in 1969 to 7.5 million tons (Table 3) as a result of strikes at plants of The Steel Company of Canada, Limited (Stelco) and The Algoma Steel Corporation, Limited. Production rose at all other plants.

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 1969 rose significantly. Only minor tonnages are imported. Construction of a new blast furnace is under way at Dominion Foundries and Steel, Limited (Dofasco) and another is planned at Algoma although the construction schedule has not yet been announced.

CRUDE STEEL

Production of crude steel declined 8.3 per cent in 1969, to 10.3 million tons (Table 4). The decline was a result of strikes at Stelco and Algoma plants in Ontario. Castings production rose 10.6 per cent to 154,706 tons. Open-hearth furnaces produced 51 per cent of total crude steel, down from 55 per cent in 1968; oxygen furnaces accounted for 31 per cent, which is the same as for the previous year; electric furnaces produced 18 per cent of the total in 1969 compared with 13.8 per cent in 1968. In future years, production by both basic oxygen and electric furnaces, especially the former, is expected to replace that by open hearths in both percentage and, beginning about 1973, absolute terms. Furnace installations in the foreseeable future are likely to include oxygen and electric types only and some existing open-hearth capacity will be removed from service in the next few years.

* 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" (50 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. Both are available from the Mineral Resources Branch or The Queen's Printer.

Total crude steel capacity was 13.3 million tons at the end of 1969, only a slight increase from that of 1968. However, investment projects under way or planned will raise annual capacity to 15.5 million tons by early 1973.

SHIPMENTS OF STEEL PRODUCTS

Notwithstanding the lengthy labour strikes at Stelco and Algoma, the total tonnage of hot- and cold-rolled products shipped to domestic consumers in 1969 was 2.2 per cent greater than in 1968 (Table 7) and at an all-time high. As was expected, net shipments of rolled products (Table 6) was lower than the previous year, but only by a quarter of a million tons. Cold-rolled products were about the same as in 1968 with most of the reduced shipments occurring in hot-rolled products.

After discounting special trends due to strikes at producers and consumers, steel demand was strong in 1969 from most consuming industries and for most rolled products. Main underlying factors contributing were high rates of investment for building construction, including $3.4 billion for housing, and $5.9 billion for machinery and equipment. Other factors such as a strong demand for consumer durables; continued continental rationalization in several sectors including transportation, machinery and electrical products industries; resource development, one effect of which is expansion of rail capacity to move large tonnages of bulk commodities; and continued high levels of demand in the United States. Consequently, steel demand was strong from the automotive industry, structural steel fabricators, the stamping and pressing industry, and producers of railroad rolling stock, appliances, industrial electrical and non-electrical machinery, fasteners and containers. The pipe and tube industry, although not quite as busy as in 1968, when large tonnages of line pipe were exported, nevertheless enjoyed a better than average year.

TABLE 3

Canada, Pig Iron Production, Shipments, Trade and Consumption, 1967-69
(net tons)

	1967	1968r	1969p
Furnace capacity, December 31	9,276,000	9,580,000	9,580,000
Production			
Basic iron	6,178,938r	7,561,936	6,556,964
Foundry iron	532,442r	560,499	628,689
Malleable iron	239,423r	260,166	275,566
Total	6,950,803r	8,382,601	7,461,219
Shipments			
Basic iron	43,724r	118,330	70,332
Foundry iron	455,268r	576,042	622,297
Malleable iron	218,566r	216,759	193,236
Total	717,558r	911,131	885,865
Imports – net tons	28,743	36,777	22,944
– value ($ 000)	1,295	1,812	1,104
Exports – net tons	485,695	548,643	721,644
– value ($ 000)	25,382	26,967	35,815
Consumption of pig iron			
Steel furnaces	6,134,811	7,379,905	6,296,304
Iron foundries	281,080	315,658	282,591
Consumption of iron and steel scrap			
Steel furnaces	4,968,422	5,372,201	5,134,762
Iron foundries	970,381	978,797	1,063,769

Source: Dominion Bureau of Statistics, Primary Iron and Steel (monthly) and Iron and Steel Mills (annual).
rRevised; pPreliminary.

TABLE 4

Canada, Crude Steel Production, Shipments, Trade and Consumption, 1967-69
(net tons)

	1967	1968[r]	1969[p]
Furnace capacity, December 31			
Steel ingot			
Basic open-hearth	6,470,000	6,970,000	6,970,000
Basic oxygen converter	3,630,000	3,800,000	3,800,000
Electric	2,292,010[r]	1,923,650	2,055,450
Total	12,392,010[r]	12,693,650	12,825,450
Steel castings	438,200	420,725	415,925
Total	12,830,210[r]	13,114,375	13,241,375
Production			
Steel ingot			
Basic open-hearth	5,225,710	6,189,450	5,292,069
Basic oxygen[e]	3,208,655	3,509,038	3,275,297
Electric	1,119,602[r]	1,410,119	1,584,480
Total	9,553,967[r]	11,108,607	10,151,846
of which continuously cast	647,252	1,068,282	1,212,813
Steel castings			
Basic open-hearth	62	*	*
Electric	146,803[r]	142,389	154,706
Total	146,865[r]	142,389	154,706
Total steel production	9,700,832	11,250,996	10,306,552
Alloy steel in total	768,202[r]	804,659	837,897
Shipments from plant			
Steel ingots	296,136	393,339	472,377
Steel castings	141,561	138,187	153,959
Rolled steel products	7,009,588	8,211,358	7,984,841
Total	7,447,285	8,742,884	8,611,177
Exports† – equivalent steel ingots	1,367,702	2,078,962	1,423,352
Imports† – " " "	1,981,073	1,884,983	2,934,414
Indicated Consumption† – equivalent steel ingots	10,314,203[r]	11,057,017	11,817,614

Source: Dominion Bureau of Statistics.
*Included with electric. †Computation by Mineral Resources Branch.
[r]Revised; [p]Preliminary; [e]Estimated.

OUTLOOK AND FORECAST

Prospects for the Canadian steel industry in 1970 are reasonably good. Domestic demand is expected to remain strong during the first half of the year, partly to rebuild producer and consumer inventories following their depletion in 1969, and to ease during the second half. Imports will almost certainly decline significantly in 1970. Export potential should be good to excellent for at least the first half and probably well into the second half of 1970. Thus, Canadian crude steel production is expected to reach 11.5 million tons in 1970 which would exceed the record level of 11.25 million tons produced in 1968.

Prospects for the long term are optimistic. Recent industry statements suggest that annual raw steel production growth may average 6 to 7 per cent during the 1970's which, beginning with 1969 production as a base, would mean production in the order of 15 million tons in 1975 and 20 million tons in 1980. Although prospects are favourable in nearly all consuming industries, the likelihood of major oil and gas pipeline construction is of particular interest to the Canadian steel industry.

Despite continuance of fiscal and monetary restraints as 1970 begins, officials of most leading industry sectors have projected relatively high rates of output during the year. Forecast 1970 investment expenditures of $17.9 billion are higher in all sectors and if this forecast is borne out, demand for steel will remain strong from the construction, machinery and transportation sectors. Capital and repair expenditures for the mining industry in 1970 are expected to exceed $1.5 billion; for manufacturing $3.5 billion; for housing $4.1 billion; and for agriculture and fishing $1.3 billion. Motor vehicle industry expectations are cautiously optimistic although labour contract negotiations, later in the year, could result in strike action that would curtail production. Continued high interest rates and restrictions in money supply may result in an easing in industrial production and thus in domestic steel demand by mid-year. Export potential for the Canadian steel industry will be favourable for 1970. Imports of rolled steel are almost certain to fall significantly in 1970 because of heavy international demand and continued high import prices. Thus, Canadian crude steel production should exceed that in 1969 by a million tons.

TRADE

Canada's balance of trade in primary steel products plus castings, forgings, pipe and wire deteriorated sharply in 1969, which is against the trend during the past decade. Exports of the above products exceeded imports in terms of both tonnage and value in 1968 for the first time in history but strikes at domestic plants in 1969, combined with reasonably strong domestic demand, resulted in a 55 per cent increase in import tonnage and a 32 per cent decrease in export tonnage in 1969.

Although imports of most steel products were higher in 1969 there were particularly large increases for semi-finished steel (slabs, blooms and hot-rolled sheet) that was purchased by domestic plants for further rolling and finishing in Canada. Imports of bar mill products and structural sections were also much higher than in 1968. The largest export reductions occurred for hot- and cold-rolled sheet, plate and ingots and semis.

The United States continued to be the most significant individual supplier of Canadian steel imports (46 per cent of the total in 1969) and market for exports (78 per cent) (Table 10). However, the six EEC countries as a bloc supplied 19 per cent of imports, Japan supplied 18 per cent and Britain accounted for 7 per cent. Latin America is Canada's second most important export market for steel after the United States, followed by Britain. Increasing amounts are being sold to other European nations.

Prospects are very good that a considerable improvement will occur in Canada's steel trade balance in 1970. Steel demand and, more importantly, steel prices on the international export market should remain very favourable to Canadian producers, especially during the first half of 1970 but also to a lesser extent throughout the year. Capacity available to serve export markets will be limited for at least the first half, however.

With most of the Canadian steel industry not subject to possible strikes in 1970, home mills will be capable of meeting most of the domestic steel demand. For this reason, together with a generally favourable domestic export-import price balance, imports are expected to fall sharply in 1970.

MANPOWER AND LABOUR

The index of employment in primary iron and steel industry declined from 130.7 in 1968 to 126.2 in 1969 (1961 = 100); total employment declined 4.4 per cent to 43,092 (Table 1). Average weekly hours worked in 1969 were 40 and earnings by hourly-rated employees averaged $140.04 a week, up 6 per cent from 1968. However, some 1.3 million man-days were lost by the labour strikes at Stelco and Algoma; the new contracts at both Stelco and Algoma cover three years. At Sydney Steel Corporation, Sydney, Nova Scotia, the plant's labour contract expired in January 1968 but was extended to April 1969 through company-union agreement. Except for a two-day wildcat strike in March 1969, a new three-year contract was signed in June without further work stoppage.

Labour contracts will expire in a number of other industries in 1970 that are of significance to the steel industry and its well-being. Those of special interest include transportation (e.g. railways, St. Lawrence Seaway), the construction trades, automotive, agricultural equipment and electrical manufacturers, and mining.

RAW MATERIALS

Consumption of most raw materials at Canadian iron and steel plants declined in 1969, roughly in comparison to the lower rates of production. Iron ore consumption, including plant sinter was 11 million net tons compared with 12.8 million tons in 1968. Consumption of ilmenite, used to make pig iron and titania slag, rose 12 per cent to about 1.6 million tons (Table 12). Lengthy strikes at several Canadian iron mines during the summer necessitated some shifts in ore supply patterns, with reduced tonnages of Labrador ore being offset by the supply of additional amounts from Ontario mines plus moderately higher imports. Domestic ore accounted for about three quarters of consumption compared with about four fifths in 1968. About two thirds of ore consumed was pelletized and much of the remainder was sintered.

TABLE 5

Canada, Production, Trade and Apparent Consumption of Primary Iron and Steel, 1960-69
(000 net tons equivalent ingot)

	Crude Steel Production	Imports[1]	Exports[1]	Indicated Consumption[2]
1960	5,809	1,353	994	6,168
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[r]	1,981	1,368	10,314[r]
1968	11,251	1,885	2,079	11,057
1969[p]	10,307	2,934	1,423	11,818

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 of stocks.
[r]Revised; [p]Preliminary.

Consumption of scrap in steel furnaces fell 4.4 per cent in 1969 while that of pig iron fell 14.8 per cent (Table 3). Scrap prices rose very sharply during the year after drifting downward since 1965 to low levels. The brokers' buying price for No. 1 heavy melting steel scrap at Hamilton, quoted in the American Metal Market, rose to $24.50 a net ton at the end of 1969 compared with a low of $13.50 in mid-1968 and $22.50 at the end of 1965. Although prices paid by steel plants may not have exactly equalled these prices, the quotes do indicate an upward trend in scrap prices. The price rise reflected external more than domestic factors, including higher United States prices and heavy demand from Europe and Japan at good prices. A trend towards corporate consolidation and a greater degree of processing was evident in the Canadian scrap industry in 1969.

Most other steelmaking raw materials were in adequate supply during 1969 with the exception of nickel and perhaps coking coal. Prices were higher for the majority, however, with one exception being manganese.

Coking coal and coke supplies became very tight in many steelmaking countries in 1969 and this may become an even more serious problem for the world steel industry in the future. Until recently, the Canadian steel industry appeared confident of ade-

TABLE 6

Canada, Net Shipments of Rolled Steel Products by Type, 1967-69
(net tons)

	1967	1968	1969
Hot-rolled products			
Semis	343,908	544,023	379,300
Rails	279,076	231,178	308,266
Wire rods	424,793	529,252	464,745
Structurals			
Heavy	373,908	459,285	464,641
Light	123,856	126,838	139,906
Bars, concrete reinforcing	495,202	646,787	699,910
Bars, other hot-rolled	694,850	754,358	744,536
Tie plate and track material	56,526	54,931	84,555
Sheet and strip	1,289,444	1,605,365	1,544,156
Plates	915,842	1,086,996	967,794
Total	4,997,405	6,039,013	5,797,809
Cold-rolled products			
Bars	74,801	71,962	81,831
Sheet, tin mill black-plate and tin-plate	1,372,051	1,510,704	1,499,340
Galvanized sheet	536,164	589,679	605,861
Total	1,983,016	2,172,345	2,187,032
Total shipments	6,980,421	8,211,358	7,984,841
Alloy steel in total shipments	395,205	459,374	422,414

Source: Dominion Bureau of Statistics, Primary Iron and Steel (monthly).

TABLE 7

Canada, Shipments of Rolled Steel Products (Carbon and Alloy) to Consuming Industries, 1967-69
(net tons)

	1967	1968	1969
Automotive and aircraft	697,591	826,077	847,669
Agricultural equipment manufacturers	191,312	156,612	155,105
Construction	1,194,946	1,442,361	1,464,012
Containers	461,942	483,588	497,979
Machinery and tools	261,606	269,586	287,589
Wire, wire products and fasteners	520,019	598,735	536,259
Resources and extraction	180,832	198,258	163,910
Appliances, utensils, stamping, pressing	518,659	544,099	603,212
Railway operating	240,300	255,737	325,991
Railway cars and locomotives	85,787	58,866	95,281
Shipbuilding	59,655	45,486	49,916
Pipes and tubes	823,079	1,123,585	947,116
Wholesalers and warehouses	811,175	969,003	1,146,923
Miscellaneous	28,149	81,892	86,874
Total	6,075,052	7,053,885	7,207,836
Direct Exports*	905,369	1,157,473	777,005
Total	6,980,421	8,211,358	7,984,841

Source: Dominion Bureau of Statistics, Primary Iron and Steel (monthly).
*Does not include exports by nonproducers, nor ingots and castings.

quate supplies of coal from sources in the United States for several years ahead but rapidly increasing offshore demand for United States coal combined with a volatile labour situation in its mining industry has led to growing concern in Canada. Consequently, Ontario producers evidenced strong interest in the possibility of receiving coal from the Canadian Rocky Mountain area where there are large reserves of good quality metallurgical coal. Some of this coal is being developed for export to Japan; recently, western European consumers have been looking to this area as a possible source of coal.

A facet of steelmaking technology that drew increasing interest in 1969 was the possibility of using directly-reduced or metallized iron ore pellets in steel furnaces, especially electric furnaces. Shortages of coke could accelerate such interest since coal not suitable for coking, as well as oil and natural gas can be utilized. Stelco, which has had a leading role in developing the SL/RN reduction process and in testing the commercial feasibility of using metallized pellets in steel furnaces, has stated that it is considering the process for its new Lake Erie steel plant site at Nanticoke. Should Stelco proceed with this process, the resulting ore reduction-electric steel furnace combination would represent an alternative to the necessarily large-scale blast furnace-basic oxygen steel furnace combination. Several relatively small ore reduction plants have been built or are under construction in several countries. The Falconbridge Nickel Mines, Limited plant at Falconbridge, Ontario is one example although its plant is one of the largest to date. This plant will use the SL/RN process to produce up to 300,000 annual tons of metallized iron-nickel pellets beginning about mid-1970. Stelco's Lake Erie plant would be expected to be much larger and, if built, might be the "breakthrough" in proving the economic feasibility that would encourage widespread application of the process in tonnage steelmaking.

Several other metallized ore plants have been or are under consideration in Canada and the higher scrap prices during the past year may encourage final decisions. Dominion Steel and Coal Corporation, Limited, now owned by the Province of Quebec through Sidbec, is planning an ore reduction facility at Contrecoeur, Quebec, to feed electric steel furnaces there and at Montreal.

Details on raw materials consumed at major integrated steel plants in Canada are listed in Table 12.

ENERGY AND REDUCTANT MATERIALS

Table 13 lists consumption of selected energy and reductant materials at integrated iron and steel plants in 1969. Although the list is not complete, the use of these materials in various processes is indicated. One significant source of energy, blast furnace gas, is not listed. This gas, recovered from the top of blast furnace stacks and cleaned, contains less than a tenth

TABLE 8

Canada, Trade in Steel Castings, Ingots and Rolled Products, 1967-69
(000 net tons)

	Imports			Exports		
	1967	1968	1969p	1967	1968	1969p
Steel castings	9.0	6.1	7.8	25.6	23.5	28.9
Steel forgings	11.9	11.9	11.1	25.4	28.6	37.8
Steel ingots	3.1	1.0	23.0	121.5	84.1	80.2
Hot-rolled products						
Semis	29.6	8.8	278.2	54.3	214.1	91.6
Rails	4.0	6.0	6.2	90.4	64.0	57.7
Wire rods	130.6	152.6	225.0	16.7	48.3	54.1
Structurals	351.8	319.4	395.9	56.7	77.5	77.9
Bars	207.9	172.8	236.7	50.2	69.5	75.4
Track material	1.9	1.7	3.2	6.0	3.2	3.5
Plates	210.1	190.8	282.4	47.3	101.6	52.9
Sheet and strip	82.1	95.4	201.4	154.9	238.1	89.7
Total, hot-rolled	1,018.0	947.5	1,629.0	476.5	816.3	502.8
Cold-rolled and other products						
Bars	11.8	11.0	20.0	6.9	11.6	11.6
Sheet and strip						
Cold-rolled	22.3	25.5	71.0	113.8	161.2	86.9
Galvanized	7.4	7.3	16.5	88.4	88.0	74.3
Other*	110.8	110.8	133.8	135.8	124.8	109.4
Pipe	220.0	188.9	209.5	74.3	283.3	170.5
Wire	62.9	67.6	92.7	7.9	18.2	15.3
Total, cold-rolled and other	435.2	411.1	543.5	427.1	687.1	468.0
Total, rolled products	1,453.2	1,358.6	2,172.5	903.6	1,503.4	970.8
Total, steel	1,477.2	1,377.6	2,214.4	1,076.1	1,639.6	1,117.7

Source: Dominion Bureau of Statistics, Trade of Canada, Compilation by Mineral Resources Branch.
*Includes hot-rolled stainless sheet and strip.
pPreliminary.

TABLE 9

Canada, Value of Trade in Steel Castings, Ingots and Rolled Products, 1967-69
($000)

	Imports			Exports		
	1967	1968	1969p	1967	1968	1969p
Steel castings	6,800	5,120	7,106	7,679	8,037	11,471
Steel forgings	13,652	14,671	11,020	12,626	14,772	19,758
Steel ingots	1,065	241	1,806	14,220	6,870	9,411
Rolled products						
Hot-rolled	133,069	123,216	211,944	71,042	107,786	83,655
Cold-rolled and other	154,808	139,824	177,399	92,238	146,517	107,681
Total	287,877	263,040	389,343	163,280	254,303	191,336
Total steel	309,394	283,072	409,275	197,805	283,982	231,976

Source: Dominion Bureau of Statistics, Trade of Canada.
Note: The values in this table relate to the tonnages shown in Table 8.
pPreliminary.

TABLE 10

Canada, Trade in Steel by Country, 1967-69
(thousand net tons)

	Imports From			Exports To:		
	1967	1968	1969p	1967	1968	1969p
United States	400.2	379.4	1,019.1	668.3	1,273.7	869.6
Britain	169.7	175.4	162.9	115.1	93.2	41.8
ECSC* Countries	518.6	459.4	418.6	49.4	58.2	16.6
Other Europe†	145.5	139.6	173.7	13.8	9.0	15.7
Africa	0.1	0.3	2.7	11.3	4.1	4.6
Japan	226.4	211.6	404.6	0.1	0.2	11.3
Other Asia	0.6	0.2	0.9	31.2	11.2	9.6
Latin America	3.3	–	–	158.4	167.2	121.1
Middle East	0.6	0.6	–	1.0	3.5	9.8
Oceania	12.2	11.1	31.9	27.5	19.1	17.6
Total	1,477.2	1,377.6	2,214.4	1,076.1	1,639.6	1,117.7

Source: Dominion Bureau of Statistics, Trade of Canada. Tabulation by Mineral Resources Branch.
Note: Products included are those listed in Table 8.
*ECSC European Coal and Steel Community. †Includes the USSR in Europe and Asia.
pPreliminary; – Nil.

of the energy in natural gas but it is estimated that in the order of 500 billion cubic feet were used in 1969 by the companies included in Table 13.

INVESTMENT AND CORPORATE DEVELOPMENTS

Capital expenditures on new iron and steel facilities in 1969 fell far short of planned objectives. At $84.7 million, investments in new steel facilities were some 43 per cent below expectations and were the lowest since 1961. Although a number of major projects were delayed by construction and steel industry strikes, corporate announcements late in 1968 and in 1969 indicate that another round of plant investment has begun that will result in a gradual increase in annual investment expenditures during the next few years. Most major projects planned will not contribute significantly to national capacity until after 1971. A significant portion of capital expenditures in the next few years, especially at Ontario plants, will be directed towards reducing air and water pollution. A survey of industry intentions late in 1969 suggested that capital and repair expenditures in 1970 will be about $204.4 million and $164.5 million.

THE ALGOMA STEEL CORPORATION, LIMITED

Capital and mine development expenditures totalled $40 million which compares with $23 million in 1968. Major items completed include major repairs and redesign of a large blast furnace and relining of a small blast furnace; installation of two new machines and rebuilding of three machines to produce grinding balls; installation of two stamping lines for the manufacture of unfinished automotive parts; and installation of settling basins at the end of the sewer system to clean the water discharged into the St. Mary's River.

Construction continued on Algoma's 160-inch plate mill which is scheduled for completion late in 1970. It will be capable of producing plate in widths up to 152 inches, the widest in Canada. Skelp rolled on this mill would permit production of pipe 48 inches in diameter. Start of construction on the basic oxygen steel plant has been scheduled for late 1970 and scheduling of the new blast furnace is still under review. Another of the company's larger blast furnaces is scheduled for relining, along with the incorporation of equipment to permit operating at higher temperature. Also to be installed is equipment to remove tar and gum from coke oven gas to purify the gas for use as fuel, and equipment to clean gas discharges from the sinter plant.

ATLAS STEELS DIVISION OF RIO ALGOM MINES LIMITED

A modernization program, which began in 1968, at this company's Welland, Ontario, plant continued in 1969. Elements of the program, to cost about $30 million in total, that were completed in 1969 or were well under way, included a cold drawing plant for bars, additional soaking pits and additional heating facilities for bars and billets.

TABLE 11

Canada, Steel, Iron, Coke and Sinter Capacity and Production at Integrated Plants[1], 1969
(net tons)

	Algoma		Cominco			QIT		
	Sault Ste. Marie	Port Colborne	Kim-berley	Dofasco Hamilton	Sysco Sydney	Tracy (Sorel)	Stelco[2] Hamilton	National Total
Crude Steel								
Facilities, Dec. 31								
Open Hearth								
Number	6	–	–	–	5	–	14	25
Capacity	1,150,000	–	–	–	1,024,000	–	4,750,000	6,924,000
Basic Oxygen								
Number	3	–	1	3	–	–	–	7
Capacity	1,450,000	–	75,000	2,270,000	–	–	–	3,800,000
Electric								
Number	–	–	–	5	1			. .
Capacity	–	–	–	50,850	30,000	–	–	2,471,375
Total Capacity	2,600,000	–	75,000	2,320,850	1,054,000	–	4,750,000	13,195,375
Production	1,726,502	–	44,479	2,278,568	1,005,899	–	3,552,220	10,306,552
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	–	3,800,000	8,980,000
Electric Furnaces								
Number	–	–	2	–	–	9	–	11
Capacity	–	–	110,000	–	–	525,000	–	635,000
Total Capacity	2,335,000	240,000	110,000	1,730,000	875,000	525,000	3,800,000	
Production	1,498,401	206,891	107,842	1,878,250	803,561	525,402	2,507,422	7,461,219[3]
Coke from Coal								
Facilities								
No. of Ovens	260	–	–	158	[4]	–	264	925
Total Capacity	1,852,000	–	–	950,000	[4]	–	1,940,000	. .
Production	1,225,634	–	–	1,055,456	[4]	–	1,539,881	5,002,275

TABLE 11 (Cont'd)

	Algoma		Cominco	Dofasco	Sysco	QIT	Stelco[2]	National
	Sault Ste. Marie	Port Colborne	Kim-berly	Hamilton	Sydney	Tracy (Sorel)	Hamilton	Total
Sinter								
Facilities								
No. of Strands	5[5]	–	1	–	1	–	1	8[5]
Total Capacity	2,240,000	–	300,000	–	273,000	–	900,000	3,713,000
Production	1,279,504	–	166,500	–	177,216	–	564,221	2,187,441

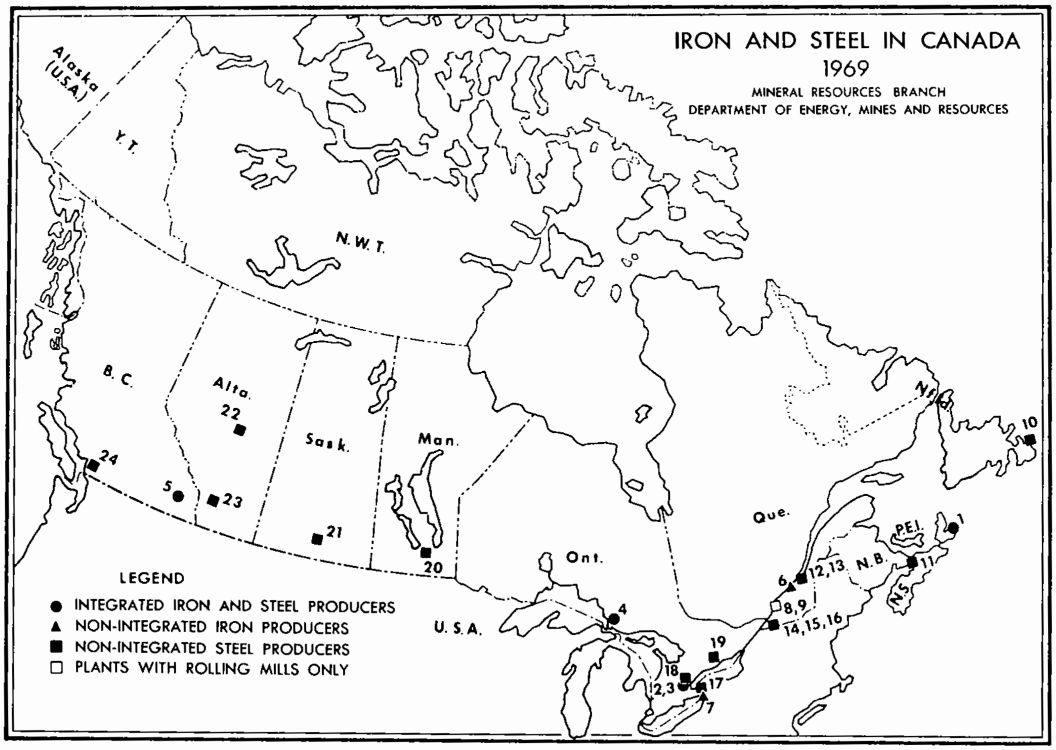
Source: Company data supplied to Mineral Resources Branch; National total from Dominion Bureau of Statistics.
[1]The seven plants listed accounted for all pig iron and 84 per cent of the crude steel produced in 1969. [2]Stelco also has an electric furnace plant (128,000 tons a year capacity) at Edmonton. [3]Production reported by individual companies exceeds DBS national total. [4]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 616,548 tons in 1969. [5]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], 1969
(net tons)

		In Iron and Steel Furnaces		
	In Sinter Plants	Pig Iron Furnaces[2]	Steel Furnaces	Total in Furnaces
Iron Ore				
Crude and concentrate	407,642	693,299[3]	99,718	793,017
Pellets	56,110	7,615,444	184,764	7,800,208
Sinter (from mines)	34,986	1,096,312	–	1,096,312
Total	498,738	9,405,055	284,482	9,689,537
Sinter (produced at plant)	–	1,236,235	542	1,236,777
Total iron ore	498,738	10,641,290	285,024	10,926,314
Contained iron	273,358	6,459,563	191,816	6,651,379
Other Iron-Bearing Materials				
Calcine and pyrite	199,080	–	–	–
Flue dust	112,024	–	–	–
Scale, sponge iron, etc.	647,739	108,827	68,300	177,127
Total	958,843	108,827	68,300	177,127
Contained iron	581,081	68,663	56,253	124,916
Other Materials				
Ferromanganese	–	148	75,198	75,346
Pig iron	–	28,096	6,442,125	6,470,221
Coal	. .	. .	. .	. .
Coke: own make	13,632	3,179,938	108	3,180,046
Purchased	15,035	622,914	16,823	639,737
Total	28,667	3,802,852	16,931	3,819,783
Scrap: own make	38,164	51,653	2,498,813	2,550,466
Purchased	7,285	150,224	656,702	806,926
Total	45,449	201,877	3,155,515	3,357,392
Stone: Limestone	127,190	554,177	175,546	729,723
Dolomite	193,189	473,266	90,321	563,587
Total	320,379	1,027,443	265,867	1,293,310
Burnt Stone: Lime	–	–	269,333	269,333
Dolomite	–	–	101,375	101,375
Total	–	–	370,708	370,708

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 1,547,103 net tons of ilmenite containing about 525,000 net tons of iron.
–Nil; . .Data confidential, only one consumer.



INDEX FOR MAP IRON AND STEEL IN CANADA 1969

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 (Tracy)
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, Rio Algom Mines Limited (Tracy)
13. Crucible Steel of Canada Ltd. (Sorel)
14. Canadian Steel Foundries Division, Hawker Siddeley Canada Ltd. (Montreal)
15. Canadian Steel Wheel Limited (Montreal)
16. Dominion Steel and Coal Corporation, Limited (Montreal)
17. Atlas Steels Division, Rio Algom Mines Limited (Welland)
18. Burlington Steel Division, Slater Steel Industries Limited (Hamilton)
19. Lake Ontario Steel Company Limited (Whitby)
20. Manitoba Rolling Mills Division, 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*, 1969

	Coal (net tons)	Coke (net tons)	Coke Oven Gas (mill. cu. ft.)	Tar and Pitch (000 Imp. gal.)	Natural Gas (mill. cu. ft.)	Fuel Oil (000 Imp. gal.)	Oxygen (mill. cu. ft.)	Electricity (mill. Kwh)
In coke ovens**	6,355,067	–	16,135	–	–	–	–	23.70
In sinter plants	. .	28,667	382	–	–	–	–	20.28
In iron furnaces	. .	3,998,076	2,444	. .	. .	31,835	12	550.80
In steel furnaces	–	16,931	2,347	. .	. .	59,078	12,395	136.60
In other uses	. .	–	38,125	. .	. .	65,266	1,001	1,636.46
Total Consumption	6,654,204	4,043,674	59,433	7,958	11,427	156,179	13,408	2,367.84

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.

BURLINGTON STEEL DIVISION OF SLATER STEEL INDUSTRIES LIMITED

Burlington Steel Company will complete a second continuous casting machine for steel billets early in 1970 and is installing a larger transformer and control equipment for its 40-ton electric furnace.

CANADIAN PHOENIX STEEL & PIPE LTD.

Canadian Phoenix, which operates pipe mills at Toronto, Calgary, Edmonton and Port Moody, is studying the feasibility of integrating backwards into the production of steel. In 1969, the company's parent, August Thyssen-Hutte AG of Germany, merged with Mannesmann AG, another German firm that operates through a subsidiary a seamless pipe mill at Sault Ste. Marie, Ontario. This subsidiary, Mannesmann International Corporation Ltd., owns a substantial interest in The Algoma Steel Corporation, Limited. An investment project at the Mannesmann mill broadened the size range of pipe in 1969.

DOMINION FOUNDRIES AND STEEL, LIMITED

Capital expenditures for manufacturing facilities and land in 1969 totalled $43 million compared with $18 million in 1968. Labour problems during the year slowed expansion projects with the completion of some major projects delayed for six to eight months.

Dofasco purchased some 5,200 acres of land west of Port Burwell on the shore of Lake Erie. This will be the site of a fully integrated steel mill in 15 to 20 years. The company also purchased 110 acres of land immediately west of its present bay front operation in Hamilton. The land was acquired from Canadian Industries Limited and will, because of its location, allow Dofasco to double its ingot capacity in Hamilton.

New plant facilities and equipment completed during the year included a 48" slitting line for electrical steel, a 15-bay storage building for sheet products, and additions and improvements in research facilities. A significant expansion program is under way that will raise annual crude steel capacity from the present 2.3 million tons to 3 million tons. Expenditures on the projects in 1970 are estimated at $80 million. The company's blast furnace, when completed in 1971, will increase ironmaking capacity by at least 50 per cent. Construction continues on the hot slabbing mill, planned for completion in 1971. This new mill together with six new soaking pits and a downcoiler will add 20 per cent to the hot mill capacity.

Dofasco also announced a six-year $28-million pollution abatement program. This expenditure, in addition to the $14 million spent over the last decade, is expected to eliminate practically all of the pollution problems created at the company's plant. Major projects will include a $5-million hydrochloric acid recovery plant, a $3-million deep-bed filtration system for the removal of impurities from hot mill waters, and a new car scrubber system as part of its emission control program during the coke oven loading operation.

DOMINION STEEL AND COAL CORPORATION, LIMITED

Through DOSCO, Sidbec operates primary 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. The company has announced a 3-stage expansion program that includes projects at the Contrecoeur and Montreal works.

At Contrecoeur, in 1970, some $4 million to $6 million will be spent on improving the flat rolling mill facilities. Also in 1970, a $30-million expansion program will begin on the electric furnace shop to install two 100-ton capacity electric furnaces. The project is expected to be completed in 1971 and will raise the annual capacity at Contrecoeur to 600,000 tons. The company is also considering producing its own electric furnace feed, presumably in the form of metallized pellets. Preliminary plans call for this plant to be built at Contrecoeur but even if Sidbec decides to go ahead with this project it is not expected to start before 1972.

Sidbec also intends to install a 50-ton electric furnace at the Montreal plant and production is expected from this unit sometime in December 1970. This will increase the capacity of the Montreal plant by some 200,000 tons a year.

INTERPROVINCIAL STEEL AND PIPE CORPORATION LTD. (IPSCO)

IPSCO began the installation of an 100-ton electric furnace at its Regina plant to supplement the two 32-ton units. This new unit is expected to be in operation by April 1970 but will produce at the rate of 40 tons a heat, based on a 4-hour cycle from charging to pouring. Thus by April 1, 1970, the new plant capacity will be 210,000 ingot tons annually. Further modifications to the melt shop teeming area, increased soaking capacity and the installation of larger electric furnace transformers will raise ingot capacity from 210,000 tons to 300,000 tons a year.

A second spiral pipe mill is under construction in Germany and will be test operated in Germany prior to an expected shipping date from Hamburg of July 15, 1970. Arrival of the spiral mill in Regina is expected in August, with production expected to begin in September 1970. This mill will double the company's large diameter pipe capacity at Regina to 96,000 tons a year.

LAKE ONTARIO STEEL COMPANY LIMITED

Lake Ontario Steel completed a rolling mill expansion and installed larger electric furnace transformers in 1969. The company also announced that it is considering doubling raw steel capacity, now 300,000 tons a year, and is considering the use of metallized iron ore pellets. However, no timetable regarding these decisions has been announced.

THE STEEL COMPANY OF CANADA, LIMITED

The Steel Company of Canada, Limited announced plans in 1969 for a major expansion program at its Hilton Works, Hamilton, Ontario. The program is expected to cost more than $100 million and to be completed in 1974. Major elements will include three 120-ton basic oxygen steelmaking furnaces to raise annual raw steel capacity from 4.75 million tons to about 6 million tons, and a bloom and billet mill, mainly for billets to release the existing two blooming mills for the production of slabs. Eight open-hearth furnaces will be removed as part of the program. Other programs completed or under way at the Hilton Works in 1969 included a new stripping crane, two soaking pits at the slabbing mill, and miscellaneous plant improvements. Improvements and/or additions were made to rolling mills at Montreal and Edmonton and a new electric-weld tube mill was installed at the Page Hersey Works in Welland, Ontario. Rod pickling at the Parkdale Works in Hamilton is being converted from sulphuric to hydrochloric acid while Canadian Liquid Air Ltd., which supplies oxygen to Stelco's Hamilton plants, is doubling oxygen capacity to 1,600 tons a day at its plant located at the Hilton Works. Sheet pickling lines at the Hilton Works still using sulphuric acid will also be converted to hydrochloric acid. These projects bring to $23 million the expenditures in the last 10 years that the company has authorized on air and water quality control equipment.

Preliminary site preparation began in 1969 on part of the 6,600 acres Stelco purchased near Nanticoke on Lake Erie in 1968. The company awarded a contract for design and engineering of an 80-inch semicontinuous hot strip mill. This would be the first facility to be built at the site, to be known as the Lake Erie Project. The final decision to proceed with construction, at a possible cost of $150 to $200 million, will await completion of design and engineering studies. Actual construction could begin before the middle of 1970 and the mill, with an annual capacity of at least 1.5 million tons of hot rolled sheet, could be completed in 1973. The company plans to install primary iron and steel facilities, possibly by the mid-1970's, and an SL/RN iron ore reduction plant feeding electric steelmaking furnace is being considered.

Early in 1969, Stelco acknowledged that it was discussing with a Spanish firm the possible joint construction of a cold rolling plant in Spain for sheet and strip. No further announcements were made.

SYDNEY STEEL CORPORATION

Sysco announced an $84-million expansion and modernization program for its plant at Sydney, Nova Scotia. The program consists of two phases. The first will provide for vacuum degassing units by 1971 and an improvement of rail finishing facilities by 1972. The second phase will begin with the building of two basic oxygen converter furnaces to replace some of the company's older open-hearth furnaces. Associated with the B.O. furnaces will be continuous slab and bloom casters. The second phase is scheduled for completion before the end of 1974 and will raise crude steel capacity from 1.05 million tons annually to about 1.25 million tons.

TABLE 14

Canada – Most Favoured Nations Tariff on Selected Iron and Steel

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. (effective 4/6/69)	per ton	free	free	$2.50
37600-1	Sponge iron		free	free	free
37700-1	Ingots of iron or steel, n.o.p. (effective 4/6/69)	per ton	free	free	$5.00
37800-1	Iron or steel, semi-finished, namely: blooms, slabs, billets or sheer bars		free	5%	10%
37900-1	Bars or rods, hot-rolled		5%	10%	20%
37905-1	Bars or rods, cold-rolled (effective 4/6/69)		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
37950-1	Shapes or sections, n.o.p., not further manufactured than extruded or drawn (effective 4/6/69)		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 (effective 4/6/69)		5%	15%	30%
38110-1	Plate of iron or steel, n.o.p. (effective 4/6/69)		5%	12½%	25%
	Sheet or strip				
38201-1	Sheet or strip, hot-rolled		5%	10%	20%
38202-1	Sheet or strip, cold-rolled (effective 4/6/69)		5%	12½%	25%
38203-1	Sheet or strip, coated with tin or enamel (effective 4/6/69)		10%	12½%	25%
38204-1	Sheet or strip, coated with zinc (effective 4/6/69)		7½%	12½%	25%
38205-1	Sheet or strip, n.o.p. (effective 4/6/69)		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. (effective 4/6/69)		15%	15%	27½%

TABLE 14 (Cont'd)

Tariff Item		British Preferential	Most Favoured Nation	General
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 (effective 4/6/69)	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: 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 decreased to 317,537 short tons in 1969, almost 7 per cent less than in 1968. Substantially reduced output in the Northwest Territories and British Columbia, together with smaller reductions in several other provinces, offset increases in the Yukon Territory, Newfoundland and New Brunswick. Much lower production by Pine Point Mines Limited in the Northwest Territories, which terminated high-grade ore shipments about mid-December 1968, accounted for a large portion of the 7 per cent reduction in total output. In July 1969 operations were suspended at the zinc-lead-copper-silver mine and mill of Western Nuclear Mines, Ltd. in northern Saskatchewan. Later in the year Anvil Mining Corporation Limited began tune-up operations at its lead-zinc-silver property in the Yukon Territory. Because of higher metal prices, the value of Canadian lead output was some $4.7 million higher than that of 1968.

Primary refined lead output totalled 187,143 short tons compared with 202,100 tons in 1968. Cominco Ltd. operated its smelter and refinery at Trail, British Columbia, at somewhat 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 33,000 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. Much of the 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 smelters in Europe and the United States.

Exports of ores and concentrates were 2.5 per cent less than in 1968, with more than 70 per cent of them going to the United States and Japan. Metal exports in 1969 were almost 23 per cent less than in 1968, with the United States and Britain continuing to be the major customers.

UNITED STATES IMPORTS AND STOCKPILES

Primary refined lead production in the United States in 1969 was more than 22 per cent higher than in 1968. United States imports of lead metal and lead in ores and concentrates totalled 391,500 tons in 1969, almost 9 per cent less than those in 1968. An increase in the imports of lead in ores and concentrates was more than offset by a substantial reduction in the imports of refined metal. The longshoremen's strike on the United States' east coast and gulf coast docks, which began late in 1968 and was not settled until mid-February 1969, was a factor contributing to the reduction of metal imports.

In July 1969, the United States government authorized the release of 100,000 short 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. At year-end, some 25,000 tons were sold, leaving an unsold balance of 75,000 tons. Of a prior stockpile release of 50,000 tons for government use only, authorized in April 1965, only about 7,000 tons had been sold by the end of December 1969. On December 4, 1969, the Office of Emergency Preparedness (OEP) announced a new objective for lead maintained in strategic and critical materials stockpiles for conventional war requirements. This new objective is 530,000 short tons

*Mineral Resources Branch.

TABLE 1

Canada, Lead Production, Trade and Consumption, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Production				
All forms[1]				
British Columbia	115,587	31,069,618	102,548	31,051,550
Northwest Territories	125,137	33,636,984	102,500	31,037,000
New Brunswick	54,350	14,609,250	56,140	16,999,343
Newfoundland	18,914	5,084,119	21,094	6,387,318
Yukon Territory	3,611	970,629	15,400	4,663,120
Ontario	12,901	3,467,629	12,745	3,859,322
Nova Scotia	2,600	698,901	2,607	789,407
Saskatchewan	2,662	715,723	2,505	758,510
Quebec	2,937	789,272	1,405	425,222
Manitoba	1,477	397,037	593	179,389
Total	340,176	91,439,162	317,537	96,150,181
Mine Output[2]	363,356		336,304	
Refined[3]	202,100		187,143	
Exports				
Lead contained in ores and concentrates				
United States	36,465	6,466,000	62,211	10,865,000
Japan	36,300	5,593,000	37,808	7,078,000
West Germany	29,483	3,821,000	18,070	2,995,000
Belgium and Luxembourg	28,107	4,104,000	12,194	2,216,000
Britain	7,503	1,050,000	7,860	1,381,000
Other countries	5,995	992,000	2,032	295,000
Total	143,853	22,026,000	140,175	24,830,000
Lead in pigs, blocks and shot				
United States	54,028	13,300,000	45,593	12,226,000
Britain	50,848	10,486,000	42,243	10,100,000
West Germany	7,285	1,505,000	7,107	1,745,000
India	6,726	1,422,000	3,733	900,000
Netherlands	11,350	2,366,000	3,170	759,000
Norway	563	111,000	1,635	367,000
Japan	3,777	791,000	1,542	380,000
Denmark	1,440	330,000	825	207,000
Argentina	–	–	770	204,000
Other countries	2,764	555,000	472	114,000
Total	138,781	30,866,000	107,090	27,002,000
Lead and lead-alloy scrap (gross weight)				
United States	4,483	581,000	5,189	1,152,000
Belgium and Luxembourg	–	–	524	34,000
Britain	611	118,000	467	132,000
West Germany	161	194,000	48	10,000
Other countries	473	72,000	84	21,000
Total	5,728	965,000	6,312	1,349,000

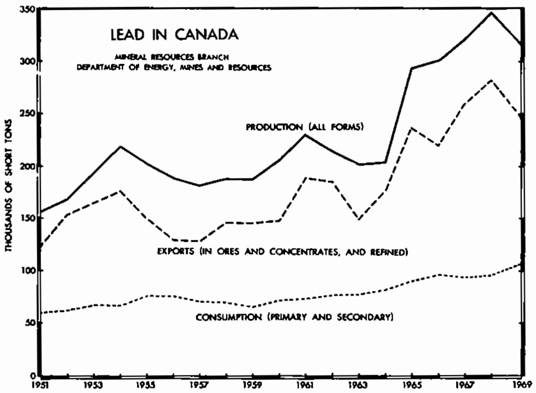
TABLE 1 (cont'd)

	1968		1969p	
	Short tons	$	Short Tons	$
Lead fabricated materials not elsewhere specified				
United States	3,325	1,160,000	3,563	1,291,000
Britain	–	–	109	90,000
Australia	–	–	7	4,000
Other countries	161	134,000	13	6,000
Total	3,486	1,294,000	3,692	1,391,000
Imports				
Lead pigs, blocks and shot	152	54,000	131	56,000
Lead oxide; litharge, red lead, mineral orange	2,633	740,000	3,261	967,000
Lead fabricated materials, not elsewhere specified	397	319,000	408	324,000
Total	3,182	1,113,000	3,800	1,347,000

	1968			1969p		
	Primary	Secondary[4]	Total	Primary	Secondary[4]	Total
	(short tons)			(short tons)		
Consumption						
Lead used for, or in the production of:						
Antimonial lead	1,445	*	*	2,179	*	*
Battery and battery oxides	22,254	3,203	25,457	28,596	4,035	32,631
Cable covering	3,702	*	*	2,812	*	*
Chemical uses:						
white lead, red lead, litharge, tetraethyl lead, etc.	21,602	*	*	21,795	*	*
Copper alloys: brass, bronze, etc.	313	*	*	380	*	*
Lead alloys - solders	2,144	2,285	4,429	3,043	2,914	5,957
- other (including babbitt, type metal, etc.)	297	2,601	2,898	249	2,059	2,308
Semifinished products: pipe, sheet, traps, bends, blocks for caulking, ammunition, foil, collapsible tubes, etc.	12,615	1,104	13,719	11,249	2,113	13,362
Other	2,028	2,750	4,778	1,849	2,666	4,515
Total**	66,400	28,260	94,660	72,152	35,118	107,270

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.
pPreliminary; – Nil.



whereas, prior to the announcement, it had been zero. The lead inventory in the stockpile at the end of 1969 amounted to some 1.15 million tons, of which 0.62 million tons were considered to be surplus to conventional and nuclear war requirements.

In April 1969, Bill H.R. 9788, to establish flexible import quotas on lead and zinc ores, concentrates, and refined metals, was introduced in the House of Representatives. The bill was subsequently referred to the Ways and Means Committee for further study.

WORLD PRODUCTION AND CONSUMPTION

Non-communist world mine production of lead, according to statistics published by the International Lead and Zinc Study Group, was 2.70 million short tons in 1969, or almost 9 per cent higher than in 1968. Substantial increases in output in the United States and Australia, together with higher production in the Republic of South Africa, Yugoslavia, Sweden and Mexico more than offset declines in Canada, West Germany, Ireland, Peru 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 3.57 million short tons, about 347,400 tons more than in 1968. The United States, West Germany, Spain and Japan reported the largest increases in refined lead production.

Mine production of lead in the United States rose substantially from 374,121 tons in 1968 to 521,167 tons in 1969. Increased output from mines in the New Missouri Lead Belt in southeast Missouri accounted for most of the increase. Primary refined lead output in the United States totalled 1,116,630 tons in 1969 compared with 913,366 tons in 1968.

Consumption of lead in the non-communist world rose in 1969 to a record high of 3.43 million short tons, an increase of more than 6 per cent from 1968.

TABLE 2

Canada, Lead Production, Trade and Consumption, 1960-69
(short tons)

	Production		Exports				
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total	Imports Refined[3]	Consumption[4]
1960	205,650	158,510	51,336	96,449	147,785	620	72,087
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	193,235r	126,194	132,320	258,514	438	93,953
1968	340,176	202,100	143,853	138,781	282,634	152	94,660
1969p	317,537	187,143	140,175	107,090	247,265	131	107,270

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.
pPreliminary; rRevised.

The United States remained the world's largest consumer, using 1.26 million tons or some 56,000 tons more than in 1968. The major increases occurred in the use of lead for storage batteries, gasoline antiknock additives and collapsible tubes.

In reviewing the statistical position and outlook for lead at its October 1969 meeting in Geneva, Switzerland, the International Lead and Zinc Study Group noted that non-communist world supply and demand were in close balance at that time. For 1970, the Study Group forecast a possibility of supplies becoming easier. Although a continuing strong expansion of metal production was forecast for 1970, it was expected that the growth in consumption would be more modest. In reviewing progress in lead since the Study Group was set up ten years ago, it was noted that lead consumption had increased at an average compound growth rate of 3.8 per cent a year.

Lead smelter capacity was increased in 1969 with the coming on stream of two new plants, with combined annual capacity of some 150,000 tons of refined lead, in southeast Missouri, to treat new mine production from that district. The two projects were actually in operation in 1968 but, because of labour shortages, strikes and some technical operating problems, it was not expected that normal production rates would be reached until late in 1969 or the first quarter of 1970. A new Imperial Smelting Furnace (ISF) plant was opened in Japan. Another ISF plant is scheduled to open in Italy in 1970. Japan also planned increases in refining capacity at its existing plants in each of the years 1970 and 1971.

In 1968-69 five large lead mines were opened in the New Missouri Lead Belt district of southeastern Missouri. Because of labour shortages, strikes, and some specific technical operating problems it was, however, not expected that all these new mines would reach normal operating conditions before late 1970. In September 1969, the Anvil mine in Canada began operations at an annual rate of some 90,000 tons of lead in concentrates. Australia's lead mine output increased substantially in 1969 and a further rise was planned for 1970. Smaller increases in mine output over the next few years were planned in the United States, Mexico, Argentina, Bolivia, Peru, Spain, France, Italy, Sweden, Yugoslavia, Morocco, Republic of South Africa, Iran, Japan and Korea.

OUTLOOK

Canada's mine production of lead in 1970 is forecast to be some 400,000 short tons, and during the period 1971-75 it could range between 400,000 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 antiknock compounds to raise the octane rating of gasoline accounts for about 25 per cent of total lead consumption in Canada and for about 20 per cent of consumption in the United States. Should governments decide to legislate the removal of lead from gasoline, a market weakness could develop if tetraethyl lead goes in a hurry. 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. It is also possible that the use of tetraethyl lead in gasoline may continue. Devices have been developed to reduce the lead content of exhaust gases to permissible levels, but they have not yet been adopted commercially. The applicability of these devices, the degree of air pollution properly attributable to lead compounds, and the problems of operating motor vehicles on nonleaded gasoline, leaves the market outlook for lead in this important industrial use uncertain.

The recent upward revision, from zero to 530,000 tons, in the United States lead stockpile objective, removed a substantial quantity of stockpiled lead which had been overhanging the market.

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

TABLE 3

Non-communist World Mine Production of Lead, 1968-69
(short tons)

	1968	1969p
United States	374,100	521,200
Australia	417,300	489,900
Canada	363,400	336,300
Mexico	178,200	185,000
Peru	181,800	174,200
Yugoslavia	123,200	132,500
Morocco	89,300	. .
Sweden	77,300	84,100
Republic of South Africa	67,000	83,400
Spain	78,500	78,900
Japan	70,400	70,600
Ireland	68,600	57,500
West Germany	63,300	45,700
Italy	39,600	40,500
Other countries	282,800	396,900
Total	2,474,800	2,696,700*

Source: International Lead and Zinc Study Group.
*Total includes estimates for those countries for which figures are not available.
pPreliminary; . . Not available.

Missouri Lead Belt area, a greater portion of Canada's exports might have to be marketed in countries other than the United States.

CANADIAN DEVELOPMENTS

YUKON TERRITORY

A substantial increase in lead output in 1969 in the Yukon Territory resulted from initiation of operations in September at the 5,500-ton-a-day concentrator of Anvil Mining Corporation Limited at its lead-zinc-silver property near Ross River. A 20 per cent increase in the mill capacity to 6,600 tons daily was planned for the spring of 1970. When the mill reaches full capacity, annual output could amount to 110,000 tons of lead contained in concentrates. Production by United Keno Hill Mines Limited was somewhat higher than in 1968 because of the greater quantity of ore milled. At the company's Husky exploration project, crosscuts are being driven towards the favourable mineralized zone. United Keno has also increased its activity in general exploration work in the Yukon.

Venus Mines Ltd. planned to bring into production its gold-silver-lead-zinc property on the west shore of the Windy Arm of Tagish Lake, about 17 miles south of Carcross. A 300-ton-a-day concentrator was under construction with operations expected to begin by the summer of 1970. Hart River Mines Ltd. continued exploration work at its silver-base-metals property in the Yukon some 85 air miles northeast of Dawson City. Hudson Bay Mining and Smelting Co., Limited collared a portal at its silver-lead-zinc "Tom" claims on the Canol Road near the Yukon-Northwest Territories border. The company planned to drive an adit in 1970. It will provide access for underground exploration of the deposit.

NORTHWEST TERRITORIES

Although Pine Point Mines Limited, 69 per cent owned by Cominco Ltd., remained Canada's leading mine producer of lead at its zinc-lead property near Pine Point on the south shore of Great Slave Lake, its output was considerably reduced from that of 1968. The decrease resulted from the cessation, in December 1968, of production of direct-shipping high-grade ore. Output from the company's Sphinx mine operation (the Pyramid orebodies) served as a partial replacement for the high-grade ore. The Sphinx mine began production on January 1, 1969. Coronet Mines Ltd. and Buffalo River Exploration Limited arranged to have a joint study prepared to determine the feasibility of bringing into production their zind-lead properties in the Pine Point area. Texas Gulf Sulphur Company continued exploration and development work on its zinc-lead-silver deposit on the shores of Strathcona Sound on Baffin Island, about 500 miles north of the Arctic Circle. Some 2,000 feet of development work was done and additional work on the project was planned for 1970. Cadillac Explorations Ltd. continued diamond drilling and exploration work on its Prairie Creek silver-lead-zinc property in the Nahanni Mining district some 110 miles due west of Fort Simpson. Further adit work and underground drilling were planned for 1970.

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. Reeves MacDonald Mines Limited continued development work at its nearby Annex mine and expected to bring this new lead-zinc-silver orebody into production about April 1970.

Increased exploration and development activity were reported in many sections of British Columbia because of the continuing good demand for the major base-metals. Development work continued at the Ruth-Vermont lead-zinc-silver property of Columbia River Mines Ltd. in the East Kootenay district near Golden. The company planned to bring its mine and a 500-ton-a-day mill into production about mid-1970. Dolly Varden Mines Ltd. was considering bringing into production in 1970 its silver-lead-zinc property near Alice Arm. Further exploration and development work were done at the silver-lead property of Interprovincial Silver Mines Ltd. northeast of Atlin near the Yukon border.

MANITOBA-SASKATCHEWAN

Byproduct lead was again produced in Manitoba and Saskatchewan 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. Western Nuclear Mines, Ltd. also accounted for a substantial portion of the provinces' output prior to ceasing operations, in July 1969, at its Par zinc-lead-copper-silver mine and 350-ton mill at Hansen Lake in northern Saskatchewan.

ONTARIO

Production of lead in Ontario in 1969 was slightly lower than that of 1968 because of reduced output by Noranda Mines Limited (Geco Division) as a result of a labour strike which closed down its mine and mill about mid-November 1969. The strike was still in effect at year-end.

Exploration work and diamond drilling continued at the new zinc-copper-silver-lead discovery of Mattagami Lake Mines Limited on the south side of Sturgeon Lake in northwestern Ontario about 45 miles southeast of Sioux Lookout. Mattagami holds 60 per cent interest in the property and the remaining 40 per cent

TABLE 4

Principal Lead Producers in Canada, 1969

Company and Location	Mill Capacity (short tons ore/day)	Grade of Ore Milled in 1969 (principal metals) Lead %	Zinc %	Copper %	Silver (oz/ton)	Ore Produced 1969 (1968) (short tons)	Lead in Concentrates and Direct-Shipping Ores 1969 (1968) (short tons)	Remarks
YUKON TERRITORY - NORTHWEST TERRITORIES								
Anvil Mining Corporation Limited, Ross River, Y.T.	5,500	3.5	5.6	–	1.2	. . (–)	11,376 (–)	Mill tune-up operations began in September 1969. Mill capacity being increased to 6,600 tons a day.
Pine Point Mines Limited, Pine Point, N.W.T.	8,000	3.2	7.4	–	. .	3,604,980 (2,138,000)[1]	102,810 (137,469)	New 3,000 ton-a-day mill addition began operations in January 1969.
United Keno Hill Mines Limited, Calumet and Elsa mines, Mayo District, Y.T.	500	4.56	4.67	–	27.98	87,483 (60,800)	3,860 (3,709)	Husky mine being developed and prepared for production.
BRITISH COLUMBIA								
Canadian Exploration, Limited Jersey mine, Salmo	2,150	1.01	2.76	–	0.055	517,648 (506,220)	4,652 (6,690)	Current operations are concentrated on mining of ore remnants and pillar recovery.
Cominco Ltd., Sullivan mine, Kimberley	10,000	. .	. .	–	. .	2,157,522 (2,155,749)	94,095 (87,178)	
Bluebell mine, Riondel	700	. .	. .	–	. .	230,956 (251,497)	8,958 (11,171)	
Mastodon-Highland Bell Mines Limited, Beaverdell	115	0.87	0.93	–	13.74	37,120 (36,413)	323 (292)	
Reeves MacDonald Mines Limited, Remac	1,200	1.43	4.69	–	. .	201,215 (309,311)	2,322 (2,820)	New Annex mine expected to begin production before mid-1970.
Utica Mines Ltd., Keremeos	350	. .	. .	–	. .	74,915 (128,652)	68 (103)	

TABLE 4 (cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Grade of Ore Milled in 1969 (principal metals) Lead %	Zinc %	Copper %	Silver (oz/ton)	Ore Produced 1969 (1968) (short tons)	Lead in Concentrates and Direct-Shipping Ores 1969 (1968) (short tons)	Remarks
Western Mines Limited,[2] Myra Falls, Vancouver Island	1,000	0.8	7.2	1.7	1.54	373,850 (330,223)	. . (. .)	Development at Paramount property was seriously curtailed by very heavy snowfalls followed by snow and rock slides.
MANITOBA - SASKATCHEWAN								
Hudson Bay Mining and Smelting Co., Limited	6,000 (treated at central mill at Flin Flon)							
Flin Flon mine, Flin Flon, Man.		. .	3.3	1.7	0.8	622,400 (806,500)	572[3] (1,507)[3] (Flin Flon and Chisel Lake combined)	Routine underground exploration and development.
Chisel Lake mine, Snow Lake, Man.		0.4	13.7	0.7	0.8	282,400 (278,400)		
Western Nuclear Mines, Ltd., Hanson Lake mine, Hanson Lake, Saskatchewan	350	6.01	10.42	0.57	. .	59,718 (60,789)	2,761 (2,717)	Operations ceased July 1969.
ONTARIO								
Ecstall Mining Limited (Texas Gulf Sulphur Company), Kidd Creek mine, Timmins	9,000	. .	. .	. .	. .	3,617,226 (3,614,860)	12,524 (12,454)	Planning program of underground development work including shaft sinking.
Noranda Mines Limited (Geco Division), Manitouwadge	4,000	. .	4.90	2.48	2.34	1,320,000 (1,495,369)	. . (1,257)	Operations suspended November 22, 1969 by labour strike which was still in effect at year-end.
Willecho Mines Limited, Lun-Echo mine, Manitouwadge	Ore custom-milled	0.26	4.06	0.44	2.13	318,149 (346,444)	580 (624)	Developing new incline below the bottom (1350′) mining level to open up new ore.

TABLE 4 (cont'd)

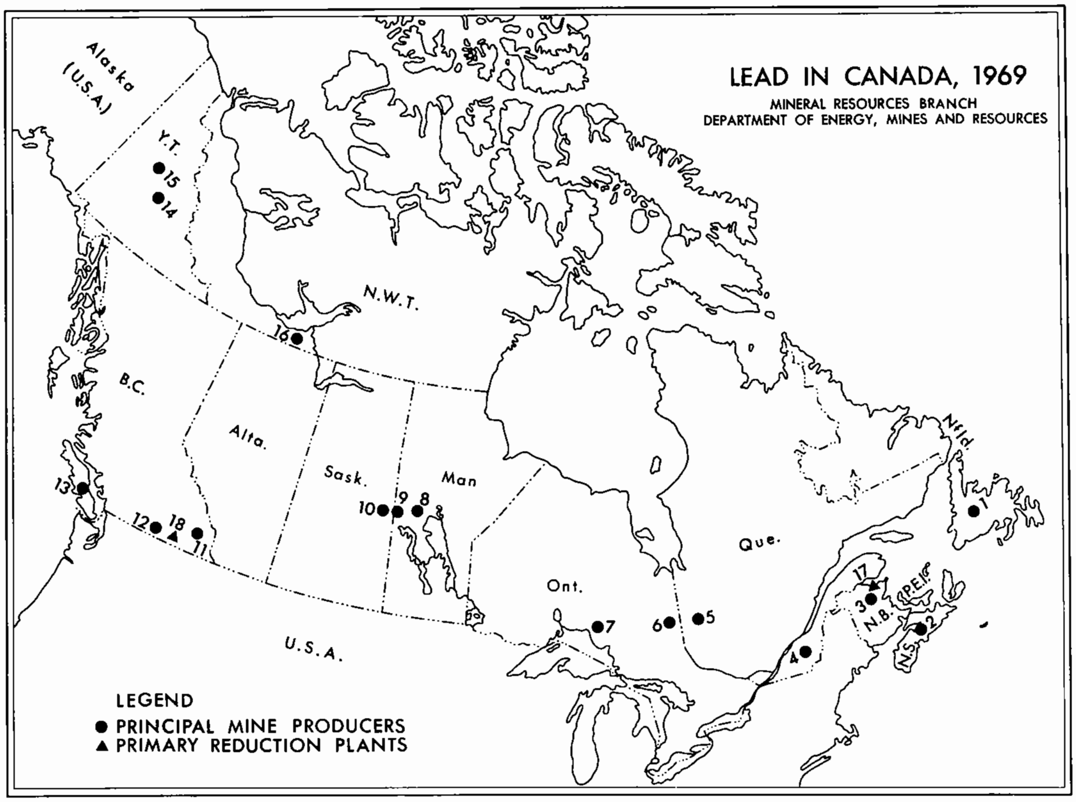
Company and Location	Mill Capacity (short tons ore/day)	Grade of Ore Milled in 1969 (principal metals) Lead %	Zinc %	Copper %	Silver (oz/ton)	Ore Produced 1969 (1968) (short tons)	Lead in Concentrates and Direct-Shipping Ores 1969 (1968) (short tons)	Remarks
Willroy Mines Limited, Manitouwadge	1,700	0.06	2.38	0.91	0.61	127,300 (174,336)	47 (96)	Company continued to prepare the Big Nama Creek orebody for mining operations using trackless mining methods.
QUEBEC								
Manitou-Barvue Mines Limited, Golden Manitou mine, Val d'Or	1,300	0.202	2.72	0.538	2.27	198,605 (181,250)	339 (107)	Copper and zinc ore milled separately.
		–	–	0.538	. .	170,070 (285,160)	– (–)	
Sullivan Mining Group Ltd. (Cupra Division), formerly Cupra Mines Ltd., Stratford Centre	1,500	0.47	3.38	2.52	1.07	246,009 (225,702)	1,010 (359)	Opening three new underground levels from internal shaft.
Sullivan Mining Group Ltd. (Solbec Division), formerly Solbec Copper Mines, Ltd., Stratford Centre	Ore custom-milled	0.96	4.21	1.07	2.086	185,288 (262,076)	1,572 (1,563)	Mine on salvage basis.
NEW BRUNSWICK								
Brunswick Mining and Smelting Corporation Limited, No. 12 mine, Bathurst	5,000	3.04	8.05	0.33	2.13	1,696,408 (1,724,465)	28,677 (38,509)	Cut-and-fill mining methods, utilizing modern trackless mining equipment, are being introduced.
No. 6 mine, Bathurst	2,500	2.28	5.78	0.35	1.87	1,134,224 (984,280)	15,993 (18,256)	Construction work continued on the gyratory crusher installation.
Heath Steele Mines Limited, Newcastle	3,000	1.33	4.00	1.46	1.71	321,403 (391,363)	1,601 (3,491)	Mill capacity increased to 3,000 tons a day. Developing ore zones at depth.
Nigadoo River Mines Limited,[4] Bathurst	1,000	2.57	2.54	0.35	3.71	321,397 (204,793)	6,552 (3,974)	

TABLE 4 (cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Grade of Ore Milled in 1969 (principal metals)				Ore Produced 1969 (1968) (short tons)	Lead in Concentrates and Direct-Shipping Ores 1969 (1968) (short tons)	Remarks
		Lead %	Zinc %	Copper %	Silver (oz/ton)			
NOVA SCOTIA								
Dresser Minerals, Division of Dresser Industries, Inc., Walton	125	5.5	0.58	0.28	5.5	49,870 (49,786)	2,648 (1,895)	Carrying out exploration work at lower levels.
NEWFOUNDLAND								
American Smelting and Refining Company (Buchans Unit), Buchans	1,250	7.07	12.78	1.12	4.01	371,000 (378,000)	24,870 (25,595)	

Source: Company reports.
[1]Figure represents tons of ore milled. In 1968, company also shipped 353,000 tons of direct-shipping ore of grade averaging 19.0 per cent lead and 25.0 per cent zinc. [2]Production for fiscal years ending September 30. [3]Lead content of lead concentrates only. [4]Production for fiscal years ending August 31.

– Nil; . . 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. Sullivan Mining Group Ltd. (Cupra Division), formerly Cupra Mines Ltd.
   Sullivan Mining Group Ltd. (Solbec Division), formerly Solbec Copper Mines, Ltd.
5. Manitou-Barvue Mines Limited
6. Ecstall Mining Limited
7. Noranda Mines Limited (Geco Division)
   Willecho Mines Limited
   Willroy Mines Limited
8. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake mine)
9. Hudson Bay Mining and Smelting Co., Limited (Flin Flon mine)
10. Western Nuclear Mines, Ltd.
11. Canadian Exploration, Limited
    Cominco Ltd. (Sullivan and Bluebell mines)
    Reeves MacDonald Mines Limited
12. Mastodon-Highland Bell Mines Limited
    Utica Mines Ltd.
13. Western Mines Limited
14. Anvil Mining Corporation Limited
15. United Keno Hill Mines Limited
16. Pine Point Mines Limited

PRIMARY REDUCTION PLANTS

17. East Coast Smelting and Chemical Company Limited
18. Cominco Ltd.

is held by Abitibi Paper Company Ltd. The results of the first 26 drill holes indicated an ore zone which is expected to contain between 10 and 15 million tons of ore within a depth of 600 feet from surface. The company is considering bringing the property into production in 1972. Open-pit mining appears to be possible for the first few years. The discovery, made late in 1969 by an aerial geophysical survey, sparked a major staking rush and intensive exploration work in the area by many other mining companies.

QUEBEC

Lead production in Quebec remained small with the two principal producers being the Cupra and Solbec Divisions of Sullivan Mining Group Ltd., both at Stratford Centre in the Eastern Townships. After completion of shaft sinking, a major development program, to open up the ore, was started at the silver-base-metals property of D'Estrie Mining Company Ltd. adjacent to the Cupra mine at Stratford Centre. The company was considering bringing the property into production in 1970, with the ore to be custom-milled at the Cupra concentrator.

NEW BRUNSWICK

The program of new construction and alterations continued at the smelter complex of East Coast Smelting and Chemical Company Limited at Belledune. Intermittent operations at much below full capacity resulted in an output of 16,800 tons of refined lead in 1969 compared with 11,800 tons in 1968. Operations were shut down during the second half of 1969 at the zinc-copper-lead property of Heath Steele Mines Limited near Newcastle. The shutdown permitted the company to expand its mine and concentrator facilities, which almost doubled capacity to 1 million tons of ore annually. Construction and installation of equipment were completed in December and it was planned to begin production at full capacity in January 1970. Mine ore reserves were reported to be sufficient to sustain operations at present capacity rates for at least 20 years.

The Anaconda Company (Canada) Ltd. and Cominco Ltd. announced that their jointly-owned Caribou zinc-lead-copper property, about 25 miles southwest of Bathurst, would be brought into production at an estimated initial cost of some $7 million. The property is owned 75 per cent by Anaconda and 25 per cent by Cominco and the finances required will be provided on the same basis. One mineral zone, to be mined first, contains a limited tonnage of copper ore. It is being developed for production, with operations scheduled to begin the latter part of 1970. A second zone contains a large tonnage of lead-zinc-silver sulphides and the feasibility of bringing this much larger deposit into production was under investigation.

Restigouche Mining Corporation, Ltd. was considering bringing into production its lead-zinc-silver property about 50 miles west of Bathurst. Negotiations were still in progress regarding the sale of concentrates and, if these are concluded satisfactorily, it was expected that the deposit would be brought into production about mid-1971 at a rate of 1,000 tons a day, using open-pit mining methods. The orebody contains 3,270,000 tons grading 4.6 per cent lead, 5.9 per cent zinc, and 2.5 ounces silver a ton. Chester Mines Limited, an affiliate of Sullivan Mining Group Ltd., did further diamond drilling and other exploration work on its copper-lead-zinc property in Northumberland county in the Newcastle area.

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 antiknock additive in gasoline. Lead consumed for these two purposes in the United States in 1969 accounted for about 60 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 qualities 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 5

United States Consumption of Lead by End-Use, 1968-69
(short tons)

	1968	1969P
Batteries	513,703	558,121
Gasoline antiknock additives	261,897	271,128
Pigments	109,734	101,886
Solder, type metal, terne metal and bearing metals	121,923	109,735
Ammunition and collapsible tubes	91,503	90,042
Caulking	49,718	41,888
Cable sheating	53,456	54,078
Sheet and pipe	49,369	41,247
Miscellaneous	77,487	65,078
Estimated undistributed consumption	–	42,000
Total	1,328,790	1,375,203

Source: United States Bureau of Mines Mineral Industry Surveys, Lead Industry in December 1969.
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 13.5 cents a pound at the beginning of 1969, increased in six consecutive 1/2-cent increments to 16.5 cents. The last increase to 16.5 cents occurred December 11 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 13 cents a pound at the beginning of 1969. Throughout the year it rose in seven consecutive 1/2-cent increments to 16.5 cents. On the London Metal Exchange (LME), the settlement and cash seller's price showed an almost continuous rising trend throughout 1969. The low price for the year was £105.875 per long ton (12.3 cents a pound Can.) on January 2. A high of £145.500 (16.9 cents Can.) was reached on December 2, and at year-end the price was £139.875 (16.2 cents Can.).

TARIFFS

CANADA	Most Favoured Nation
Ores of metals, n.o.p.	free
Lead, old, scrap, pig and block	free
Lead, in bars and in sheets	5%*
UNITED STATES	
All lead-bearing ores	0.75¢ per lb on lead content
Unwrought lead:	
Lead bullion	1.0625¢ per lb on 99.6% of the lead content
Other	1.0625¢ per lb on lead content
Lead waste and scrap	1.0625¢ per lb on 99.6% of the lead content

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1969) T.C. Publication 272.
*On and after January 1, 1970
n.o.p. – not otherwise provided for.

Lime and Limestone

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 ($Ca(OH)_2$). Physical properties influence its use as a building stone or as a crushed stone. Limestone is often used as a crushed stone because it is available near major urban centres where markets exist and because it is mined, crushed and sized with somewhat less expense than harder rock–sometimes by or in close association with companies producing lime or cement. Approximately 80 per cent of the volume of crushed stone produced in Canada is limestone and the total volume of limestone produced for all purposes represents about 85 per cent of the production of stone of all kinds.

The bulk of the limestone produced in Canada in 1969 was used eventually in some phase of the construction industry. The value of construction in Canada in 1969, at $13 billion, was 6 per cent greater than the value for 1968, despite work stoppages, high interest rates and deferred construction projects. Canadian construction in 1970 is forecast to reach a value of $14 billion but the amount of limestone input to the industry will not increase in that proportion.

Non-construction uses for limestone absorb between 6 and 9 per cent of total limestone production and include use in the metallurgical, pulp and paper, sugar refining, glass manufacturing and chemical industries.

Of the six major raw materials used in the manufacture of portland cement, limestone accounts for about 83 per cent of total by weight; this amount represents less than 15 per cent of limestone production. Approximately 4 per cent is utilized in the production of lime.

LIMESTONE*

CANADIAN INDUSTRY AND DEVELOPMENTS

Atlantic Provinces

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. Scotia Limestone Limited 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 new operation, providing sized limestone to the Scott Paper Limited at Abercrombie, Nova

*Mineral Resources Branch.

*Not including limestone mined for cement or lime manufacture, or that mined by cement or lime manufacturers for use as a crushed stone aggregate.

TABLE 1

Canada, Limestone Production, Trade and Consumption, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Production[1]				
By province				
Newfoundland	–	–	440,000	560,000
Quebec	28,608,749	29,017,042	30,050,000	31,100,000
Ontario	26,296,923	29,973,826	24,600,000	28,600,000
British Columbia	3,284,656	4,809,756	3,100,000	4,550,000
Manitoba	1,553,925	2,899,678	2,200,000	2,700,000
Saskatchewan	15	100	–	–
New Brunswick	222,700	671,000	550,000	1,140,000
Alberta	140,206	571,492	22,000	645,000
Nova Scotia	236,000	828,000	370,000	1,240,000
Total	60,343,174	68,770,894	61,332,000	70,535,000
Exports				
Crushed limestone and refuse				
United States	1,706,918	2,462,000	1,652,439	2,479,000
Stone, crude, not elsewhere specified				
United States	252,445	258,000	159,176	407,000
Belgium and Luxembourg	90	4,000	100	6,000
West Germany	–	–	20	2,000
Other countries	61	2,000	23	1,000
Total	252,596	264,000	159,319	416,000
Imports				
Crushed limestone, limestone refuse[2]				
United States	..	..	1,362,893	2,268,000
Crushed stone, including stone refuse, n.e.s.				
United States	1,375,884	3,200,000	59,249	972,000
Italy	3,433	52,000	1,671	44,000
Sweden	90	6,000	102	6,000
Other countries	173	8,000	70	5,000
Total	1,379,580	3,266,000	61,092	1,027,000
Limestone flux and calcareous stone, used for manufacturing of lime and cement[3]				
United States	1,287,784	3,118,624	1,362,091	2,971,746
Consumption				
In production of cement	11,269,000e		11,790,000e	
In production of lime	2,592,000e		3,093,000e	
Miscellaneous	60,343,174		61,332,000	
Total	74,204,174		76,215,000	

Source: Dominion Bureau of Statistics.
[1] Producers' shipments plus quantities used by producers. Does not include limestone produced for lime and cement, but does include marl used for agricultural purposes.
[2] New Import class, effective 1969.
[3] U.S. Department of Commerce, United States Exports of Domestic and Foreign Merchandise (Report F.T.410). Values are in U.S. dollars.
pPreliminary; – Nil; eEstimated; . . Not available.

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.

Quebec

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, in 1969, 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 comparatively small 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.

Ontario

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 the year.

The limestone industries of Ontario are described in detail in publications of the Ontario Department of Mines.

Western Provinces

From east to west through the southern half of Manitoba, 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

TABLE 2

Canada, Consumption of Limestone, 1967
(producers' shipments by use)

	1967[r]	
	Short Tons	$
Production of cement (domestic plants)	11,058,249	..
Production of lime (domestic plants)	2,561,000[e]	..
Metallurgical[1]	3,219,371	4,215,130
Pulp and paper	391,354	1,208,975
Glass	128,935	480,285
Sugar refining	57,774	122,263
Other chemical uses	255,180	230,936
Pulverized for agricultural and fertilizer use	1,351,086	3,054,722
Pulverized for other uses[2]	870,398	1,345,236
Road metal	34,488,000	35,590,648
Concrete aggregate	13,253,218	12,976,950
Rubble and riprap	562,882	851,025
Railroad ballast	1,134,495	1,309,797
Structural[3]	58,001	2,792,102
Other uses[4]	1,384,823	1,884,026
Total	70,774,766	

Source: Dominion Bureau of Statistics.
[1]Includes: Flux iron and steel furnaces, lining open-hearth furnaces, flux nonferrous smelters, shipments to foreign cement and lime plants.
[2]Includes whiting, asphalt filler, dusting coal mines and other uses.
[3]Includes building stone, monumental stone, flagstone, curbstone, paving blocks.
[4]Includes crushed stone for artificial stone, roofing granules, poultry grit, stucco dash, terrazzo chips, rock wool and other miscellaneous uses.
[e]Estimated; .. Not available; [r]Revised.

TABLE 3

Canada, Limestone Consumption, 1959-1968

	Cement Mfg.	Lime Mfg.	Miscellaneous*	Total
1959	8,175,733	3,062,152	36,691,804	47,929,689
1960	7,965,872	2,669,574	36,475,371	47,110,817
1961	8,145,376	2,592,831	38,220,418	48,958,625
1962	9,294,196	2,668,480	41,623,473	53,586,149
1963	9,384,412	2,703,709	51,021,396	63,109,517
1964	10,275,353	2,710,253	57,019,890	70,005,496
1965	11,517,771	2,927,691	62,178,833	76,624,295
1966	12,374,564	2,800,000[e]	69,964,571	85,139,135
1967	11,058,249[r]	2,561,000[e]	57,155,517[r]	70,774,766[r]
1968	11,269,000[e]	2,592,000[e]	60,343,174	74,204,174
1969[p]	11,790,000[e]	3,093,000[e]	61,332,000	76,215,000

Source: Dominion Bureau of Statistics.
*Includes limestone used for metallurgical, chemical, agricultural and construction purposes.
[e]Estimated; [p]Preliminary; [r]Revised.

construction industries. The possibility of utilizing marl, and 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 occur. In southwestern Alberta, high-calcium limestone is mined at Exshaw, Kananaskis and Crowsnest chiefly for the production of cement and lime, for metallurgical and chemical uses and for use as a crushed stone. Similar uses are made of limestone quarried at Cadomin, near Jasper.

In British Columbia, large volumes of limestone are mined each year for cement 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 for cement manufacture. During the past year, 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.

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.

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 putting, 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 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.

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 to co-ordinate all phases of development and provide for optimum utilization of these non-renewable resources are required.

Canada is a net importer of limestone.

LIME

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 1969, 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 1969 in Nova Scotia, Prince Edward Island, Saskatchewan and British Columbia, the needs in each of these provinces being supplied from plants in neighbouring provinces or states.

During 1969, 17 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 90 kilns was maintained–19 rotary, 68 vertical, 1 vibratory-grate and 2 rotary-grate. Lime production in 1969 was 1,718,155 tons but 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, is not recorded in Table 4.

Atlantic Provinces

Lime production in the Atlantic Provinces during 1969 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 originaly intended for captive use in the production of magnesium hydroxide from sea-water but when a market developed for lime for waste neutralization 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 1969. Towards the end of the year Havelock Lime Works Ltd. was investigating the feasibility of establishing a lime-producing facility at Havelock, New Brunswick.

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 was under construction during the past year and was scheduled for start-up in early 1970.

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. Modern techniques and equipment for quarrying, crushing, screening, handling and transporting are used to provide "carbide" stone, crushed stone and pulverized "Agstone". Hydrated lime made during calcium carbide–acetylene manufacture is sold for commercial use.

Aluminum Company of Canada, Limited produced magnesia and lime from a brucitic limestone deposit at Wakefield from 1940 until the end of February 1968, at which time the plant was closed.

TABLE 4

Canada, Lime Production and Trade, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Production*				
By type				
Quicklime	1,219,271	13,945,000	1,462,150	. .
Hydrated lime	220,696	3,441,000	256,005	. .
Total	1,439,967	17,386,000	1,718,155	20,108,301
By province				
Ontario	1,013,712	11,771,960	1,129,516	12,787,781
Quebec	304,210	3,452,783	451,571	4,759,680
Alberta	76,984	1,414,679	85,782	1,736,220
Manitoba	42,454	670,207	51,286	824,620
New Brunswick	2,607	76,006	–	–
Total	1,439,967	17,385,635	1,718,155	20,108,301
Imports				
Quick and hydrated				
United States	24,691	513,000	41,138	792,000
Britain	59	2,000	64	4,000
France	20	11,000	24	13,000
Total	24,770	526,000	41,226	809,000
Exports				
Quick and hydrated				
United States	84,382	985,000	194,528	2,288,000
Bermuda	255	5,000	275	6,000
Bahamas	265	6,000	255	7,000
St. Pierre-Miquelon	5	. . .	60	1,000
Panama	197	4,000	42	1,000
Other countries	159	2,000	–	–
Total	85,263	1,002,000	195,160	2,303,000

Source: Dominion Bureau of Statistics.
*Shipments and quantities used by producers. In 1968, 901,396 tons were shipped and 538,571 tons were used at the producing plants.
pPreliminary; . . . Less than $1,000; – Nil. . . Not available.

Lime is produced for captive use by Quebec Sugar Refinery at St. Hilaire.

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, which will double the plant capacity, was being installed during 1969. Some stone was produced for flux, for cement plants and as pulverized limestone for agricultural uses. 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 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 and Bonnechere Lime Limited operated a kiln at Carleton Place producing a small amount of lime.

Early in 1969, Reiss Lime Company of Canada, Limited began construction of docking facilities on Lake Huron, just west of Spragg, 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 will begin by mid-1970 at an initial capacity of 65,000 tons a year.

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 1969.

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 metal-

TABLE 5

Canada, Consumption of Lime, 1967-68
(producers' shipments by use)

	1967		1968	
	Short Tons	$000	Short Tons	$000
Chemical and Metallurgical				
Iron and steel plants	275,170	3,214	291,273	3,532
Pulp mills	175,109	2,137	160,679	2,114
Nonferrous smelters	22,510	285	28,782	368
Sugar refineries	31,471	510	32,609	488
Cyanide and flotation mills	13,473	183	25,154	361
Water and sewage treatment	35,763	564	39,958	671
Other industrial[1]	715,673	7,218	724,018	7,423
Construction				
Finishing lime	65,982	1,349	62,943	1,428
Mason's lime	28,130	410	27,587	461
Sand-lime brick	7,321	93	7,364	63
Agrigultural	10,684	154	12,335	125
Road stabilization	–	–	1,232	20
Other uses	41,613	450	26,033	332
Total	1,422,899	16,567	1,439,967	17,386

Source: Dominion Bureau of Statistics.
[1]Includes uranium plants, glass works, fertilizer plants, tanneries and other miscellaneous industrial uses.
–Nil.

TABLE 6

Canada, Lime Production, Trade, Apparent Consumption, 1960-69
(short tons)

	Production[1]			Imports	Exports	Apparent Consumption[2]
	Quick	Hydrated	Total			
1960	1,213,597	315,971	1,529,568	33,820	21,668	1,541,720
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	90,125	1,354,887
1968	1,219,271	220,696	1,439,967	24,770	85,263	1,379,474
1969[p]	1,462,150	256,005	1,718,115	41,226	195,160	1,564,221

Source: Dominion Bureau of Statistics.
[1] Producers' shipments and quantities used by producers. [2] Production plus imports less exports.
[p] Preliminary.

lurgical use, high-calcium stone for metallurgical use, and high-calcium quicklime and hydrated lime for the chemical, metallurgical and construction industries.

There was no production of commercial lime in British Columbia in 1969.

MARKETS, OUTLOOK AND TRADE

The metallurgical industry provides the largest single market for lime. With the increased application of the 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.

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 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,

TABLE 7

World Production of Quicklime and Hydrated Lime,
Including Dead-Burned Dolomite,
Sold or Used, 1967-68
(thousand short tons)

Country	1967	1968[p]
USSR[e]	21,661	22,046
United States	17,974	18,637
West Germany	11,180	11,722
Italy[e]	5,401	5,512
Japan	3,397	3,996
France	4,187	4,417
Canada	1,423	1,439
Brazil	1,494	..
Romania	1,157	1,157
Austria	751	644
Other countries	20,203	11,321
Total	88,828	80,891

Source: U.S. Bureau of Mines, Minerals Yearbook Preprint 1968.
[p] Preliminary; .. Not available; [e] Estimated.

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 States in recent years, iron and steel producers have integrated backwards into lime manufacture.

Canada is a net exporter of lime.

PRICES

Limestone prices vary greatly depending on the type of stone, the chemical quality, usually based on CaO content, and the degree of processing required. The location of the consumer and the quantity of limestone required are important as well as the availability of the material. Refuse could be sold for as little as 50¢ a ton. The December 29, 1969 issue of *Oil, Paint and Drug Reporter* lists a price of $14.25 to $19.00 for calcium carbonate, natural, dry ground, air-floated, 325 mesh, bags, f.o.b. works.

In 1968 shipments of quicklime averaged $11.44 per ton and hydrated $15.59 per ton, at the plant. Total lime shipments averaged $12.07 per ton in 1968 and $11.70 in 1969.

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Limestone, not further processed than crushed or screened	free	free	25%
Flagstone, sandstone and all building stone, not hammered, sawn or chiselled	free	free	20%
Paving, blocks of stone	free	7½%	35%
Flagstone and building stone, other than marble or granite, sawn on not more than two sides	free	7½%	35%
Building stone, sawn more than two sides but not sawn on more than four sides	5%	7½%	10%
Building stone, sawn or cut more than four sides	7½%	12½%	15%
Lime (effective 4/6/69)	free	free	free
UNITED STATES			
Limestone, crude, broken, or crushed for manufacture of fertilizer	free		
Limestone, crude, not suitable for use as monumental, paving, or building stone			
On and after Jan. 1, 1969	16¢ per short ton		
On and after Jan. 1, 1970	14¢ " " "		
Lime, hydrated			
On and after Jan. 1, 1969	1.5¢ per 100 lbs incl. weight of container		
On and after Jan. 1, 1970	1¢ per 100 lbs incl. weight of container		
Lime, other			
On and after Jan. 1, 1969	1.5¢ per 100 lbs incl. weight of container		
On and after Jan. 1, 1970	1¢ per 100 lbs incl. weight of container		

Further tariff reductions for the above lime items will occur on Jan. 1, 1971 and Jan. 1, 1972.

Magnesite

W.E. KOEPKE*

Magnesite and other magnesium bearing minerals are used as a raw material for producing magnesium metal** but more commonly they are valued for their use as basic refractories. Magnesite ($MgCO_3$) contains 47.6 per cent magnesia and when heated to sufficiently high temperatures disassociates into carbon dioxide and magnesia (MgO), the latter being a refractory material. Dolomite ($Ca,Mg(CO_3)$), brucite ($Mg(OH_2)$), and sea-water may also be used as a source of magnesia.

The terms 'calcined magnesia' (or 'calcined magnesite') and 'dead-burned magnesia' (or 'dead-burned magnesite') are applied to the products resulting from calcining magnesite or brucite to $1650^{\circ}F$ and $2640^{\circ}F$, respectively; the former is chemically active, the latter is inactive. The term 'periclase' is commonly applied to a high-grade, dead-burned magnesia, calcined at temperatures above $3100^{\circ}F$ (periclase is also the name of a naturally occurring mineral).

Calcined magnesia is used in manufacturing flooring cements, rayon, insulation, specialty fertilizers, rubber, pulp and paper, refractories and in a variety of chemicals. Dead-burned magnesia is used either directly as a refractory or as a constituent of refractory bricks and mortars, such as in metallurgical furnaces and kilns. Other magnesium compounds include: magnesium hydroxide, used in the manufacture of pulp and paper, pharmaceuticals, and sugar processing; magnesium chloride, used to produce magnesium metal, and in the manufacture of cements, ceramics and various chemicals; and precipitated magnesium carbonate, which can also be used in many of the foregoing manufacturing processes.

OPERATIONS IN CANADA

Canadian Refractories Limited, a wholly-owned subsidiary of Dresser Industries, Inc., Dallas, Texas, was Canada's sole producer of magnesite on a commercial scale in 1969. Production of magnesite (actually dead-burned magnesite produced from a magnesite-dolomite rock) from the company's mine at Kilmar, southwestern Quebec, was valued at $3 million in 1969, about the same as in the previous

*Mineral Resources Branch.

**The production of magnesium metal is dealt with in another chapter of the Canadian Minerals Yearbook.

TABLE 1

Canada, Magnesite, Production and Trade, 1968-69

	1968		1969P	
	Short Tons	$	Short Tons	$
Production,[1] Quebec				
Dolomitic magnesite	..	3,045,984	..	3,000,000
Exports				
Crude refractory materials[2]				
United States	900,384	1,476,000	1,121,594	1,492,000
Other countries	–	–	2	1,000
Total	900,384	1,476,000	1,121,596	1,493,000
Imported[3] by United States from Canada				
Refractory magnesia, including fused magnesia and dead-burned magnesia and dolomite	793	41,948	4,141	238,744
Magnesite brick	16,822	2,814,449	22,689	3,898,374
Imports				
Magnesia, dead-burned and sintered				
United States	35,701	2,912,000	32,470	3,046,000
Yugoslavia	5,284	370,000	5,043	415,000
West Germany	–	–	4,845	189,000
Greece	1,432	108,000	3,369	302,000
Other countries	5	...	1,552	105,000
Total	42,422	3,390,000	47,279	4,057,000
Magnesia, not elsewhere specified				
United States	3,161	340,000	3,699	408,000
Britain	15	3,000	44	4,000
Total	3,176	343,000	3,743	412,000
Magnesium oxide[4]				
United States	1,354	422,000	..	..
Britain	34	16,000	..	..
Total	1,388	438,000	..	..
Dolomite calcined				
United States	9,906	204,000	7,659	161,000
	Thousands of Units		Thousands of Units	
Magnesite firebrick and other shapes				
United States	380	1,754,000	273	1,476,000
Austria	34	104,000	88	222,000
West Germany	41	44,000	65	121,000
Britain	294	233,000	1	1,000
Total	749	2,135,000	427	1,820,000

Source: Dominion Bureau of Statistics, except where otherwise indicated.

[1]Includes the value of dead-burned magnesite used and shipped. [2]Includes dolomite, kyanite, magnesite, magnesium carbonate and other crude refractory materials. [3]Not recorded separately in the official Canadian trade statistics. The figures shown are from United States General Imports, Report FT 135, the values being in United States dollars. These materials are also exported from Canada to other countries, but the quantities and values are not available. [4]Not available as a separate class commencing in 1969.

PPreliminary; .. Not available; ... Less than $1,000; – Nil.

year. The magnesite-dolomite rock, mined by underground methods, is crushed, beneficiated by heavy-media separation at the minesite, and hauled to a dead-burning plant, one mile from the mine. The beneficiated ore is fed into an oil-fired rotary kiln to produce dead-burned magnesite clinker, which is then crushed and sized. Most of the clinker is hauled to the company's refractory plant at Marelan, a distance of 12 miles; small quantities of the clinker are sold to other refractory producers. At the Marelan refractory plant, the clinker is used to manufacture magnesite and chrome brick and block, ramming mixes, castables, cements and other refractories. Imported clinkers, chrome ores, and high-purity magnesia are also used for manufacturing some of the company's products.

TABLE 2

Canada, Magnesite and Brucite Production* 1960-69

	$
1960	3,279,021
1961	3,064,403
1962	3,431,873
1963	3,439,890
1964	3,569,619
1965	4,010,927
1966	3,948,599
1967	3,515,917
1968	3,045,984
1969p	3,000,000

Source: Dominion Bureau of Statistics.

*Dead-burned magnesite and brucitic magnesia shipped. For some years includes small quantities of serpentine and magnesium hydroxide used or shipped.

pPreliminary.

In September 1968, Sea Mining Corporation Limited, a joint venture of Continental Ore Corporation, New York, and Frederick J. Gormley Limited, started producing magnesium hydroxide from seawater at Aquathuna, near Stephenville, Newfoundland. Principal raw materials for the process are sea-water, sulphuric acid, and lime which is manufactured on site using local limestone. Sea Mining Corporation had planned to produce magnesia as well as magnesium hydroxide but there has been no confirmation as to whether that portion of the plant has been completed.

For some years, Canadian Magnesite Mines Limited has been attempting to develop a magnesite deposit in the Townships of Deloro and Adams, about 7 miles southeast of Timmins, Ontario. The company has experienced difficulty in developing a suitable process to produce a marketable dead-burned magnesite, but in 1969 was partly successful in obtaining a high-grade magnesia for chemical and pharmaceutical uses. A small pilot plant has been in operation for several years and in 1969 plans were made for a larger plant.

Magnesite deposits also occur in other parts of Ontario, in Newfoundland, Nova Scotia, Saskatchewan, British Columbia, and the Northwest Territories. Brucite occurrences have been reported in Nova Scotia, Quebec, Ontario and British Columbia. From 1941 to 1968, brucitic limestone was produced at Wakefield, Quebec, by Aluminum Company of Canada, Limited, for manufacturing magnesia and lime. Brucitic limestone occurs at Rutherglen, Ontario.

TABLE 3

Available Data on Consumption of Magnesia in Canada, 1967-68
(short tons)

	1967	1968
Refractory brick, cements, mixes	76,901	43,927
Paper and paper products	22,940	21,374
Glass wool and fibre	6,271	6,867
Foundry	4,757	7,567
Other*	1,749	3,394
Total	112,618	83,129

Source: Dominion Bureau of Statistics.
Breakdown and adjustments by Mineral Resources Branch.

*Includes: fertilizers, rubber production, ferrosilicon, sugar processing, etc.

PRICES

According to *Engineering and Mining Journal, December 1969,* and *Oil, Paint and Drug Reporter, December 29, 1969,* United States prices were as follows:

Magnesite, dead-burned grain,	
f.o.b. Luning, Nevada, bulk	$53.00 a short ton
bags	$60.00 a short ton
f.o.b. Port Joe, Florida, bulk	$92.00 a short ton
Magnesia, technical, heavy,	
bulk, car lots, f.o.b. Nevada	
85% 2000 mesh	$42.00 a short ton
90% 325 mesh	$53.00 a short ton
93% 325 mesh	$56.00 a short ton

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Magnesite, crude rock	free	free	free
Magnesite, dead-burned or sintered, n.o.p. magnesite, caustic calcined, n.o.p., plastic magnesia; magnesium oxide, n.o.p.	15%	15%	30%

UNITED STATES	
Magnesite crude	
Jan. 1, 1969 to Dec. 31, 1969	$4.20 per long ton
Jan. 1, 1970 to Dec. 31, 1970	$3.67 per long ton
Magnesite, caustic calcined	
Jan. 1, 1969 to Dec. 31, 1969	$8.40 per long ton
Jan. 1, 1970 to Dec. 31, 1970	$7.35 per long ton
Magnesite brick	
Jan. 1, 1969 to Dec. 31, 1969	0.3¢ per lb +4%
Jan. 1, 1970 to Dec. 31, 1970	0.25¢ per lb + 3.5%

Reductions under the Kennedy Round of the General Agreement on Tariffs and Trade will lower United States tariffs to $2.62 and $5.25 per long ton and 0.19¢ per pound +2.5%, respectively, on and after January 1, 1972.

Magnesium

D. B. FRASER*

Magnesium is found in sea-water, in which it is the third most abundant element, in brines and evaporite deposits, and in brucite, magnesite, dolomite, and other minerals.

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. Magnesium remelt or extrusion ingot is produced to all specifications. Other magnesium products include master alloys, rods, bars, wire, and structural shapes.

For Commercial-grade magnesium, the crowns are remelted and cast into ingot forms. This grade is suitable for general fabrication purposes and for alloying with aluminum. The High Purity grade does not represent significant tonnages and is mainly used to make Grignard reagents. The Refined grade is particularly suited for chemical laboratory use, and as a reducing agent for uranium, zirconium, titanium and beryllium or similar applications where impurity control is important.

Production of magnesium in 1969 as reported by the Dominion Bureau of Statistics was 10,485 tons. The annual report of Dominion Magnesium Limited for 1969 gives the shipments of magnesium as 11,325 tons and production of magnesium crowns as a record 11,698 tons. All furnace capacity was in operation during the year except for a seven-week delay that affected one 40-retort electric furnace which was converted to longer retorts and natural gas heating. In addition to magnesium and calcium, the company produced magnesium-zirconium master alloy, magnesium alloy extrusions, barium, and strontium.

Domestic consumption of magnesium was 5,654 tons in 1968, the latest year for which statistics are available. The principal use was as an additive in aluminum alloys. Imports of metal and alloys amounted to 2,454 tons in 1969. All but 8 tons of these imports were from the United States. Imports of wrought magnesium are not reported separately. Such items are mainly mill forms of sheet from the United States, whose exports to Canada in 1969 amounted to 476 tons valued at $944,437 (US).

Exports of magnesium metal went mainly to the United States and Britain, and in smaller quantities to 20 other countries. Canadian foreign trade statistics record only the dollar value of magnesium exports.

* Mineral Resources Branch.

TABLE 1

Canada, Magnesium Production and Trade, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Production* (metal)	9,929	6,181,992	10,485	7,093,714
Imports				
Magnesium metal				
United States	1,295	1,013,000	2,023	1,552,000
West Germany	558	296,000	–	–
USSR	550	293,000	–	–
Total	2,403	1,602,000	2,023	1,552,000
Magnesium alloys				
United States	301	1,568,000	423	1,084,000
Britain	1	4,000	8	14,000
Total	302	1,572,000	431	1,098,000
Exports				
Magnesium metal				
United States	. .	1,978,000	. .	1,643,000
Britain	. .	1,684,000	. .	1,227,000
West Germany	–	–	. .	452,000
France	. .	329,000	. .	366,000
Argentina	. .	61,000	. .	239,000
Switzerland	. .	31,000	. .	144,000
Mexico	. .	122,000	. .	140,000
Spain	–	–	. .	126,000
Other countries	. .	56,000	. .	389,000
Total	. .	4,261,000	. .	4,726,000

Source: Dominion Bureau of Statistics.
*Magnesium metal in all forms and in magnesium alloys produced for shipment, less remelt.
pPreliminary; – Nil; . . Not available.

Imports from Canada into the United States as reported by the U.S. Department of Commerce included 2,524 tons of magnesium or alloys and 635 tons of scrap in 1969. 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 output of primary magnesium in 1969 was 216,100 tons, about half of which was produced in the United States. The USSR and Norway were the next largest producers and Canada, Italy, Japan and France accounted for the remainder. Secondary magnesium is recovered in a number of countries, adding approximately the following amounts, based on reports for the year 1968, to total supply: United States 14,900 tons; Federal Republic of Germany 2,900 tons; Britain 4,500 tons (1967); and Japan 6,700 tons.

A further source of supply is the United States government stockpile of magnesium metal, from which 26,500 tons were sold to industrial users in 1969. Sales were made from the 55,000-ton amount authorized in October 1969 for disposal. At the end of 1969 there were 25,100 tons remaining from the 55,000 tons. The total inventory in the stockpile at the end of 1969 was 117,075 tons; the amount required to be held as a strategic inventory was 78,000 tons.

World consumption of magnesium has more than doubled during the 1960's and this growth in markets has led to a steady expansion of production facilities. Most of the current expansion is in the United States, where new sources of magnesium chloride are being developed and where an advance in electrolytic smelting technology offers the possibility of magnesium production at substantially lower cost. The new electrolytic plants will produce both magnesium and chlorine, requiring a market for both products. Capital costs for new electrolytic capacity in the United States are about $850 (US) a ton of annual capacity exclusive of raw material facilities.

The Dow Chemical Company, the major United States producer, expanded the capacity of its plant at Freeport, Texas from 95,000 to 120,000 tons annually, employing in the 25,000-ton addition a technology that permits recovery of chlorine. This company also plans to begin production late in 1971 from a new plant at Dallesport, Washington, which will treat magnesium chloride derived from Great Salt Lake brines in Utah. Another magnesium smelter project based on Great Salt Lake brines is that of National Lead Company. Its 45,000-ton annual-capacity plant is expected to be completed late in 1971. Chlorine, lithium compounds, potassium sulphate and other compounds will be recovered as co-products of magnesium.

TABLE 2

Canada, Magnesium Metal Consumption
1960, 1967 and 1968
(short tons)

	1960	1967	1968
Consumption (metal)			
Castings[1]	158	631	593
Extrusions[1]	230	659	935
Aluminum alloys	1,339	3,253	3,713
Other uses[2]	472	511	413
Total	2,199	5,054	5,654

Source: Dominion Bureau of Statistics.
[1]Includes a small amount of other wrought products.
[2]Includes magnesium used for cathodic protection, in reducing agents, and in other alloys.

American Magnesium Company began production in June, 1969 from an electrolytic plant at Snyder, Texas with a planned capacity of 30,000 tons annually. Oregon Metallurgical Corporation planned to start production from a 10,000-ton smelter at Albany, Oregon in 1970; the entire output will be used in titanium reduction operations. Alamet Division of Calumet & Hecla, Inc. closed its 9,200-ton plant at Selma, Alabama.

The tight supply situation continued in the United States in 1969. Production of primary magnesium totalled 99,886 tons and shipments were 117,702 tons. Imports, including ingot, alloys, semi-fabricated forms, and scrap totalled 4,528 tons; exports were 27,373 tons. Consumption was 8 per cent (about 9,000 tons) greater than in 1968 and exports were 9,000 tons greater. The increased demand was met to a large extent by releases of metal from the government stockpile; primary production increased only slightly.

TABLE 3

Canada, Magnesium Production, Trade and Consumption
1960-69

	Production[1]	Imports		Exports	Consumption[2]
	Metal (short tons)	Alloys (short tons)	Metal (short tons)	Metal $	Metal (short tons)
1960	7,289	. .	. .	3,232,805	2,199
1961	7,635	. .	. .	3,608,523	2,776
1962	8,816	. .	. .	3,967,932	3,614
1963	8,905	. .	. .	3,676,725	3,641
1964	9,353	187	1,594	3,951,386	3,762
1965	10,108	166	1,641	4,456,255	4,473
1966	6,723	330	3,011	3,452,000	5,187
1967	8,887	206	1,493	3,696,000	5,054
1968	9,929	302	2,403	4,261,000	5,654
1969p	10,485	431	2,023	4,726,000	. .

Source: Dominion Bureau of Statistics.
[1]Magnesium metal in all forms and in magnesium alloys, produced for shipment, less remelt. [2]Consumption as reported by consumers.
pPreliminary; . . Not available.

TABLE 4

World Primary Magnesium Production, 1960 and 1968-69 (thousand short tons)

	1960	1968	1969e
United States	40.0	98.4	106.0
USSR	27.0	44.1	. .
Norway	14.3	34.5	35.0
Canada	7.3	9.9	9.8
Italy	5.9	8.2	7.5
Britain	1.7	–	. .
Japan	2.3	6.2	7.0
France	2.3	4.9	. .
China	1.1	1.1	. .
Poland	0.2	0.3	. .
West Germany	0.3	–	. .
Total	102.4	207.6	216.1*

Source: 1960 and 1968 American Bureau of Metal Statistics, and Metallgesellschaft A.G.; 1969 U.S. Bureau of Mines, Commodity Data Summaries, January 1970.
*Total includes 5.8 thousand short tons for other non-communist countries and 45.0 thousand short tons for communist countries.
eEstimated; . . Not available; – Nil.

Expansion of production capacity in the rest of the world is proceeding at a much slower pace than in the United States. A Norwegian and West German firm are joining to build a plant of 28,000-ton annual capacity in West Germany, with completion scheduled in 1971. The French producer, Pechiney-Ugine, plans to increase the capacity of its Marignac plant in 1970 from 6,300 to 7,700 tons annually.

OUTLOOK

New production plants are under construction or planned in the United States and the Federal Republic of Germany. Installed capacity in the United States increased by 40 per cent in 1969, and by the end of 1971 will have increased by a further 65 per cent if all production plans are implemented and on schedule. Including the German installation, world productive capacity by the end of 1971 will be in the order of 420,000 tons annually, compared with 240,000 tons in 1968 and 287,000 tons in 1969. These increases together with a current surplus of 39,000 tons in the United States stockpile, leave little doubt of the adequacy of magnesium supply in the next few years.

USES

The major uses of magnesium are for alloying with aluminum (40 per cent of total industrial use), for structural products (26 per cent), for cathodic protection (7 per cent) and as a reducing agent (7 per cent).

As a structural material, an extensive technology has been developed to utilize the properties of magnesium alloys and mill forms. Industry has been gradually accepting magnesium for its intrinsic properties of strength, lightness, and rigidity. For many applications both zinc and aluminum are firmly established and market penetration by magnesium for those applications has been difficult except where finished products show a distinct advantage in cost or performance. Extrusions and rolled products of magnesium are available for a wide variety of applications. Diecastings are likely to show the best growth rate as new alloys have recently been developed. Also, an increase in the number and size of producers will improve the supply base and should cause manufacturers to re-assess the possibilities of magnesium in the design and engineering of products, particularly for the automotive market.

TABLE 5

Estimated World Primary Magnesium Capacity, 1969

	Annual Capacity (short tons)
CANADA	
Dominion Magnesium Limited, Haley, Ont.	12,000 (F)
FRANCE	
Pechiney-Ugine, Magnesium Thermique, Marignac	6,300 (F)
Planet-Wattohm S.A.	1,000 (F)
ITALY	
Societe Italiana per il Magnesio e Leghe di Magnesio, S.P.A., Bolzano	7,000 (F)
JAPAN	
Furukawa Magnesium Company, Oyame	6,600 (F)
Ube Kosan KK, Ube	3,000 (F)
NORWAY	
Norsk Hydro-Elektrisk, Heroya	40,000 (E)
UNITED STATES	
American Magnesium Company, Snyder, Texas	30,000 (E)
The Dow Chemical Company, Freeport, Texas	120,000 (E)
Titanium Metals Corporation, Henderson, Nevada	12,000 (E)
USSR	50,000 (E)

Process: F Ferrosilicon; E Electrolytic.

TABLE 6

Planned Additions to Primary Magnesium Capacity, 1970-71

		Annual Capacity (short tons)
UNITED STATES		
The Dow Chemical Company, Dallesport, Wash.	(1971)	48,000 (E)
National Lead Company, Great Salt Lake, Utah	(1971)	45,000 (E)
Oregon Metallurgical Corporation, Oregon	(1970)	10,000 (E)
FEDERAL REPUBLIC OF GERMANY		
Norsk Hydro-Elektrisk (50%) and Salzdetfurth A.G. (50%)	(1971)	28,000 (E)
FRANCE		
Pechiney-Ugine, Magnesium Thermique	(1970)	1,400 (F expansion)

Process: F Ferrosilicon; E Electrolytic.

Other uses are in incendiary devices, and as a Grignard reagent in the manufacture of pharmaceuticals and industrial chemicals such as tetraethyl and tetramethyl lead compounds.

PRICES

The domestic quotation at the end of 1969 for standard alloys was 34 cents a pound.

The United States price of magnesium metal as quoted in *Metals Week* of December 29, 1969 was as follows:

Magnesium metal, per lb, 10,000-lb lots,	
Pig, ingot, 99.8%	35.25 – 36.65¢
Notched ingot	36.00 – 37.45¢
Magnesium diecasting alloy, per lb, carloads, delivered east of Rockies	30¢

TARIFFS

CANADA Item No.		Most Favoured Nation
35105-1	Magnesium metal, not including alloys, in lumps, powders, ingots, or blocks (effective June 4, 1969)	5%
34910-1	Alloys of magnesium, namely: ingots, pigs, sheets, plates, strips, bars, rods and tubes (effective June 4, 1969)	5%
34915-1	Magnesium scrap	free

UNITED STATES		
628.55	Magnesium metal, unwrought,	
	On and after Jan. 1, 1969	32%
	On and after Jan. 1, 1970	28%
	Magnesium waste and scrap	duty suspended to June 6, 1970
628.57	Magnesium, unwrought alloys	
	On and after Jan. 1, 1969	12.8¢ per lb on Mg content + 6%
	On and after Jan. 1, 1970	11¢ per lb on Mg content + 5.5%
628.59	Magnesium metal, wrought	
	On and after Jan. 1, 1969	10.5¢ per lb on Mg content + 5.5%
	On and after Jan. 1, 1970	9.4¢ per lb on Mg content + 4.5%

NOTE: Further reductions in the above U.S. items will occur, effective Jan. 1, 1971 and Jan. 1, 1972.

Manganese

G. P. WIGLE*

Canada imported 107,954 tons of manganese (Mn content) in ores and concentrates valued at $5,259,000 in 1969 compared with 69,209 tons valued at $3,942,000 in 1968. Brazil became Canada's principal source of manganese, supplying 60,948 tons or 56 per cent of 1969 imports compared with 16 per cent in 1968. Imports of ferromanganese, silicomanganese and spiegeleisen were 29,083 tons valued at $3,973,000 compared with 29,285 tons valued at $3,842,000 in 1968.

Manganese ores were in plentiful supply on world markets in 1969. Published prices for manganese ore containing 48 per cent manganese were about 57 cents a long ton unit, c.i.f. eastern United States ports, in the early part of the year. In August and September prices were 53 cents and in December published prices were 53 to 57 cents a long ton unit of clean 48 per cent Mn ore. The newer producers such as Australia, Gabon and Brazil can expand their large, mechanized manganese production facilities and adequate supplies seem assured.

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 19.5 million tons was not significantly increased from 1968. 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, in descending order, from 2.4 to 1.3 million tons in 1969 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 1,964,535 tons and consumption of 2,270,221 tons in 1969. The leading suppliers were Brazil, Gabon, Australia, India, and the Republic of South Africa. United States imports of ferromanganese were 290,115 tons compared with 214,125 tons in 1968. United States consumption of ferromanganese was 1,051,782 tons.

*Mineral Resources Branch.

TABLE 1

Canada, Manganese Trade and Consumption, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Imports				
Manganese, in ores and concentrates[1]				
Brazil	11,238	561,000	60,948	2,857,000
Ghana	16,306	766,000	15,122	658,000
Congo-Kinshasa	11,827	496,000	13,440	537,000
Republic of South Africa	4,298	160,000	10,023	397,000
United States	4,979	717,000	5,656	699,000
Other countries	20,561	1,242,000	2,765	111,000
Total	69,209	3,942,000	107,954	5,259,000
Ferromanganese including spiegeleisen[2]				
Republic of South Africa	26,508	3,390,000	22,655	2,820,000
United States	1,215	233,000	1,627	383,000
Norway	100	19,000	184	30,000
Japan	78	22,000	33	9,000
France	40	18,000	25	12,000
Total	27,941	3,682,000	24,524	3,254,000
Silicomanganese, including silico spiegeleisen[2]				
Republic of South Africa	–	–	3,519	546,000
Norway	38	11,000	920	138,000
United States	199	32,000	120	35,000
Yugoslavia	560	56,000	–	–
USSR	547	61,000	–	–
Total	1,344	160,000	4,559	719,000
Exports				
Ferromanganese[2]				
United States	963	116,000	5,508	781,000
Colombia	–	–	4	1,000
Sweden	55	6,000	–	–
Total	1,018	122,000	5,512	782,000
Consumption[2]				
Manganese ore				
Metallurgical grade	122,730		. .	
Battery and chemical grade	2,174		. .	
Total	124,904		. .	

Source: Dominion Bureau of Statistics.
[1]Mn content. [2]Gross weight.
pPreliminary; –Nil; . . Not available.

TABLE 2

Canadian Manganese Imports, Exports and Consumption, 1960-69
(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[p]	107,954	24,524	4,599	5,512	..	..

Source: Dominion Bureau of Statistics.
[1]From 1964, Mn content, prior years gross weight.
[p]Preliminary; .. Not available.

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 the ability to work-harden to a high degree. 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 one 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 was battery and chemical grade.

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 1968 (1967) was 71,470 (61,667) tons and of silicomanganese was 21,904 (18,910) tons; consumption of two other important ferroalloys, ferrosilicon and ferrochrome, was 51,449 (34,807) tons and 34,696 (19,557) 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.

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

TABLE 3

World Production of Manganese Ores
(thousands of short tons)

Country	Per cent Mn[e]	1967	1968[p]	1969[e]
USSR	. .	7,909	8,000[e]	8,000
Republic of South Africa	30+	2,003	2,173	2,400
India	32–53	1,735[2]	1,709[2]	1,800
Brazil	38–50	1,037	1,572	1,500
Gabon	50–53	1,264	1,283	1,300
China	30+	770	1,000	880
Australia	35–54	615	826	850
Ghana	48+	549	456	500
Japan	30–43	374	356	360
Congo (Kinshasa)	48+	299	355	328
Hungary	30–	237	230	233
Morocco	35–53	315	177	246
Guyana	36–42	197	144	170
Ivory Coast	32–47	165	129	147
Romania	35	88[e]	88	88
Philippines	30+	95	73	84
Mexico	45+	75	65	70
New Hebrides	49–55	80	60	70
Italy	30–	52	56	54
Malaysia	30–40	94	50	72
Iran	35+	46	47	47
Thailand	40+	87	45	66
Other countries[1]		279	274	275
Total		18,383	19,225	19,500

Sources: U.S. Bureau of Mines, Minerals Yearbook 1968;
[1]Includes some 25 countries, each producing less than 35,000 tons a year. [2]Indian Mining and Engineering Journal; 1969, author's estimate.
[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 "	1.50 "
low-carbon	80–85	7.00 "	.75 "
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, 1968-69
(short tons, gross weight)

	1968	1969
Ferromanganese:		
high-carbon	852,641	925,894
medium and low-carbon	106,892	125,888
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.

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 1969 and used in producing ferromanganese, silicomanganese and manganese metal varied in grade from 35 per cent to 53 per cent manganese and averaged 50.6 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.

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.

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.

PRICES

United States prices published by *Metals Week* of December 29, 1969, were:

Manganese ore
per long ton unit (22.4 lb) Mn content
Min. 48% Mn (low impurities) 53–57¢ nominal
Min. 46% Mn 50¢ nominal

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	$164.50 nominal
78% Min. Mn	170.00 "
low-phosphorus	185.00 "
Imported standard 74–76% Mn delivered Pittsburgh-Chicago	$160–164
Medium carbon per lb Mn	17.75¢
"MS" manganese, per lb Mn	19.0¢
Super "MS" manganese per lb Mn	23.0¢
Low-carbon, per lb Mn	
0.10% C	28.65¢
0.30% C	28.65¢
0.75% C	28.65¢
Ferromanganese silicon, 0.05% C per lb alloy	15.55¢
Ferromanganese briquettes per lb alloy	8.50¢

Manganese metal
Electrolytic metal, 99.9%,
per lb Mn, boxed, f.o.b.
shipping point,

Regular	30.25¢
Hydrogen-removed	30.25¢
4–5% N	31.25¢
6% N	33.25¢

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¢
High Mn, 15.5–17% Si, 1.75–2.25% C	8.95¢
16–18½% Si, 2% C	8.45¢
18½–21% Si, 1½% C	8.75¢
Briquettes	9.55¢

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General
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	0.2¢ per lb on Mn content
	(duty temporarily suspended to end of June 1970)	
	On and after Jan. 1, 1969	0.2¢ per lb on Mn content
	On and after Jan. 1, 1970	0.17¢ per lb on Mn content
632.32	Manganese metal, unwrought, waste and scrap	
	(duty temporarily suspended on waste and scrap to end of June 1970)	
	On and after Jan. 1, 1969	1.7¢ per lb + 13% ad val
	On and after Jan. 1, 1970	1.6¢ per lb + 12% ad val
607.35	Ferromanganese	
	Not containing over 1% C	
	On and after Jan. 1, 1969	0.4¢ per lb on Mn content + 3.5%
	On and after Jan. 1, 1970	0.4¢ per lb on Mn content + 3%
607.36	Ferromanganese	
	Containing over 1% but not over 4% C	
	On and after Jan. 1, 1969	0.7¢ per lb on Mn content
	On and after Jan. 1, 1970	0.6¢ per lb on Mn content

TARIFFS (Cont'd)

607.37	Ferromanganese		
	Containing over 4% C		
	On and after Jan. 1, 1969	0.5¢ per lb on Mn content	
	On and after Jan. 1, 1970	0.43¢ per lb on Mn content	

Note: Further tariff reductions will take place on the above United States manganese items on Jan. 1, 1971, and Jan. 1, 1972.

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

Mercury

J.G. GEORGE*

The Pinchi Lake mine, located some 30 miles north of Fort St. James, British Columbia, was again in 1969 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 the mill processing about 700 tons of cinnabar ore a day. 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.

Late in 1969, Silverquick Development Co. (B.C.) Ltd. reported that it had almost completed construction of a 500 ton-a-day concentrator at its mercury property near Gold Bridge in the Bridge River district of southern British Columbia. The company's mine, mill and roasting facilities were scheduled to begin operations in April 1970, with an annual production goal reported to be 3,000 flasks (76 pounds each) 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 the same grade. All of these reserves are in the No. 1 open-pit area. Empire Mercury Corporation Ltd. completed a further program of underground diamond drilling 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 diamond drilling and other exploration work on its mercury prospect near Cominco's Pinchi Lake mine. Several 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 1969, at 133,600 pounds, were substantially below the 197,900 pounds imported in 1968. Statistics on Canadian production and exports of mercury are not available. Reported consumption in Canada in 1968 was 327,939 pounds. Consumption figures for 1969 are not available.

WORLD REVIEW

In 1969, Spain and Italy together produced about 40 per cent of the estimated world mine output of 280,000 flasks of mercury. The seven largest producing countries, in declining order of output, were Spain, Italy, Russia, United States, Mainland China, Mexico and Yugoslavia.

Mine output of mercury in the United States continued the upward trend which began in 1965, and rose to an estimated 30,000 flasks in 1969 compared with 28,874 flasks in 1968. 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 1969 in the United States was 74,404 flasks. Accurate statistics are not available on consumption in other countries but Britain, France, Japan, Russia, and West Germany are reported to be consuming greater quantities of mercury. The substantial increases in world consumption of mercury in recent years are largely due to world-wide expansion of the production of chlorine and caustic soda, and to the rapid growth of the electrical industry. Mercury is used as a cathode in the electrolytic preparation of chlorine and caustic soda.

*Mineral Resources Branch.

TABLE 1

Canadian Mercury Production, Trade and Consumption, 1968-69

	1968		1969p	
	Pounds	$	Pounds	$
Production	. .	. .	. .	. .
Imports				
Mexico	22,300	168,000	65,400	465,000
United States	59,400	447,000	37,800	260,000
Yugoslavia	69,800	521,000	15,800	109,000
Spain	30,400	224,000	10,800	78,000
Netherlands	–	–	3,800	27,000
Other countries	16,000	117,000	–	–
Total	197,900	1,477,000	133,600	940,000
Consumption, metal				
Heavy chemicals	239,497		. .	
Electrical apparatus	27,363		. .	
Gold recovery	1,766		. .	
Miscellaneous	59,313		. .	
Total	327,939		. .	

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

TABLE 2

Canadian Mercury Production, Trade and Consumption, 1960-69

	Production	Imports		Exports	Consumption
	Metal (Pounds)	Metal (Pounds)	Salts $	Metal (Pounds)	Metal (Pounds)
1960	–	243,091	6,915	1,918	139,627
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
1969p	. .	133,600	. .	. .	. .

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

Mercury supply and demand were in reasonably close balance in 1969. Cessation, in February, of sales of surplus stocks of mercury held by the United States Atomic Energy Commission (AEC) was offset by increased production in several countries including Canada, Mexico, and Spain, which provided adequate supplies for mercury consumers. Although Cominco Ltd.'s Pinchi Lake mine was brought into production in the latter part of 1968, it was not until 1969 that it reached the full production stage. Mercury prices fluctuated within a relatively narrow range during the year, with the New York price varying between a high of $545 and a low of $480. a flask. The market was somewhat depressed in mid-May when the United States Office of Emergency Preparedness (OEP) announced that the strategic stockpile objective for mercury had been reduced from 200,000 to 126,500 flasks. This reduction created a surplus of almost 73,600 flasks which, however, requires Congressional approval before it can be released. Another bearish jolt hit the market in June when 15,000 flasks of mercury held by AEC were declared to be surplus to its requirements. Sale of this surplus, which does not require Congressional authorization prior to its being sold, began in October at a maximum monthly rate of 1,500 flasks. All such sales are made to United States domestic consumers only.

TABLE 3

World Production of Mercury
(flasks of 76 pounds)

	1965	1968	1969p
Spain	74,661	57,262	60,000
Italy	57,320	52,215	52,000
Russia[e]	40,000	45,000	*
United States	19,582	28,874	30,000
Mainland China[e]	26,000	20,000	*
Mexico	19,203	13,230	18,000
Yugoslavia	16,419	15,558	15,000
Japan	4,689	5,049	*
Turkey	2,755	4,320	*
Philippines	2,384	3,506	*
Peru	3,117	3,125	*
Other countries[e]	1,743	7,335	105,000
Total	267,873	255,474	280,000

Sources: Minerals Yearbook 1968, United States Department of the Interior, for 1965 and 1968 figures. Commodity Data Summaries January 1970, Bureau of Mines, United States Department of the Interior, for 1969 statistics.

pPreliminary; eEstimated; *Data not available; estimate included in figure for "Other Countries".

At the end of 1969, United States government stockpiles contained a total of 200,090 flasks of mercury; the stockpile objective being 126,500 flasks. These stocks are exclusive of excess mercury held by AEC. In January and February 1969, some 2,300 flasks of surplus AEC stocks were sold, thus fully completing the disposal of a total of 75,500 flasks of surplus AEC material which became available for sale in 1965 and 1966. Of the additional 15,000 flasks of surplus AEC stocks, only 800 flasks had been sold by the end of 1969.

OUTLOOK

Because of the United States government's declared surplus of about 73,600 flasks and some 14,000 flasks of surplus AEC stocks available for disposal, an adequate supply appears to be in prospect for 1970 and some years thereafter. This potential supply is such that the expected gain in consumption may not come close to restoring balance. 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 almost 45 per cent of mercury consumed in the United States in 1969. 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 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.

TABLE 4

United States Mercury Consumption, by Uses, Primary and Secondary in Origin,
(flasks of 76 pounds)

Use	1965	1968	1969^p
Agriculture (includes fungicides and bactericides for industrial purposes)	3,116	3,430	2,685
Amalgamation	268	267	194
Catalysts	924	1,914	2,796
Dental preparations	1,619	2,089	1,534
Electrical apparatus	16,097	17,484	14,472
Electrolytic preparation of chlorine and caustic soda	8,753	17,453	20,678
General laboratory use	1,119	1,246	1,313
Industrial and control instruments	4,628	3,935	2,433
Paint:			
Antifouling	255	392	244
Mildew-proofing	8,211	10,174	9,486
Paper and pulp manufacture	619	417	558
Pharmaceuticals	418	424	314
Redistilled	12,131	8,252	9,419
Other	15,402	7,945	11,167
Total	73,560	75,422	79,405*

Sources: Minerals Yearbook 1968, United States Department of the Interior, for 1965 and 1968 figures. Mineral Industry Surveys, United States Department of the Interior, Bureau of Mines, for 1969 statistics.

^p Preliminary; *The items do not add to the total which has been increased to cover approximate total consumption.

PRICES

The price of mercury per flask (76 pounds) f.o.b. New York, as quoted in *Metals Week* fluctuated in 1969 between a high of $545 in February and a low of $480 in October. Average for the year was $505.04 a flask, compared with an average of $535.55 for 1968. The London ex-warehouse price, as quoted in *Metal Bulletin (London)*, remained at £223 per flask (76 pounds) from the beginning of January 1969 until early in August when it dropped to £215-223. The next price change occurred late in October when the quotation rose to £225-235. About mid-November the price settled at £235 and remained at this level for the rest of the year.

TABLE 5

Average Monthly Prices of Mercury in 1969
at New York and London
($U.S. per flask of 76 pounds)

	New York	London* (U.S. Equiv.)
January	528.182	535.20
February	537.263	535.20
March	520.476	535.20
April	500.952	535.20
May	516.238	535.20
June	495.000	535.20
July	499.318	535.20
August	485.238	516.00(Low) – 535.20 (High)
September	491.095	516.00(Low) – 535.20 (High)
October	483.913	518.67(Low) – 538.40 (High)
November	506.889	559.50
December	495.952	564.00

Sources: Metals Week for the New York Prices; Metal Bulletin (London) for the London prices.
*Ex-warehouse prices.

TARIFFS

	Most Favoured Nation
CANADA	
Mercury metal	free
UNITED STATES	
Mercury ore	free
Mercury metal, unwrought	17¢ 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.

*On and after January 1, 1970.

Molybdenum

G.P. WIGLE*

Production of molybdenum in Canada in 1969 was 30.3 million pounds valued at $52.6 million compared with 22.5 million pounds valued at $37.3 million in 1968. Canada was second only to the United States among world producers of molybdenum, and supplied approximately 21 per cent of estimated non-communist world production of 142.1 million pounds.

Estimated non-communist world mine production capacity at the end of 1969 was 145 million pounds of molybdenum a year. Production exceeded estimated consumption by about 5 per cent and an excess of capacity is expected to continue for at least four years, thus assuring adequate supplies for continuing growth in consumption.

Most of the production increase, of about 11 per cent from 1968, came from Canada and the United States. Further substantial additions to molybdenum output are assured in both countries from new molybdenum and copper-molybdenum production facilities scheduled for completion during the next several years with several being developed for production as 1969 progressed.

American Metal Climax, Inc., the world's largest producer, increased its molybdenum prices on May 5, 1969, by 10 cents a pound. The prices became US $1.72 (Canadian $1.86) a pound of contained molybdenum in molybdenite (MoS_2) concentrate and US $1.92 (Canadian $2.07) a pound of contained molybdenum in molybdenum trioxide (MoO_3).

The United States General Services Administration, in November 1969, offered some 3 million pounds of molybdenum in concentrates for sale, from national stockpile surplus, at current producer prices. Later in the same month the GSA announced that it had completed arrangements for the sale of an additional 12.3 million pounds to four principal domestic producers for delivery over the next eight years. Sales from stockpile in 1968 were 2.7 million pounds of molybdenum; they were 1.8 million pounds in 1967.

PRODUCTION AND DEVELOPMENTS

CANADA

Brenda Mines Ltd., under Noranda Mines Limited management, started initial tune-up operations in December on its copper-molybdenum property some 24 miles west of Kelowna in British Columbia. The new crushing and concentrating plant is equipped to handle 24,000 tons of open-pit ore a day. Capital expenditure to bring the operation to full production was estimated at $63 million. The orebody was estimated at 177 million tons averaging 0.183 per cent copper and 0.049 per cent molybdenum.

British Columbia Molybdenum Limited, a subsidiary of Kennecott Copper Corporation, completed its second full year of operation at its 6,000-ton-a-day mine and concentrator near Alice Arm, British Columbia. Production in 1969 was 5,567,700 pounds of molybdenum in molybdenite (MoS_2) concentrates.

Boss Mountain Division of Brynnor Mines Limited, in the Cariboo District of central British Columbia, produced 2,342,000 pounds of molybdenum in MoS_2 concentrates in 1969. Ore extraction was 547,500 tons averaging 0.23 per cent molybdenum and recovery was 92.7 per cent. Ore reserves above the adit level were maintained at 3 million tons but grade was revised, because of dilution, to 0.24 per cent molybdenum from the previously estimated 0.28 per cent. The new internal shaft was sunk to 885 feet below the adit and lateral development started.

*Mineral Resources Branch.

TABLE 1

Canada, Molybdenum Production, Trade and Consumption, 1968-69

	1968		1969P	
	Pounds	$	Pounds	$
Production (shipments)[1]				
British Columbia	19,783,544	32,552,722	27,337,257	47,123,801
Quebec	2,680,729	4,765,236	2,954,387	5,499,316
Total	22,464,273	37,317,958	30,291,644	52,623,117
Exports				
Molybdenum in ores and concentrates				
Britain	7,185,800	12,690,000	7,502,000	13,733,000
France	1,994,300	3,554,000	3,798,700	6,867,000
Japan	4,530,800	10,306,000	3,684,300	8,063,000
Netherlands	3,470,100	6,285,000	3,484,300	6,478,000
West Germany	2,774,400	5,505,000	3,096,100	6,112,000
Sweden	1,145,900	2,302,000	1,595,500	3,058,000
Italy	515,400	956,000	899,800	1,738,000
Belgium and Luxembourg	271,800	546,000	742,600	1,525,000
Brazil	18,200	36,000	224,400	417,000
Poland	320,100	586,000	139,100	251,000
Other countries	477,700	909,000	505,800	1,050,000
Total	22,704,500	43,675,000	25,672,600	49,292,000
Imports				
Molybdic oxide[2]				
United States	1,359,300	1,490,000	76,600	80,000
Ferromolybdenum				
United States[3]	284,600	367,243	482,609[5]	1,035,545[5]
Consumption (Mo content)				
Ferrous and nonferrous				
Alloys	1,490,024		..	
Electrical and electronics	12,734		..	
Other uses[4]	40,674		..	
Total	1,543,432		..	

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.[5] first 11 months only.
PPreliminary; .. Not available.

Endako Mines Ltd. produced 18,804,719 pounds of molybdenum of which 12,962,224 pounds were in molybdenite (MoS_2) concentrates and 5,842,495 pounds were in the roasted product, molybdic oxide (MoO_3). Average grade of ore milled was 0.189 per cent MoS_2 and recovery was 85.96 per cent. Concentrator throughput was 26,600 tons a day and an average of 35,400 tons of ore and waste were mined per operating day. The new larger roaster was operating at an annual capacity of 9 million pounds of contained molybdenum at the end of 1969. Briquette production at a plant rate of 1,200 pounds of contained molybdenum an hour was expected to start in mid-1970. Proven and probable ore reserves at the end of 1969 were 214 million tons averaging 0.146 per cent MoS_2.

TABLE 2

Canada, Molybdenum Production, Trade and Consumption, 1960-69
(pounds)

	Production[1]	Exports ores and concentrates (Mo content)	Imports: Calcium Molybdate[2]	Imports: Molybdic Oxide[3]	Imports: Ferro-molybdenum[4]	Consumption[5]
1960	767,621	..	236,936	656,062	230,600	1,042,077
1961	771,358	..	46,648	266,399	211,779	1,135,610
1962	817,705	..	103,274	328,424	121,358	1,261,380
1963	833,867	..	148,402	258,765	125,869	1,306,193
1964	1,224,712	..	..	490,500	271,605	1,261,454
1965	9,557,191	..	..	759,500	398,460	1,702,589
1966	20,596,044	..	..	665,500	522,800	1,261,387
1967	21,376,766	23,792,700	..	452,600	316,692	1,430,895
1968	22,464,273	22,704,500	..	1,359,300	284,600	1,543,432
1969^{p}	30,291,644	25,672,600	..	76,600	..	..

Source: Dominion Bureau of Statistics.
[1] Producers' shipments (Mo content) molybdenum concentrates, oxide and ferromolybdenum.
[2] Gross weight including vanadium oxide and tungstic oxide. [3] Gross weight. [4] U.S. exports to Canada reported in United States Exports of Domestic and Foreign Merchandise (Report F. T. 410) gross weight. [5] Mo content of molybdenum products, reported by consumers.
^{p}Preliminary; .. Not available.

TABLE 3

Molybdenum Production in Ores and Concentrates, 1967-69
(Mo content, thousands of pounds)

	1967	1968	1969^{e}
United States	90,097	93,477	99,710
Canada	21,224^{r}	22,464^{r}	30,292^{p}
Chile	10,752	8,521	9,600
Peru	2,037	1,750	480
South Korea	613	423	
Japan	558	500^{e}	
Norway	605	600^{e}	(2,035)
Mexico	322	300^{e}	
Philippines	55	95	
Total	126,263	128,130	142,117

Sources: Dominion Bureau of Statistics; U.S. Bureau of Mines, Minerals Yearbook; Company annual reports.
^{e}Estimated; ^{r}Revised; ^{p}Preliminary.

Red Mountain Mines Limited, near Rossland in south central British Columbia, milled 202,062 tons averaging 0.35 per cent MoS_2 to produce 738,810 pounds of molybdenum in molybdenite concentrates.

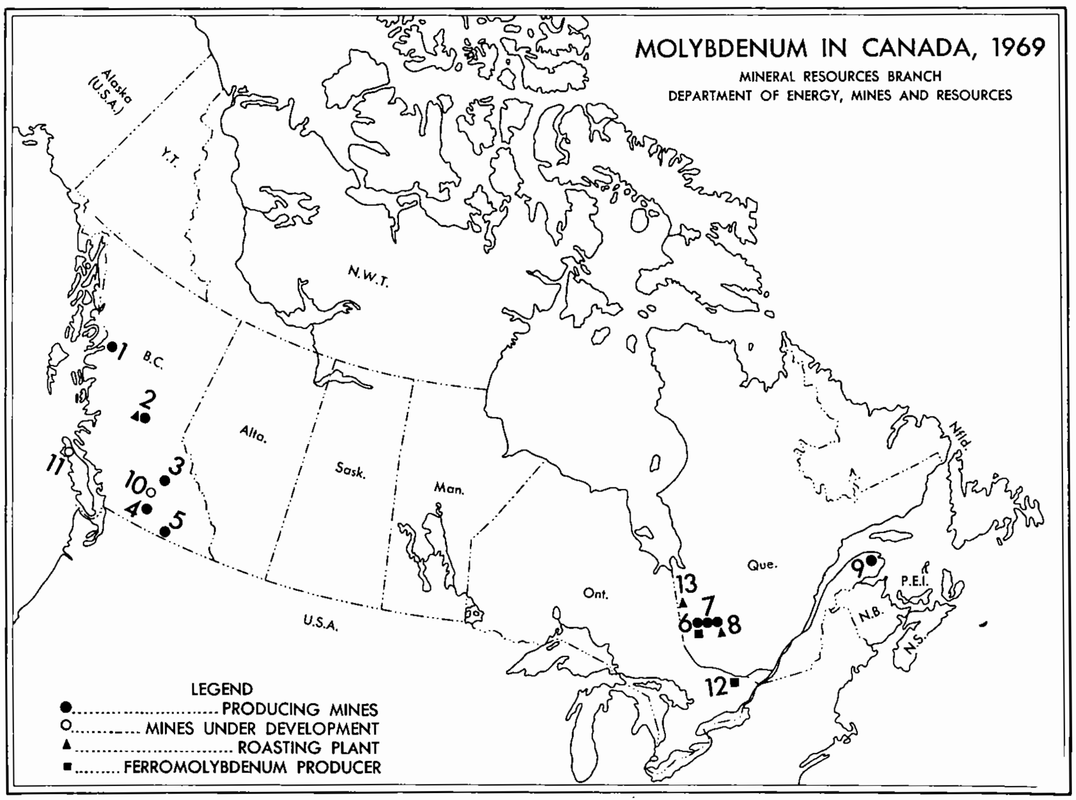
Lornex Mining Corporation Ltd., managed by Rio Algom Mines Limited, proceeded with construction and development in preparation for production from its large copper-molybdenum property, some 33 miles south of Ashcroft in the Highland Valley of British Columbia. A production rate of 38,000 tons of ore 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 latter part of 1971. Annual production was expected to be about 54,000 tons of copper and 2.5 million pounds of molybdenum.

Utah Construction & Mining Co. started 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.

Highmont Mining Corp. Ltd. proceeded with development, sampling, and metallurgical test work on its 34 claim copper-molybdenum property in the Highland Valley adjoining and east of Lornex. In October 1969 Teck Corporation Limited entered into an agreement to finance and direct continued exploration and development of the Highmont property.

Among other molybdenum and copper-molybdenum properties in British Columbia explored and studied for their production possibilities were those of Adanac Mining and Exploration Ltd., 25 miles northeast of Atlin, Bell Molybdenum Mines Limited near Alice Arm, Della Mines Ltd. in the Cassiar district, Gibraltar Mines Ltd. 35 miles north of Williams Lake, the Mt. Copeland property of King Resources Company, Sileurian Chieftain Mining Company Limited in the Alice Arm area, and Valley Copper Mines Limited in the Highland Valley.

The molybdenum producers in eastern Canada, all in Quebec, produced nearly 3 million pounds of molybdenum in 1969. They were: Molybdenite Corporation of Canada Limited at Lacorne, Preissac Molybdenite Mines Limited and Cadillac Moly Mines Limited in the Lake Preissac area near Val d'Or, and Gaspé Copper Mines, Limited, which produces by-product molybdenum from its copper operations at Murdochville.



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. Preissac Molybdenite Mines Limited
7. Cadillac Moly Mines Limited
8. Molybdenite Corporation of Canada Limited
9. Gaspé Copper Mines, Limited

MINES UNDER DEVELOPMENT

10. Lornex Mining Corporation
11. Utah Construction & Mining Co.

PROCESSING PLANTS

2. Endako Mines Ltd.
6. Preissac Molybdenite Mines Limited
8. Molybdenite Corporation of Canada Limited
12. Masterloy Products Limited (ferroalloy plant)
13. Beattie-Duquesne Mines Limited (roaster)

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 completed and put into operation in late 1969 an enlarged new ferroalloy plant. Masterloy's production in 1969 was 820,000 pounds of ferrocolumbium, 210,000 pounds of ferromolybdenum and 140,000 pounds of ferrovanadium.

UNITED STATES

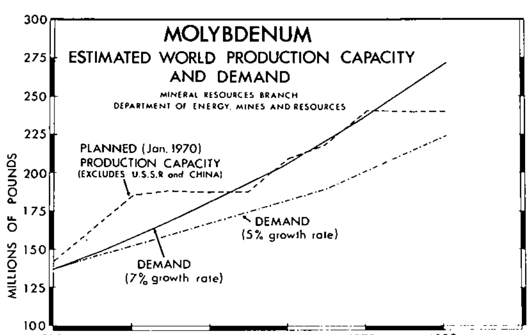
The United States has the largest annual production of molybdenum. It has produced more than half the world supply since 1925 and exported 57.6 million pounds of molybdenum in concentrates in 1969. New molybdenum production facilities planned for completion during the next several years will maintain the United States' dominance among world molybdenum producers by a wide margin to 1980 despite presently projected 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 production projects being undertaken in the world is the AMAX development of its Henderson ore deposit, near the Urad, for completion in the 1970's, with 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).

Molybdenum Corporation of America increased the capacity of its Questa, New Mexico, mine to about 14 million pounds a year. Questa production in 1969 was 10.9 million pounds of molybdenum.

The Anaconda Company brought to production in 1969 a large new open-pit copper mine at Twin Buttes, Arizona. Provision was made for the recovery of byproduct molybdenum and production of molybdenite concentrates was expected early in 1970.



Duval Corporation expected to start production in early 1970 at its Sierrita open-pit copper-molybdenum property in Pima County, Arizona. The ore zone was estimated to contain 414 million tons averaging 0.35 per cent copper and 0.036 per cent molybdenum. Provision was made for recovery of molybdenum, annual production of which was expected to be some 14 million pounds at the planned mining and milling rate of 72,000 tons a day.

CONSUMPTION 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, an additive which is adaptable to any steelmaking process, containing 55 to 75 per cent Mo, by means of the electric arc furnace or the thermite process.

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 straightforward operation, losses are small, and addition is commonly made in the oxide form or as ferromolybdenum. 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, 1968
(thousands of pounds of contained molybdenum)

	1968
Steel (ingots and castings)	
High speed and tool	3,173
Stainless	6,059
Alloy (excluding stainless)	19,939
Carbon	2,969
Other steel	109
Cast irons	4,210
Cutting and wear resistant materials	317
Welding and hardfacing rods and materials	418
Nonferrous alloys	2,543
Electrical materials	23
Chemical and ceramic uses	
Catalysts	1,792
Pigments	1,170
Lubricants	751
Other	235
Miscellaneous and unspecified	5,563
Total	49,271

Source: U.S. Bureau of Mines, Minerals Yearbook.

OUTLOOK

Production of molybdenum in the non-communist countries during the past decade achieved an annual growth of between 6 and 7 per cent. USSR and China produced molybdenum but only doubtful estimates of their production are possible and they are not included in this review.

Presently planned production capacity within North America will exceed demand projections based on 7 per cent annual growth during the years 1970 to 1974. The following four years would show a close balance of supply and demand unless there is further expansion of capacity in the meantime. It is worth observing that during 1969 considerable new production reached a well-supplied market at improved prices; this may indicate that ready availability of supply is encouraging consumption and diversified use.

Among Canadian consumers of molybdenum and its intermediate products are:

In Nova Scotia: Sydney Steel Corporation, Sydney.

In Quebec: Crucible Steel of Canada Ltd., Sorel; Dominion Engineering Works, Limited, Lachine; Canadian Steel Foundries Division of Hawker Siddeley Canada Ltd., Montreal; Sorel Steel Foundries Limited, Sorel; Canron Limited, Trois-Rivières.

In Ontario: The Algoma Steel Corporation, Limited, Sault Ste. Marie; Atlas Steels Division of Rio Algom Mines Limited, Welland; Dominion Foundries and Steel, Limited, Hamilton; Fahralloy Canada Limited, Orillia; The Steel Company of Canada, Limited, Hamilton; The Wabi Iron Works, Limited, New Liskeard.

In Manitoba: Amsco Joliette Division of Abex Industries of Canada Ltd., Selkirk.

In Alberta: Irving Industries (Foothills Steel Foundry Division) Ltd., Calgary.

In British Columbia: A-1 Steel and Iron Foundry (Vancouver) Ltd., Vancouver; Cae Machinery Ltd., Vancouver.

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. 29, 1969
Molybdenum concentrates,			
95% MoS_2, containers extra			
molybdic oxide (MoO_3)	US $1.62	US $1.72	US $1.72
" " 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

TARIFFS

Tariff No.		British Preferential	Most Favoured Nation	General
CANADA				
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, 1970 except for molybdenum oxide	free	15%	25%

UNITED STATES		
601.33	Molybdenum ores and concentrates	
	On and after Jan. 1, 1969	19¢ per lb on Mo content
	" " Jan. 1, 1970	16.5 ¢ " " "
418.26	Calcium molybdate	
	On and after Jan. 1, 1969	16¢ per lb on Mo content + 4.5%
	" " Jan. 1, 1970	14¢ " " " + 4%
419.60	Molybdenum compounds	
	On and after Jan. 1, 1969	16¢ per lb on Mo content + 4.5%
	" " Jan. 1, 1970	14¢ " " " + 4%
628.72	Molybdenum metal, unwrought	
	On and after Jan. 1, 1969	16¢ per lb on Mo content + 4.5%
	" " Jan. 1, 1970	14¢ " " " + 4%
628.74	Molybdenum metal, wrought	
	On and after Jan. 1, 1969	20%
	" " Jan. 1, 1970	17.5%
628.70	Molybdenum metal, waste and scrap (suspended)	
	On and after Jan. 1, 1969	16.5%
	" " Jan. 1, 1970	14.5%
607.40	Ferromolybdenum	
	On and after Jan. 1, 1969	16¢ per lb on Mo content + 4.5%
	" " Jan. 1, 1970	14¢ " " " + 4%

NOTE: Further tariff reductions on the above items will be in effect Jan. 1, 1971 and Jan. 1, 1972.

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

Natural Gas

J.W. FRASER*

In response to strong domestic and export demand, net new production rose 17.0 per cent to 1,979,309 million cubic feet, or 5,423 million cubic feet daily in 1969, surpassing the 15 per cent increase achieved in 1968. Growth in Canadian markets, particularly in Ontario, Quebec and Alberta, increased domestic sales to 2,310 million cubic feet daily, up 10.1 per cent over 1968. Exports also increased to 1,863 million cubic feet daily, up 12.5 per cent, but this contrasted with increases of 17.8 per cent in 1968, and 18.8 per cent attained in 1967. Imports dropped to 96 million cubic feet daily, less than half the 1968 level, as a result of the first full year of operation of the Great Lakes Transmission system, which provided additional supplies of western Canadian gas to eastern markets.

Developments in the Strachan-Ricinus area provided the focal point for industry activity in Alberta, but the search for new reserves was widespread throughout the province. In Saskatchewan, the decline in provincial reserves which had occurred in recent years was reversed with the discovery of a new field in the west central area of the province. In the Arctic, Panarctic Oils Ltd. made a significant gas discovery at its Drake Point well on Melville Island, but it is considered non-commercial at present because of the remote location. Total Canadian reserves rose by 9 per cent to 51,950,995 million cubic feet, marking the second highest increase since the Canadian Petroleum Association began making estimates in 1955.

In November, the National Energy Board (NEB) began hearings on a number of applications for permits to export gas from Canada. The total of all volumes applied for in the applications amount to more than 9 trillion cubic feet over the life of the permits. The applications were made by four companies presently exporting gas from Canada and one new company, Consolidated Natural Gas Limited, which is seeking approval to build a new pipeline system across southern Saskatchewan to take gas from Alberta to markets in the midwestern United States. In addition to hearing the specific applications, the NEB also heard submissions relating to the general principles and methods developed over the years by the Board to evaluate applications. The hearings continued until March, 1970, and a decision is not expected until mid-1970.

Three of the companies with applications in the current NEB hearings – Westcoast Transmission Company Limited, Trans-Canada Pipe Lines Limited (TransCanada PipeLines Limited) and Consolidated – are also involved with other groups which have put forth three separate proposals for the construction of major new pipeline systems which could reach potential new reserves as far north as the Mackenzie Delta area, and possibly the Prudhoe Bay area in Alaska. Under the schemes, deliveries have been projected as high as 1,800 to 2,500 million cubic feet daily. The large demands which would arise from such major pipelines, combined with the export increases currently before the NEB and increased domestic requirements, indicates the tremendous growth potential facing the natural gas producing and pipeline industries today.

PRODUCTION

Net new production in 1969 totalled 1,979,309 million cubic feet or 5,423 million cubic feet daily. This represents an annual increase of 17.0 per cent, somewhat higher than the 15 per cent growth achieved in 1968.

*Mineral Resources Branch.

TABLE 1

Canadian Natural Gas Fields Producing 10 Million Mcf or More, 1968-69
(numbers in brackets refer to map location)

	1968 (Mcf)	1969 (Mcf)
Alberta		
Crossfield (1)	146,985,691	152,607,267
Edson (19)	74,121,878	92,198,978
Waterton (11)	83,532,456	90,443,380
Westerose South (2)	79,541,761	90,273,407
Windfall (5)	56,205,683	70,241,399
Medicine Hat (10)	54,742,455	57,650,046
Cessford (4)	53,494,272	54,824,522
Crossfield East (1)	41,618,826	53,526,600
Harmattan-Elkton (8)	51,165,004	49,808,096
Harmattan-East (8)	44,861,334	49,459,691
Homeglen-Rimbey (9)	42,699,680	47,973,109
Carstairs (12)	41,354,823	44,810,623
Pembina (7)	39,723,764	41,569,851
Kaybob South (25)	3,058,102	40,897,572
Gilby (9)	24,708,134	39,263,664
Provost (15)	35,966,978	34,456,607
Wildcat Hills (20)	31,107,984	33,951,482
Nevis (14)	33,340,502	32,476,535
Ghost Pine (28)	14,953,960	27,779,209
Lookout Butte (3)	19,777,945	27,465,708
Carson Creek (13)	29,685,761	27,345,908
Sylvan Lake (2)	17,615,743	25,492,529
Hussar (16)	20,543,226	24,215,328
Pine Creek (6)	33,263,156	22,925,719
Kaybob (25)	21,043,414	22,638,840
Minnehik-Buck Lake (23)	22,602,888	20,586,806
Jumping Pound (17)	19,038,264	20,365,093
Brazeau River (37)	29,289	18,009,725
Judy Creek (13)	16,393,152	17,385,188
Jumping Pound West (17)	13,741,323	17,355,500
Wimborne (12)	13,341,574	16,967,117
Bindloss (26)	11,973,010	16,021,487
Westlock (21)	13,437,641	15,879,194
Olds (12)	13,923,943	14,919,643
Pincher Creek (3)	17,738,231	14,529,819
Viking-Kinsella (38)	8,211,819	14,372,318
Lone Pine Creek (12)	7,924,259	14,144,936
Rainbow (39)	8,490,241	14,094,889
Worsley (24)	13,067,436	12,825,789
Swan Hills (13)	10,826,541	12,638,696
Wayne-Rosedale (28)	10,633,265	12,510,133
Turner Valley (18)	12,814,957	12,185,491
Fort Saskatchewan (21)	12,997,299	12,185,381
Countess (16)	8,572,233	11,009,537
Carbon (28)	6,424,544	11,005,048
Okotoks (18)	10,481,824	10,560,178
Alderson (10)	8,141,279	10,406,339
Golden Spike (22)	9,467,421	10,297,338
British Columbia		
Clarke Lake (35)	103,605,080	102,176,861
Laprise Creek (30)	26,857,891	26,210,563
Nig Creek (32)	20,260,890	19,064,315
Jedney (30)	19,106,079	18,486,525
Rigel (34)	14,807,814	15,395,358
Saskatchewan		
Coleville-Smiley (36)	12,204,535	12,765,403

Source: Provincial government reports. Volumes shown are gross production figures measured at pressure base of 14.65 psia, standard pressure for provincial government statistics.

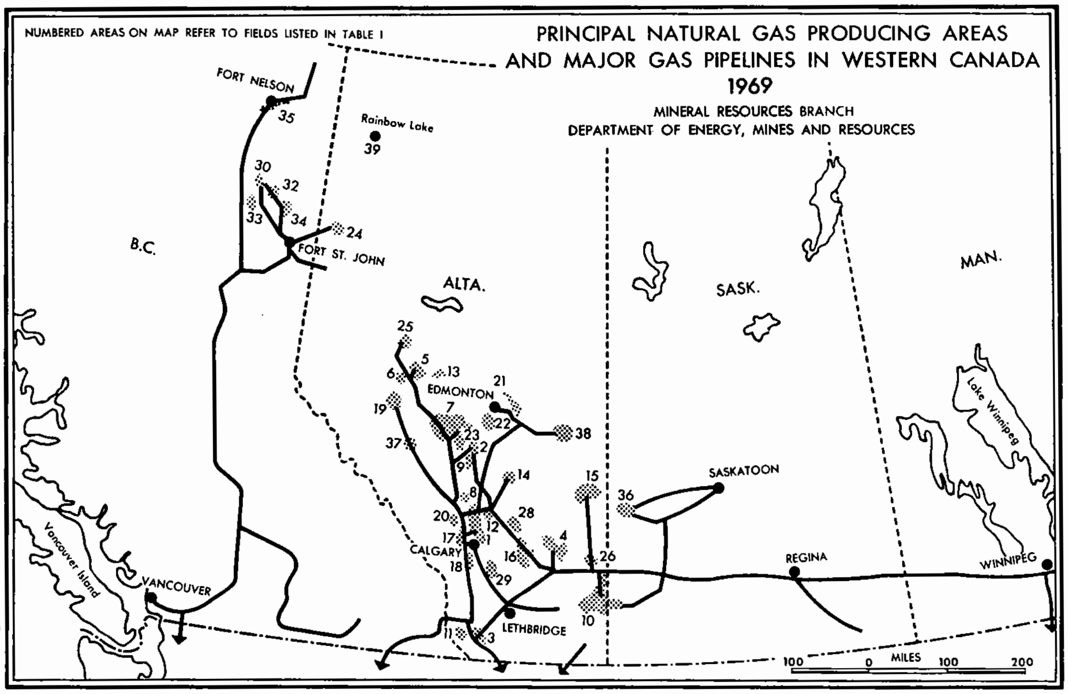
Alberta continued to be the main producing province, accounting for 81 per cent of the Canadian total. The Crossfield field remains the largest producing field in the province, but substantial production increases in the Edson field moved it ahead of Waterton and Westerose South as the second ranking producer in 1969. Production from British Columbia made up 15 per cent of the Canadian total, with the Clarke Lake field contributing approximately one third of the provincial output. The remainder comes from a number of smaller fields.

As a conservation measure, natural gas is re-injected in a number of fields to increase recovery of liquid hydrocarbons by maintaining reservoir pressures. For example, much of the gas processed at the new processing facilities in the Kaybob South field, over the next several years, will be re-injected after natural gas liquids and sulphur have been removed, in order to obtain the maximum possible recovery of those products from the reservoir. At other fields, such as Golden Spike and Rainbow Lake, natural gas is being re-injected as part of enhanced recovery schemes designed to increase crude oil production. Excess gas production may also be re-injected in depleted fields or specially developed subsurface caverns where it is stored until required during peak demand periods in the winter. In Table 2, the amounts shown as re-injected in Ontario and Saskatchewan, and the volumes shown under Distributor's Storage in Alberta, represent gas stored in this manner.

EXPLORATION AND DEVELOPMENT

ALBERTA

Much of the industry effort in 1969 was concentrated in the Strachan-Ricinus area, approximately 100 miles northwest of Calgary, but the successes in this area stimulated the search for major gas reserves all along the foothills and deep basin area in central and southwestern Alberta. The Ricinus area was developed as exploration for Devonian pinnacle reefs moved south from Strachan late in 1968. However, the first



well in the area, Pacific Pan Am Ricinus 7-19-35-8 W 5, penetrated a thick section of oil-bearing sands in the Upper Cretaceous Cardium formation, before reaching the Devonian reef which was gas bearing. Thus, two potential pay zones are present in the Ricinus area. Some subsequent wells have also found oil in the Cardium, while others have found wet gas.

In 1969, the Alberta Oil and Gas Conservation Board (AOGCB) designated the limits of the Strachan field to cover an area of 22 sections, which included five gas wells. The AOGCB also established the limits of the Ricinus field, starting one mile south of Strachan and extending southward over an area 11 miles long and from 3 to 7 miles wide, containing 52 sections. In the latter part of 1969, a Devonian reef discovery was drilled northwest of the Ricinus field limits. The well, Banff et al Ricinus 6-25 is reported to have 690 feet of high porosity reef reservoir containing gas with a hydrogen sulphide concentration of 35 per cent. Early in 1970, the AOGCB designated a nine section block around the discovery as the Ricinus West field.

Seventeen miles southeast of the Ricinus field production casing has been run to evaluate two indicated Devonian reef gas discoveries. Shell Cdn-Sup Bearberry 12-21-33-6 W 5 is reported to have penetrated 850 feet of reef in the Leduc formation, containing 520 feet of reservoir development. Gas from the well is extremely sour, having a hydrogen sulphide content of about 90 per cent. Five miles to the northeast, a second well, Shell Cdn-Sup Lobley 10-3-34-6 W 5, is reported to have encountered a thinner gas section with hydrogen sulphide content of about 6 per cent.

The significance of a number of other discoveries was not fully established in 1969 pending further evaluation and development drilling. In the southwestern corner of the province, Mutex IOE Plains Coleman 6-11-9-4 W 5 was completed as a potential Wabamun gas well, 20 miles northwest of the Waterton field which produces from the Wabamun and one other zone. Twenty-five miles northeast of Calgary, Penzl Mobil Irricana 6-28-28-27 W 4 discovered gas in the same horizon from which production is obtained in the large Crossfield field, approximately 5 miles to the southwest. In central Alberta, gas was reported in the Leduc reef at Voyager et al S. Innisfail 8-9-34-1 W 5, 3 miles south of the Innisfail oilfield. Fifteen miles northwest of the Zama oilfield in northwestern Alberta a gas discovery was reported at Del Norte et al Amigo 14-12-120-8 W 6. Northeast of the Zama field, in the Cameron Hills area, a potential dual zone Devonian gas well was reported at Chiefco BluCr Indian 2-5-125-18 W 5.

TABLE 2

Pressure Maintenance Injection and Storage of Natural Gas in Canada, 1968-69
(Mcf)

	1968 Input	1969P Input
Alberta		
Aerial	–	170,022
Ante Creek	425,866	1,015,752
Bigstone	1,534,823	2,244,897
Carson Creek	26,036,384	20,195,946
Carstairs	2,656,033	2,619,124
Crossfield	10,409,245	10,727,884
Crossfield East	7,169,312	2,601,665
Duhamel	149,596	133,193
Gilby	391,046	267,446
Golden Spike	8,467,279	9,233,976
Harmattan East	38,616,507	37,911,024
Harmattan-Elkton	33,114,498	32,477,407
Joarcam	1,288,827	1,211,448
Judy Creek	257,816	54,203
Jumping Pound	164,224	–
Kaybob South	107,000	23,874,078
Leduc-Woodbend	1,176,345	1,361,870
Pembina	6,472,194	2,299,839
Rainbow	3,104,067	7,510,351
Rainbow South	147,085	679,682
Rowley	1,392	–
Turner Valley	832,037	494,340
Waterton	9,546,772	9,705,198
Westerose South	13,975,650	12,479,698
Willesden Green	–	60,306
Windfall	46,923,584	37,388,119
Wizard Lake	–	246,189
Zama	–	182,678
Distributor's Storage		
Bow Island	1,349,471	1,784,900
Carbon	1,639,143	2,590,354
Lloydminster	–	287,587
Viking-Kinsella	592,266	1,461,365
Total (14.65 psia)	216,548,462	223,270,541
Volume (adjusted to 14.73 psia)	215,379,100	222,064,880
Ontario	48,986,569	54,916,596
Saskatchewan (14.73 psia)	4,532,164	6,504,731
Total, Canada (14.73 psia)	268,897,833	283,486,207

Source: Provincial government reports.
P Preliminary; – Nil.

In total, 139 exploratory wells and 298 development wells were successfully completed in 1969, slightly more than the 395 new gas wells in 1968. Total footage drilled for all wells declined slightly in 1969. At year-end, there were 2,194 operating wells out of 2,692 capable of production.

BRITISH COLUMBIA

Development footage increased by 7 per cent but exploratory drilling declined by almost one third, causing the total footage drilled in 1969 to decrease by 19 per cent. One Slave Point gas well, FPC Chevron Peggo b-53-I, was completed in the Sahdoanah Creek area, approximately 90 miles northwest of Fort Nelson, where several potential gas wells have been drilled in recent years. Other indicated Slave Point discoveries were completed near the Clarke Lake field, southeast of Fort Nelson. Dome Petroleum Limited began drilling in the previously untested Bowser Basin area of northwestern British Columbia. Their well, Dome et al Ritchie A-3-J, was suspended at a total depth of 6,932 after encountering shallow gas shows which may be more fully evaluated in 1970.

Shell Canada Limited completed its offshore drilling program off the British Columbia coast in May, and the semi-submersible drilling rig which was used has been moved out of the area. Fourteen wells were drilled over a two-year period, in the area extending from the southwest coast of Vancouver Island to the northern end of Hecate Strait. Although a thick sedimentary section was encountered and some oil and gas shows were reported, no commercial accumulations were found. Offshore acreage under federal permits in this area amounted to 15.7 million acres at the end of 1969, slightly higher than at the end of 1968.

In total, 17 exploratory wells and 26 development wells were successfully completed, compared to 19 exploratory and 15 development in 1968. Gas wells capable of production in the province increased by 38 to 683.

SASKATCHEWAN AND MANITOBA

Substantial new reserves were discovered in 1969 by Banff Oil Ltd. in the Cold Lake area of west central Saskatchewan, approximately 200 miles northwest of Saskatoon. After an extensive exploration program, Banff completed nine successful gas wells in shallow Blairmore sands. First deliveries from the area to the Saskatchewan Power Corporation are expected to start in the fall of 1970. North Canadian Oils Limited continued its development program in the Hatton field of southwestern Saskatchewan, under its agreement with the Saskatchewan Power Corporation. A total of 18 exploratory wells and 24 development wells were

TABLE 3

Canada, Production of Natural Gas, 1968-69
(14.73 psia)

	1968r		1969p	
	Mcf	$	Mcf	$
Gross				
New Brunswick	112,967		105,976	
Quebec	137,573		137,897	
Ontario	11,974,385		11,334,274	
Saskatchewan	68,102,885		69,711,632	
Alberta	1,633,327,028		1,883,544,046	
British Columbia	278,948,274		322,527,685	
Northwest Territories	708,728		684,177	
Total, Canada	1,993,311,840		2,288,045,687	
Waste and flared				
Saskatchewan	11,295,574		10,713,632	
Alberta	58,114,759		60,879,431	
British Columbia	11,292,881		12,472,051	
Northwest Territories	666,126		640,454	
Total, Canada	81,369,340		84,705,568	
Reinjected				
Saskatchewan	35,685		–	
Alberta	211,817,557		215,973,744	
British Columbia	7,788,471		8,057,812	
Total, Canada	219,641,713		224,031,556	
Net				
New Brunswick	112,967	96,878	105,976	90,883
Quebec	137,573	20,636	137,897	20,684
Ontario	11,974,385	4,598,927	11,334,274	4,353,041
Saskatchewan	56,771,626	7,302,529	58,998,000	7,573,067
Alberta	1,363,394,712	185,356,207	1,606,690,871	218,432,804
British Columbia	259,866,922	27,875,502	301,997,822	32,394,817
Northwest Territories	42,602	17,979	43,723	18,452
Total, Canada	1,692,300,787	225,268,658	1,979,308,563	262,883,748
Processing shrinkage				
Saskatchewan	2,477,731		2,318,798	
Alberta	190,043,128		229,363,263	
British Columbia	6,418,702		6,221,703	
Total, Canada	198,939,561		237,903,764	
Net new supply, Canada	1,493,361,226		1,741,404,799	

Source: Dominion Bureau of Statistics.
r Revised; p Preliminary; – Nil;

TABLE 4

Canada, Production, Trade and Total Sales of Gas, 1959-69
(Mcf)

	Net new Production	Imports	Exports	Sales in Canada
1959	417,334,527	11,962,811	84,764,116	278,226,823
1960	522,972,327	5,570,949	91,045,510	320,701,484
1961	655,737,644	5,574,355	168,180,412	370,739,542
1962	946,702,727	5,575,466	319,565,908	412,061,509
1963	1,111,477,926	6,877,438	340,953,146	451,598,298
1964	1,327,664,338	8,046,365	404,143,095	504,503,388
1965	1,442,448,070	15,673,069	403,908,528	573,016,494
1966	1,341,833,195	43,550,818	426,223,806	635,514,622
1967	1,471,724,535	52,871,671	505,164,622	698,223,437
1968r	1,692,300,787	88,227,825	607,355,445	765,786,814
1969p	1,979,308,563	37,732,703	669,815,767	843,164,967

Source: Dominion Bureau of Statistics. Figures in Tables 4 and 12 differ for imports and exports because of different reporting procedures and timing.
p Preliminary; r Revised.

TABLE 5

Canada, Liquids and Sulphur Recovered from Natural Gas, 1959-69

	Propane (barrels)	Butane (barrels)	Condensate/ Pentanes plus (barrels)	Sulphur (long tons)
1959	1,690,114	1,424,452	2,259,413	261,015
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
1968r	15,977,317	10,499,003	33,200,698	3,042,105
1969p	17,941,218	11,759,888	38,488,103	3,714,312

Source: Dominion Bureau of Statistics and provincial government reports.
p Preliminary; r Revised.

completed in 1969, compared to 5 exploratory and 42 development in 1968. At year-end, there were 323 wells operating, out of 486 wells capable of production.

In Manitoba, exploratory drilling was up almost one third but declines in development drilling more than offset this gain as total footage dropped almost 20 per cent. No gas discoveries were made by the drilling, which was concentrated in the southwest corner of the province. Although no wells were drilled in the Manitoba portion of the sedimentary basin underlying the Hudson Bay area, the first offshore well in Hudson Bay was drilled in 1969. The well, Aquitaine et al Hudson Walrus A-71, located 250 miles east of Churchill, Manitoba, reached 3,926 feet, but was suspended short of its proposed total depth because of the necessity to move drilling equipment out of the Bay before ice built up in Hudson Strait. Non-commercial shows of oil and gas were found in separate horizons but were not tested. The well may be re-entered in another drilling season to complete it. Acreage under federal permits in the Hudson Bay – Hudson Strait area increased from 97.8 million acres at the end of 1968 to 125.8 million acres at the end of 1969.

TABLE 6

Canada, Wells Drilled, by Province, 1968-69

	Oil		Gas		Dry[1]		Total	
	1968	1969	1968	1969	1968	1969	1968	1969
Western Canada								
Alberta	556	464	395	437	897	942	1,848	1,843
Saskatchewan	387	528	47	42	489	592	923	1,162
British Columbia	46	42	34	43	106	81	186	166
Manitoba	28	15	–	–	38	67	66	82
Yukon and Northwest Territories	2	–	2	2	32	54	36	56
Westcoast-offshore	–	–	–	–	8	4	8	4
Hudson Bay-offshore	–	–	–	–	–	2	–	2
Sub-total	1,019	1,049	478	524	1,570	1,742	3,067	3,315
Eastern Canada								
Ontario	9	5	61	49	106	164	176	218
Quebec	–	–	–	–	1	3	1	3
Atlantic Provinces	–	–	–	–	11	–	11	–
Eastcoast-offshore	–	–	–	–	–	1	–	1
Sub-total	9	5	61	49	118	168	188	222
Total, Canada	1,028	1,054	539	573	1,688	1,910	3,255	3,537

Source: Canadian Petroleum Association.
[1] Includes suspended wells; – Nil.

TABLE 7

Footage Drilled in Canada for Oil and Gas, by Province, 1968-69

	Exploratory		Development		All Wells	
	1968	1969	1968	1969	1968	1969
Alberta	5,039,906	4,858,852	3,747,208	3,737,169	8,787,114	8,596,021
Saskatchewan	1,756,654	1,923,654	1,536,119	1,728,425	3,292,773	3,652,079
British Columbia	656,669	426,457	394,199	421,426	1,050,868	847,883
Manitoba	63,316	82,629	100,003	63,318	163,319	145,947
Northwest Territories	119,510	274,401	3,676	–	123,186	274,401
Westcoast-offshore	80,822	36,923	–	–	80,822	36,923
Hudson Bay-offshore	–	5,143	–	–	–	5,143
Total, western Canada	7,716,877	7,608,059	5,781,205	5,950,338	13,498,082	13,558,397
Ontario	163,614	317,569	130,642	86,437	294,256	404,006
Quebec	5,990	21,023	–	–	5,990	21,023
Atlantic Provinces	20,284	–	–	–	20,284	–
Eastcoast-offshore	–	13,085	–	–	–	13,085
Total, eastern Canada	189,888	351,677	130,642	86,437	320,530	438,114
Total, Canada	7,906,765	7,959,736	5,911,847	6,036,775	13,818,612	13,996,511

Source: Canadian Petroleum Association.
– Nil.

TABLE 8

Canada, Estimated Year-End Marketable Reserves of Natural Gas, 1968-69 (millions of cubic feet)

	1968	1969
Alberta	39,119,502	41,508,096
British Columbia	7,462,938	8,339,347
Saskatchewan	705,036	849,740
Eastern Canada	222,587	247,514
Northwest Territories	156,398	1,006,298
Total	47,666,461	51,950,995

Source: Canadian Petroleum Association.

NORTHWEST TERRITORIES AND THE YUKON

The first significant gas discovery in the Canadian Arctic was drilled in 1969 as Panarctic Oils Ltd., the government-industry consortium, began the drilling phase of its exploration program. The initial discovery well, Panarctic Drake Point L-67, located on the northeast tip of Melville Island, spudded in April but drilling was suspended at 8,454 feet because of an uncontrolled flow of gas and water from the well. A new well, Panarctic Drake Point K-67A, was started 1,200 feet east of the first well in September, and it reached a total depth of 10,671 feet early in 1970. Five separate pay sections were encountered in the second well, which yielded gas flows of up to 13 million cubic feet per day. Some free oil was recovered on one test. Although this well would be considered a gas well in the established production areas of Canada, it is at present considered non-commercial because of its remote location. However, the discovery of such substantial hydrocarbon accumulations in the early stages of an exploration program is very encouraging. Panarctic drilled and abandoned two other tests on Melville Island. Late in December, the company spudded its fifth well, Panarctic Hoodoo Dome E-27, on the southeast corner of Ellef Ringnes Island, approximately 180 miles northeast of the Drake Point wells. Panarctic is continuing its drilling program, and at least two other companies will start drilling in the Arctic Islands during 1970.

Attention was focussed on the Mackenzie Delta area by an oil discovery, IOE Atkinson H-25, which spudded in December and recovered oil on a drillstem test from rocks of Cretaceous age early in January, 1970. This is the first discovery recorded in this area, although drilling activity has increased over the last year in the Mackenzie delta area and the area further inland to the southeast. In the southwestern corner of the Territories, one gas well was completed two miles south of the 1967 discovery well in the Pointed Mountain field. The Beaver River gas field in northern British Columbia was extended into the Yukon with the completion of a new well 2 miles north of the original Beaver River discovery. The more widespread activity throughout the Territories and the Yukon resulted in a total of 56 wells being drilled compared to 36 in 1968, and total footage drilled was more than double at 274,401 feet. Land under federal permits and leases in the Northwest Territories and the Yukon rose to 441 million acres, from 324 million in 1968.

EASTERN CANADA

Although drilling was widespread in eastern Canada in 1969, no gas discoveries were made outside the established producing areas in Ontario. In southwestern Ontario, 9 exploratory wells and 40 development wells were successfully completed. Thirty of these wells were completed in Lake Erie, as drilling in the lake increased substantially over 1968. Almost all of the 3.1 million acres available offshore have been under permit for a number of years. One well, Aquitaine Sogepet et al Pen No. 1, was drilled on the shore of Hudson Bay near the Manitoba – Ontario border, opposite West Pen Island. It was abandoned at 3,393 feet, after encountering an oil-stained section in Silurian rocks. Total footage drilled in 1969 rose by 37 per cent to 404,006, due to an upswing in exploratory drilling which compensated for a drop in development activity.

In Quebec, three wells were completed and one was drilling at year-end. Shell St. Simon No. 1, located 40 miles east of Montreal, encountered encouraging gas shows while drilling but was abandoned after production tests indicated the reservoir would not support commercial production. Two other wells, one near Trois Rivières and the other in the Gaspé peninsula, were abandoned. Gulf Oil Canada Limited was drilling in the Gaspé at year-end.

Shell Canada Limited began a two-year offshore drilling program off the Nova Scotia coast in September. The first well, Shell Onondaga D-84, located 25 miles southwest of Sable Island, encountered non-commercial gas shows but was abandoned at 13,085 feet. A second well was started 80 miles to the southwest near the end of the year. The only other exploratory drilling in eastern Canada was a shallow test drilled by Premium Iron Ores Limited on Akpatok Island in Ungava Bay. However, east coast offshore activity is expected to increase considerably in 1970 when Shell puts a second rig in operation and at least two other groups begin offshore drilling operations. Companies continued to increase their offshore acreage holdings in 1969, and offshore acreage under federal permits increased by more than 50 million acres to a total of 259 million acres.

RESERVES

Canada's proved remaining marketable reserves of natural gas rose by 4,284,534 million cubic feet to 51,950,995 million cubic feet in 1969, the second largest increase since 1955, according to the estimates made by the Canadian Petroleum Association (CPA). This represents an annual growth rate of 9.0 per cent, which is double the 4.3 per cent increase registered in 1968. Revisions and extensions to existing pools added 4,734,418 million cubic feet, new discoveries accounted for an additional 1,104,452 million cubic feet and underground storage showed a net increase of 2,197 million cubic feet. Net marketable production during 1969 was estimated at 1,556,533 million cubic feet by the CPA.

NATURAL GAS PROCESSING

All of the new processing capacity put on stream in 1969 was located in Alberta, reflecting that province's importance as the main natural gas supplier in Canada. Although a substantial program of new construction and expansion was under way in 1969, some large projects carried over into 1970. As a result, only 607 million cubic feet daily of raw gas processing capacity was added by December 31, 1969 which is somewhat below the level of recent years. This additional capacity raised the total gas input capacity of all Canadian plants to 8,826 million cubic feet daily. The volume of natural gas liquids and sulphur potentially recoverable from this raw gas feed using existing processing facilities is 70,652 barrels of propane, 46,734 barrels of butane, 148,831 barrels of pentanes plus and 13,166 long tons of sulphur, on a daily basis. Such processing would produce 7,111 million cubic feet daily of dry, residue gas suitable for gas consumers, in addition to approximately 450 million cubic feet daily of residue gas which is re-injected into producing reservoirs to increase the total recovery of oil and other liquid hydrocarbons. At the end of 1969, plants located in Alberta accounted for 88 per cent of the raw gas processing capacity, more than 95 per cent of the liquid recovery capacity, and about 98 per cent of the sulphur recovery capacity.

The largest new plant completed in 1969 was that of the Amerada Division, Amerada Hess Corporation located northwest of Calgary in the Ferrier field. It has a raw gas capacity of 100 million cubic feet daily, and can produce up to 2,700 barrels of propane, 1,800 barrels of butane and 4,530 barrels of pentanes plus each day. Farther northwest, in the Brazeau River field, Hudson's Bay Oil and Gas Company Limited put a new plant on stream which is designed to process 84 million cubic feet of raw gas daily, and produce 1,520 barrels of pentanes plus and 50 long tons of sulphur. Throughout Alberta new facilities were developed to process gas from the Ferrier South, Sturgeon Lake South, Marten Hills, Simonette, Castor, Provost, Rainbow Lake and Calling Lake fields. Existing plants at Edson, Lone Pine Creek, Crossfield, Nevis and Whitecourt were also expanded.

The number of new plants and expansions scheduled for completion, including the Alberta Natural Gas Company's 900 million cubic feet re-processing plant at Cochrane, Alberta, indicate that the increase in processing capacity in 1970 will be among the highest in recent years.

TRANSPORTATION

Pipeline construction in 1969 was marked by the expansion of gathering and transmission systems to meet the demands resulting from growth in domestic and export markets. This expansion was particularly evident in Alberta, since it is the main gas producing province in Canada and is the major source of supply for both Canadian domestic supplies and exports.

The Alberta Gas Trunk Line Company undertook a major expansion of its system, which collects gas from field gathering systems throughout the province and transports it to the main trunkline systems at the Alberta borders. A 184-mile, 16- to 20-inch lateral line was extended northeastward from the northern end of the Foothills Division of the system at Edson to the Marten Hills producing area northeast of Lesser Slave Lake. A number of fields along the route were also tied in by short laterals. Reserves in the general Lac La Biche area of eastern Alberta were connected by a 204-mile, 12- to 14-inch line from Provost to Flat Lake. Near the north end of this lateral, a smaller 26-mile line connects fields in the Craigend area to the east. An additional 192 miles of pipe were laid in short laterals to producing fields and loops to the main line. New compressor capacity added to the system exceeded 130,000 horsepower. Throughout Alberta, producing companies expanded existing gathering systems and built new ones in a large number of gas fields in order to meet contract delivery schedules.

Outside Alberta, TransCanada PipeLines Limited added almost 200 miles of 36-inch loop beside the existing main transmission lines in Manitoba and Saskatchewan. Internal sandblasting of 1,100 miles of line was completed at various locations throughout the system, and new compressor capacity was added in a continuation of the company's program to increase overall system efficiency. In British Columbia, Westcoast Transmission Company Limited laid 48 miles of 24-inch line northeast of Fort Nelson in the Yoyo area, and completed 33 miles of 12-inch line in the Milligan area north of Fort St. John.

TABLE 9

Canada, Natural Gas Processing Plant Capacities, by Fields, 1969
(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
Bigstone	48	36
Black Butte	10	10
Bonnie Glen, Wizard Lake	43	36
Boundary Lake South	25	22
Braeburn	16	15
Brazeau River	84	76
Calling Lake	15	15
Carbon	155	150
Caroline (2 plants)	54	45
Carson Creek	100	48
Carstairs (2 plants)	339	284
Cessford (7 plants)	210	202
Chigwell (2 plants)	12	10
Countess	22	21
Crossfield (2 plants)	319	218
East Crossfield (2 plants)	146	87
Edson	377	339
Enchant	5	5
Ferrier (2 plants)	110	94
Ferrier South	9	8
Ghost Pine (2 plants)	102	100
Gilby (7 plants)	99	93
Golden Spike	45	reinj.
Harmattan-Elkton, Harmattan East	246	reinj.
Harmattan-Elkton (2 plants)	47	19
Homeglen-Rimbey, Westerose	422	357
Hussar (2 plants)	100	95
Innisfail	15	10
Judy Creek, Swan Hills (2 plants)	120	96
Jumping Pound	190	148
Kaybob	70	68
Kaybob South, Fox Creek	212	20
Kessler	6	5
Lac La Biche	25	25
Leduc-Woodbend	35	31
Lone Pine Creek	50	42
Marten Hills	133	130
Marten Hills South	24	24
Minnehik-Buck Lake	70	63
Morinville, St. Albert	22	20
Nevis, Stettler (2 plants)	170	139
Okotoks	30	13
Olds	50	38
Oyen	3	3
Paddle River	30	28
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)	125	118
Rainbow Lake (2 plants)	44	reinj.
Redwater	11	8
Retlaw	7	7
Samson	3	3
Savanna Creek	75	63
Sedalia	5	5
Sibbald	6	5
Simonette	15	11
Sturgeon Lake South	15	9
Sylvan Lake	32	29
Sylvan Lake, Hespero	62	53
Three Hills Creek	10	9
Turner Valley	100	85
Vulcan	25	16
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
Worsley	57	52
Pipeline at Ellerslie*	70	66
Pipeline at Empress**	1,499	1,460
Saskatchewan		
Cantuar	25	24
Coleville, Smiley	60	59
Dollard	2	2
Milton	4	4
Smiley	4	3
Steelman	38	30
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	16	16
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.

TABLE 10

Gas Pipeline Mileage in Canada, 1965-69

	1965	1966	1967	1968[r]	1969[p]
Gathering					
New Brunswick	6	6	6	6	6
Quebec	–	–	1	1	1
Ontario	1,102	1,167	1,163	1,142	1,154
Saskatchewan	560	684	714	794	848
Alberta	3,120	2,978	2,979	3,505	3,853
British Columbia	418	484	513	611	687
Total	5,206	5,319	5,376	6,059	6,549
Transmission					
New Brunswick	13	13	13	13	13
Quebec	25	112	121	148	156
Ontario	3,390	3,479	3,558	3,518	3,551
Manitoba	919	956	1,022	1,146	1,210
Saskatchewan	3,288	3,629	3,912	4,332	4,505
Alberta	5,020	5,165	5,327	5,620	5,918
British Columbia	1,551	1,580	1,660	1,758	1,844
Total	14,206	14,934	15,613	16,535	17,197
Distribution					
New Brunswick	33	32	32	32	32
Quebec	1,295	1,361	1,417	1,487	1,538
Ontario	12,699	13,315	13,737	14,497	15,063
Manitoba	1,354	1,344	1,443	1,522	1,620
Saskatchewan	1,740	1,789	1,914	2,031	2,099
Alberta	3,487	3,623	4,296	5,180	6,070
British Columbia	4,053	4,264	4,466	4,610	4,774
Total	24,661	25,728	27,305	29,359	31,196
Total, Canada	44,073	45,982	48,294	51,953	54,942

Source: Dominion Bureau of Statistics.
[p] Preliminary; [r] Revised; – Nil.

In western Canada, several gas utility companies continued to extend services. Expansion by Canadian Western Natural Gas Company Limited and Northwestern Utilities, Limited in central and southern Alberta included the installation of 750 miles of plastic pipe, in addition to steel pipelines used for new mains and transmission lines. Saskatchewan Power Corporation also used plastic pipe to add a total 68 miles to its system, which represents the smallest expansion in recent years, but most reasonably-sized communities now have gas service. In Manitoba, Greater Winnipeg Gas Company continued the northward extension of the system with a 19-mile line from Winnipeg to Stonewall and Stoney Mountain, and a 6-mile line from Lockport to Selkirk.

In Ontario, Union Gas Company of Canada, Limited installed a total of 17 miles of transmission lines at Sarnia and Woodstock, in addition to 100 miles of new distribution mains. The Consumers' Gas Company installed about 200 miles of new mains during system expansion.

MARKETS AND TRADE

Domestic sales showed a slightly higher rate of growth in 1969 than in 1968, increasing by 10.1 per cent to 2,310 million cubic feet daily. Export sales also rose by 12.5 per cent, but this contrasted sharply with the growth of 17.8 per cent in 1968 and 18.8 per cent in 1967, when exports were increasing at a rate approximately double that of sales in Canada. Total exports amounted to 680,129 million cubic feet or 1,863 million cubic feet daily.

TABLE 11

Canada, Sales of Natural Gas, by Province, 1969P

	Mcf	$	Average $/Mcf	Number of Customers Dec. 31/69
New Brunswick	58,825	169,798	2.89	1,735
Quebec	50,795,804	46,080,301	0.91	217,700
Ontario	351,460,938	282,888,753	0.80	803,866
Manitoba	47,398,425	29,703,799	0.63	124,192
Saskatchewan	78,843,108	37,489,316	0.48	143,313
Alberta	225,258,726	70,957,249	0.32	306,446
British Columbia	89,349,141	69,897,722	0.78	239,051
Total, Canada	843,164,967	537,186,938	0.64	1,836,303
Previous Totals				
1965	573,016,494	369,307,232	0.64	1,569,539
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

Source: Dominion Bureau of Statistics.
P Preliminary.

Market expansion in Ontario and Quebec continued to be a major factor contributing to the growth of Canadian sales. In 1969, sales in Ontario rose by 14.2 per cent to 963 million cubic feet daily, or 41.7 per cent of total Canadian sales. This increase, together with a 15 per cent gain in the smaller Quebec market, made up almost two thirds of the total increase in Canadian sales. More abundant supplies of western Canadian gas have been made available to these markets now that the Great Lakes system provides a second major transmission line from western Canada. As anticipated, this has resulted in a decreased demand for United States imports, which fell to 96 million cubic feet daily in 1969, less than half the 1968 level. In western Canada, Alberta markets showed the best growth as sales rose by 12 per cent to 617 million cubic feet daily, about 27 per cent of total Canadian sales. Smaller gains were made in the other provinces.

Sales in the industrial category made up more than half the total volume in all provinces except Manitoba and New Brunswick, where residential sales are highest. Industrial sales accounted for 52.6 per cent of the total Canadian volume, while commercial sales amounted to 20.0 per cent and residential sales were 27.4 per cent. Total revenue amounted to $537.2 million, of which 44.9 per cent came from residential sales, 32.7 per cent from industrial sales and 22.4 per cent from commercial sales.

Three proposals for major new pipeline systems to tap northern gas reserves dominated new marketing developments in 1969. In March, Northern Natural Gas Company, a major gas distributor in the upper mid-western United States, acquired a majority interest in Consolidated Pipe Lines Company, a Canadian company, in order to develop a Canadian pipeline system to deliver gas to its market area. The scheme consists of two phases. In the first phase, a 900-mile, 36-inch line would be built from Empress, Alberta to tie in to Northern's system at North Branch, Minnesota. Initial deliveries from Alberta fields in 1972 would be 360 million cubic feet daily, rising to 960 million cubic feet daily by 1979. An interesting feature of this system is a proposed lateral from the Tiger Ridge field in Montana to the main system near Swift Current, Saskatchewan, through which 150 million cubic feet daily would be imported for re-export through the main line. The second segment of the Consolidated plan involves construction of 1,700 miles of 36-inch line from the southwestern corner of the Northwest Territories to North Branch, through which deliveries would start in 1975 at 360 million cubic feet daily, increasing to 1,800 million cubic feet daily by 1979. Expenditures on the pipeline system alone have been estimated in the order of 1,400 million dollars.

TransCanada PipeLines Limited has also revealed plans to build a major new pipeline from northwestern Canada to connect with its existing system near Winnipeg. TransCanada, together with two United States distributors, People's Gas Company and the American Natural Gas Company system, are studying the feasibility of a large diameter pipeline which could tie-in reserves in the Pointed Mountain area of the Northwest Territories and extend northward through the Mackenzie Delta area, possibly as far as the

Prudhoe Bay area in Alaska. Early in 1970, TransCanada joined Mackenzie Valley Pipe Line Research Limited, an organization of major oil and gas transporting and producing companies, which is conducting research to solve the difficult problems of pipeline construction in northern Canada.

The third major proposal was put forward by Westcoast Transmission Company Limited and Bechtel Corporation. Through a subsidiary, Mountain Pacific Pipeline Ltd., the companies propose to carry out a two-stage plan, initially involving construction of a 995-mile, 40-inch pipeline running northward from Kingsgate on the British Columbia-Idaho border, inside the eastern British Columbia border to the Fort Liard area in the Northwest Territories. Westcoast has substantial reserves under contract in this area in the Pointed Mountain and Beaver River fields. The second stage, to be completed within five years after the first, would extend a 48-inch line more than 1,000 miles north to the Mackenzie Delta and Prudhoe Bay areas. Proposed capacity would be 800 million cubic feet daily in the first stage, increasing to 1,650 million cubic feet daily in the second stage with a maximum potential of 2,500 million cubic feet daily.

All three proposals are based on the anticipated discovery and development of significant reserves in northwestern Canada. The only major fields developed to date are at Pointed Mountain and Beaver River, but prospects for substantial additional development are favourable. In announcing their proposals, all three groups indicated they would welcome additional participation, and the pipeline systems eventually built may consist of modification or combination of one or more of the original schemes. However, by the end of 1969, the only proposal to advance to the stage of seeking regulatory approval in Canada was the first phase of the Consolidated scheme.

The Consolidated application was heard at a National Energy Board hearing together with four other applications for gas export licenses and two applications for approval of pipeline construction. The hearings, which began in November and ended in March, 1970, may produce several decisions having long range implications for the development of the Canadian gas industry. Before considering the individual applications, the Board had asked for opinions and comments on a number of broader, general issues governing the regulation of gas exports from Canada. These included comments on the criteria and methods of evaluation developed over the years by the Board to determine Canadian requirements, reserves, surplus, prices for exported gas and the duration of licenses. The Board also invited proposals for a system of priorities for the applications under consideration, in the event they exceeded surplus gas available after allowing for Canadian markets. The discussion of these issues indicated that considerable divergence of opinion exists amongst producers, distributors and others involved in the Canadian gas industry.

The firm applications heard at the hearing involve a total capital investment of approximately $222 million for pipeline facilities, and gas exports of more than 9 trillion cubic feet during the term of the licenses. Alberta and Southern Gas Co. Ltd. applied to increase its current level of exports by a maximum of 205 million cubic feet daily, beginning in November, 1970. Approval to export the required gas from Alberta had previously been received from the Alberta Oil and Gas Conservation Board. In order to handle the increased deliveries from Alberta and Southern, Alberta Natural Gas Company, which carries the gas through British Columbia to the Idaho border, sought approval for expansion of its pipeline system in southeastern British Columbia. Canadian-Montana Pipe Line Company applied for an additional 12 million cubic feet daily to increase its exports to Montana, beginning in November, 1970.

Consolidated Natural Gas Limited applied for a permit to start exporting gas at maximum rates of 358 million cubic feet daily, beginning January 1, 1971. A second condition of the permit would provide for the importation and re-export of 150 million cubic feet daily from Montana fields. An affiliated company, Consolidated Pipe Lines Company, applied for permission to build the necessary pipeline facilities, consisting of a 315-mile, 36-inch line from the Alberta Natural Gas Company line at Empress, Alberta to a connection with the Northern Natural Gas Company system at the international border near Oungre, Saskatchewan. The company would also construct a 98-mile, 16-inch line in southwestern Saskatchewan to tie-in Montana fields. The Alberta Government has approved Consolidated's application to remove gas from the Strachan-Ricinus and Kaybob South areas in Alberta, but reduced the initial permit to a total volume of 1.54 trillion cubic feet and a maximum daily volume of 240 million cubic feet, from the 2.3 trillion cubic feet total and 360 million cubic feet daily maximum originally requested.

TransCanada PipeLines Limited applied to the NEB to increase exports through its export point at Emerson, Manitoba. Beginning in November, 1970 TransCanada would increase maximum daily deliveries to its subsidiary, Great Lakes Gas Transmission Company, by 195.8 million cubic feet, to Michigan Wisconsin Pipe Line Company by 50 million cubic feet daily, and to Midwestern Gas Transmission Company by 7.2 million cubic feet daily. System capacity would also be expanded by the addition of new pipelines and compressor capacity.

Westcoast Transmission Company Limited sought approval to increase exports to meet the requirements of its major United States customer, El Paso Natural Gas Company. The proposed increase would be made in two annual increments of 76 million cubic feet daily, on November 1, 1970 and 1971. These increases would fulfill contract commitments made between Westcoast and El Paso early in 1969. However, the two companies negotiated a new contract in October, 1969 which, in effect, would replace several earlier agreements, subject to the approval of regulatory authorities. The new contract provides for deliveries of 725 million cubic feet daily starting November 1, 1971, 800 million cubic feet daily on November 1, 1972 and 850 million cubic feet daily the following year. To cover this new contract, Westcoast included in its application to the NEB a provision for a license to export a maximum of 733.3 million cubic feet daily, beginning November 1, 1971, increasing to a maximum of 809.2 million cubic feet daily by November 1, 1972. If this latter provision is granted, three previous export licenses granted to Westcoast would be cancelled, including the most recent application for the increments in 1970 and 1971. Westcoast has also applied for permission to expand its pipeline facilities, including new pipeline connections from its Fort Nelson plant to the Beaver River field, approximately 100 miles northwest of Fort Nelson on the British Columbia-Yukon border.

TABLE 12

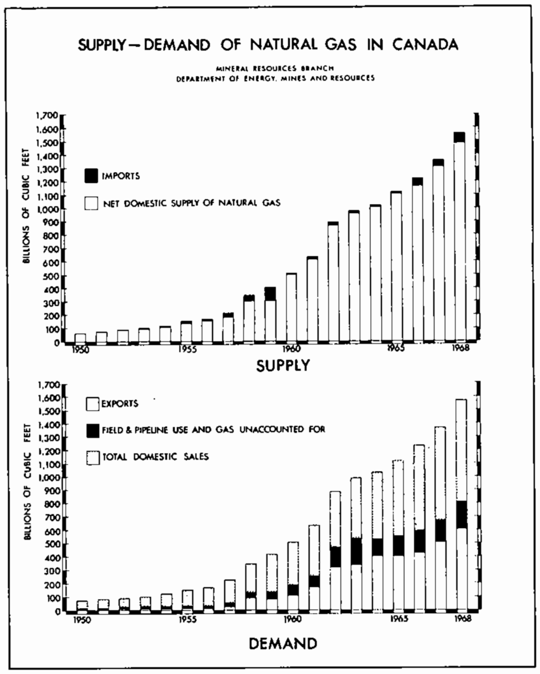
Canada, Supply and Demand of Natural Gas
(MMcf)

	1968r		1969p	
Supply				
Gross new production		1,993,312		2,288,046
Field waste and flared		– 81,369		– 84,706
Reinjected		–219,642		–224,031
Net new production		1,692,301		1,979,309
Processing shrinkage		–198,940		–237,904
Net new supply		1,493,361		1,741,405
Removed from storage	55,727		65,024	
Placed in storage	–57,758		–66,300	
Net storage		– 2,031		– 1,276
Total net domestic supply		1,491,330		1,740,129
Imports		81,554		34,936
Total supply		1,572,884		1,775,065
Demand				
Exports		604,445		680,129
Domestic Sales				
Residential	214,584		231,459	
Industrial	407,210		443,286	
Commercial	143,993		168,420	
		765,787		843,165
Field and Pipeline Use				
In production	110,839		135,757	
Pipeline	87,534		99,294	
Other	6,799		13,297	
Line Pack changes	+ 2,749		+ 3,622	
Total field, etc. use		207,921		251,970
Gas unaccounted for		– 5,269		– 199
Total demand		1,572,884		1,775,065
Total domestic demand		968,926		1,094,936
Average daily demand		2,647		2,999

Sources: Dominion Bureau of Statistics and provincial government reports.
p Preliminary; r Revised.

OUTLOOK

The present strong demand for Canadian gas in both domestic and export markets is expected to continue over the short term and for a considerable period in the future. The extent to which these demands will be met will depend upon the success of the Canadian industry in discovering and developing the large volumes of new reserves which will be required.



During 1970, growth in Canadian domestic markets is expected to continue at about the 10 per cent rate that has been maintained in recent years. Increases in exports will depend largely upon the decisions of regulatory authorities in both Canada and the United States, regarding the applications for large increases in exports which are currently before them. Gas distributors in the United States are turning increasingly to Canada for larger volumes of gas, as evidenced by these applications and the proposals for major new pipelines to tie-in northern reserves. Studies of future energy demands in the United States have pointed up the possibility of a shortage of domestic energy supplies available to meet anticipated requirements. With respect to natural gas, the problem is becoming particularly acute, and industry officials have warned of imminent shortages in some areas unless substantial supplemental supplies are forthcoming. Such warnings were emphasized by developments in the United States in 1969. Gas production there rose by 7 per cent, but, for the second consecutive year, reserve additions failed to keep pace with withdrawals, with the result that total United States gas reserves fell by 4.2 per cent. This total reserve figure does not include any allowance for gas found in the Prudhoe Bay discovery area in Alaska, but these reserves are remote from the main United States markets and no firm plans exist to transport them as yet. If all applications are approved by the NEB and the FPC in the United States, and deliveries increase on schedule in the latter part of the year, exports in 1970 will exceed 2,000 million cubic feet daily for the first time. In order to meet these increased domestic and export requirements, net new production would have to approach 6,000 million cubic feet daily.

The strong demand resulting from the combined Canadian and United States requirements has sharply increased competition for available Canadian gas supplies, which has resulted in higher wellhead prices for producers. Another significant development has been the introduction of advance cash payments to producers. For example, Consolidated Natural Gas Limited instituted a system of interest-free prepayments to producers, which are to be repayed by future production, and paid somewhat higher wellhead prices, in order to contract supplies for its new pipeline and stimulate the development of new reserves. The result has been higher wellhead prices generally as competing companies matched the increases in order to line up new reserves. The ultimate effect of these higher wellhead prices in terms of prices for Canadian consumers has yet to be determined.

COMPOSITION AND USES OF NATURAL GAS

Marketed natural gas consists chiefly of methane (CH_4) but small amounts of other combustible hydrocarbons such as ethane (C_2H_6) and propane (C_3H_8) may also be present. Methane is nonpoisonous and odourless but a characteristic odour is usually introduced into marketed natural gas as a safety measure. The heat value of natural gas averages about 1,000 British thermal units per cubic foot of gas.

Raw natural gas, as it exists in nature, may vary widely in composition. Besides the usually predominant methane, varying proportions of ethane, propane, butane and pentanes plus may be present. Water vapour is a normal constituent. Hydrogen sulphide, although not present in some Canadian natural gas, is commonly so abundant as to be an important source of sulphur. Other nonhydrocarbon gases which may be present, usually in small amounts are carbon dioxide, nitrogen and helium.

The most important use of natural gas is as a fuel for space and water heating. Gas is now extensively used in cooking 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*

Prior to 1968, nepheline syenite and feldspar were described in separate mineral reviews. The similarities between these two industrial mineral commodities, i.e., physical characteristics, end use, markets, beneficiation, and mining techniques, as well as the declining importance of feldspar and its substitution by nepheline syenite have led to the incorporation of these minerals into one review since that time.

NEPHELINE SYENITE

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. Hereafter 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 a unique material nepheline syenite – now almost an indispensable ingredient in the manufacture of glass. Today, some 38 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, Norway and the USSR, produce 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 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.

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 thirty years has become a vital 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.

*Mineral Resources Branch.

CANADIAN PRODUCTION AND DEVELOPMENTS

In 1969, shipments increased 18 per cent over 1968 to reach 502,893 short tons valued at $5,881,818. This substantial increase in producer shipments was due in large part to a shortage of feldspar – a competing product in the glass industry – in the United States. It is anticipated that this shortage situation will be alleviated in 1970 as feldspar producers in the United States have announced plans for increased production.

Production originates from two mines in Canada, both located on Blue Mountain in Methuen Township some 25 miles northeast of Peterborough, Ontario. The deposit is pear-shaped, approximately 3 miles in length, and up to 1.5 miles in width. The iron content of the rock is distributed very uniformly, but 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 at least 25 years.

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. A 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

TABLE 1

Canada – Nepheline Syenite – Production, Exports and Consumption 1968-69

	1968		1969P	
	Short Tons	$	Short Tons	$
Production (shipments)	426,595	4,738,008	502,893	5,881,818
Exports				
United States	289,883	3,528,000	364,008	4,559,000
Japan	2,246	35,000	7,673	116,000
Britain	6,614	142,000	6,378	101,000
Puerto Rico	6,000	86,000	4,315	63,000
Italy	4,110	59,000	4,136	83,000
Australia	2,942	63,000	3,001	66,000
Belgium and Luxembourg	1,357	31,000	1,092	27,000
Netherlands	5,323	60,000	952	16,000
Dominican Republic	500	7,000	764	10,000
West Germany	431	11,000	709	19,000
France	–	–	639	16,000
Other countries	3,776	67,000	1,946	44,000
Total	323,182	4,089,000	395,613	5,120,000

	1967	1968
Consumption* (available data)		
Glass and glass fibre	48,273	55,188
Whiteware	9,398	9,369
Mineral wool	8,632r	9,568
Porcelain enamel	279	219
Paint	394	569
Other	841	2,880
Total	67,817	77,793

Source: Dominion Bureau of Statistics.
*Adjusted total and breakdown from Mineral Resources Branch.
PPreliminary; rRevised.

variety of markets. The various grades produced are based on combinations of differing mesh sizes and iron content. Iron-bearing minerals are removed by electro-magnetic methods. Finished products are transported, mostly in bulk, by rail to Havelock, Ontario, some 18 miles south of the mill. From there, transportation is by rail to domestic and export markets. Exports to the United States account for about 65 per cent of sales.

International Minerals & Chemical Corporation (Canada) Limited 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. Reflecting the growing market for nepheline syenite, capacity increases were undertaken in 1969. 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.

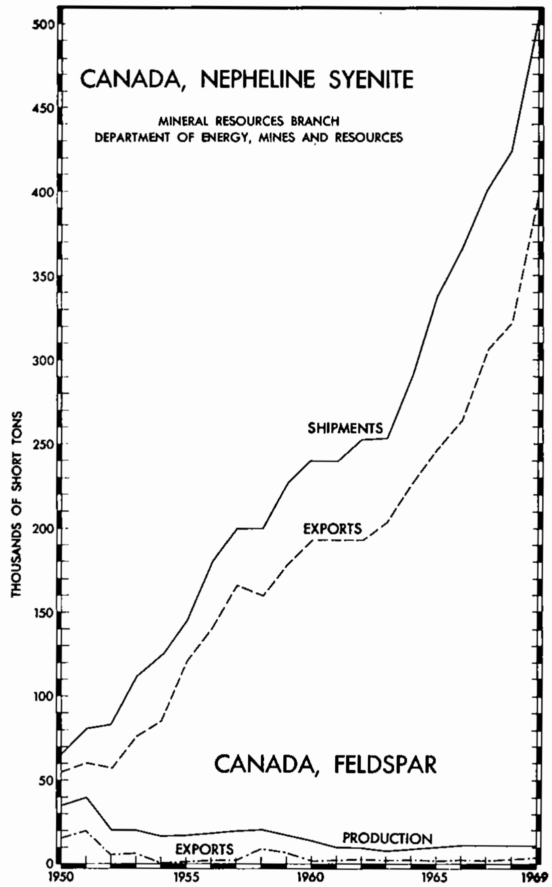
Production is railed, mostly in bulk, to Havelock for distribution to various markets. Approximately 90 per cent of the product is exported to the United States. IMC (Canada) produces three grades of nepheline syenite for glass, ceramic, enamel, fibre and other applications.

In 1969 North Rankin Nickel Mines Limited, (name changed to Tontine Mining Limited, early 1970) continued exploration work on a large nepheline syenite intrusive located near Port Coldwell on the north shore of Lake Superior. The deposit is being explored to depth while milling and marketing studies are being undertaken. Samples from the deposit have been shipped to consumers in the United States in order to determine the acceptability of the material in the glass and other consuming industries.

OTHER DOMESTIC SOURCES

Nepheline syenites are known 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.



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.

MARKETS

In 1969, 79 per cent of nepheline syenite produced in Canada was exported; about 92 per cent of this to the United States. Export markets continued to expand and in 1969 reached an all-time high of 395,613 tons.

Nepheline syenite is used in a number of industrial applications but more than 75 per cent of production is consumed in the glass industry where, as an additive to the glass batch, it lowers the melting point, promotes melting and is a source of alumina and alkalis. 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 rapidly 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. Approximately 15 per cent of production is consumed in the whitewares industry

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. Approximately 5 per cent of production is utilized as filler material.

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. These uses are minor and account for less than 5 per cent of consumption.

TABLE 2

Nepheline Syenite – Production and Exports 1960-69
(short tons)

	Production*	Exports
1960	240,636	193,298
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
1969p	502,893	395,613

Source: Dominion Bureau of Statistics.
*Producers' shipments.
pPreliminary.

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 one mile in length and extends to a depth of at least 750 feet. Both a biotite nepheline syenite and a pyroxene-hornblende nepheline syenite occur in the deposit. 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. Continued expansions in glass manufacturing assures a steadily increasing market particularly as non-returnable glass containers are being more extensively used. The market for finely ground material used in the ceramic industry and as fillers is expanding rapidly and both Canadian producers operated near capacity to meet these growing consumer demands. Their ability to supply 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. The long term outlook suggests a growth rate in markets in the order of 7 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 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.

CANADIAN PRODUCTION AND DEVELOPMENTS

Production of feldspar in Canada in 1969 was 11,743 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 feldspar silica mixture for glass manufacture. Normally the mixture contains from 30 to 50 per cent feldspar.

TABLE 3

Canada – Feldspar, Production and Trade, 1960-69
(short tons)

	Production*	Imports	Exports	Consumption
1960	13,862	1,338	3,183	7,175
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
1969p	11,743	. .	. .	. .

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

TABLE 4

Canada – Feldspar – Production, 1968-69, Consumption 1967-68

	1968		1969p	
	Short Tons	$	Short Tons	$
Production[1]	10,620	243,678	11,743	309,123
	1967		1968	
Consumption[2] (available data)				
Whiteware	6,796		6,228	
Porcelain enamel	270		303	
Cleaning compounds	690		366	
Other	815		446	
Total	8,571		7,343	

Source: Dominion Bureau of Statistics.
[1]Producers' shipments. [2]Breakdown by Mineral Resources Branch.
pPreliminary.

PRICES

United States feldspar prices as quoted in Engineering and Mining Journal of December, 1969 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 " " "	21.00
20 " flotation	11.00
200 " "	20.50 – 26.00
Georgia	
200 mesh	23.50
325 "	24.50
40 " granular	20.00
Connecticut	
30 mesh, granular	13.50
200 "	20.50
325 "	21.50
20 " "	13.50
Maine	
200-325 mesh	19.50 – 25.00

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%

UNITED STATES

522.31	Feldspar, crude	
	On and after Jan. 1, 1969	7¢ per long ton
	" " " Jan. 1, 1970	5¢ " " "
522.41	Feldspar, crushed, ground or pulverized	
	On and after Jan. 1, 1969	6%
	" " " Jan. 1, 1970	5%

Note: Further tariff reductions on the above United States feldspar items will occur on Jan. 1, 1971 and Jan. 1, 1972.

Nickel

A.F. KILLIN*

The shortage of nickel that has been evident in the non-communist world since 1966 was further accentuated in 1969 by production interruptions in the three major producing areas. Labour disturbances reduced output in Canada and Australia and a fire in the powerhouse at the Doniambo, New Caledonia, smelter of Société Le Nickel reduced production from that plant. Producers, who had been allocating nickel to established customers, were forced to reduce deliveries and consumers had to reduce consumption or buy nickel from dealers at inflated prices. United States consumers received 9 million pounds from the government stockpile, for defense purposes.

Consumption** of nickel in the non-communist world declined in response to the reduction in supplies. At 410,000 tons, consumption in 1969 was 5,000 tons less than in 1968.

Nickel production in Canada, reflecting production losses because of strikes, was 213,325 tons valued at $482,412,858, some 51,033 tons and $45,822,940 less than in 1968. Canadian consumption** rose to 14,000 tons in 1969 from the 12,500 tons used in 1968. Canadian exports in 1969 were: in ores, concentrate and matte 76,975 tons; in oxide sinter 29,009 tons; and refined metal 104,243 tons. Total export in these forms was 54,443 tons lower than in 1968.

CANADIAN OPERATIONS AND DEVELOPMENTS

Nickel was produced in Quebec, Ontario, Manitoba and British Columbia. 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 basis. One mine started production in Quebec, two in Manitoba, and ten mines were being developed to production.

QUEBEC

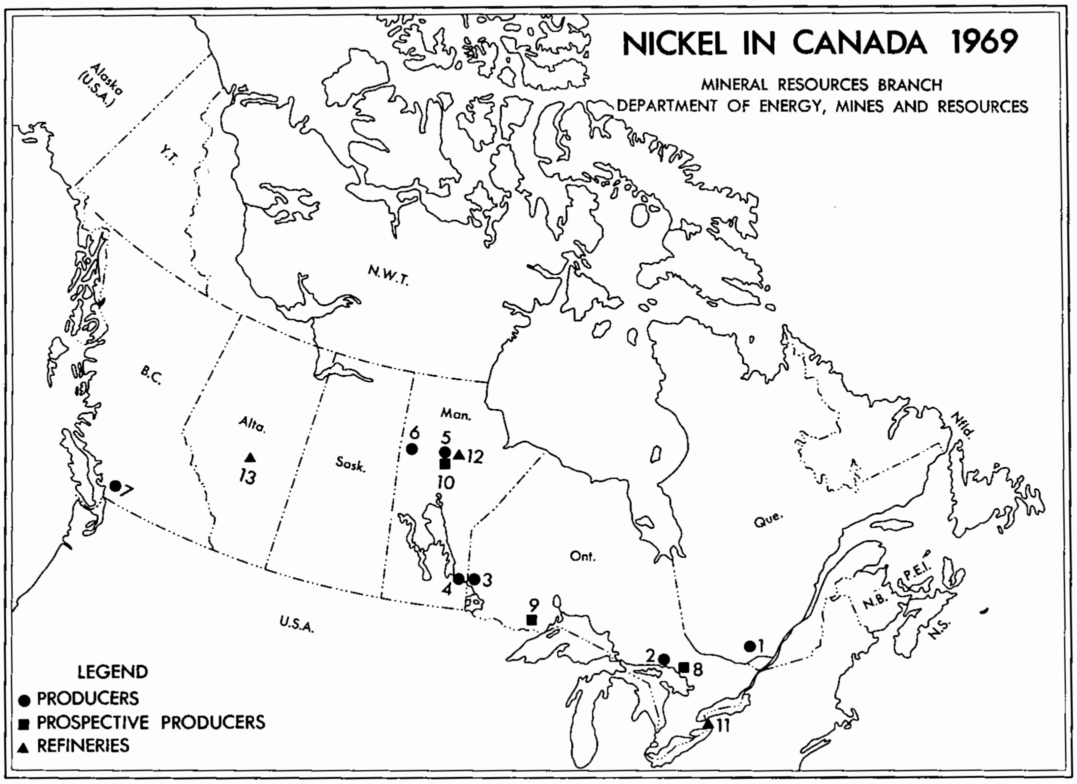
Renzy Mines Limited in Hainault Township started production in July at 800 tons of ore a day. Production from the open pit will be expanded in 1970 to 1,000 tons a day. Exploration of the low-grade nickel-copper deposit north of the main workings of Mattagami Lake Mines Limited was continued.

New Quebec Raglan Mines Limited (controlled by Falconbridge Nickel Mines, Limited) continued exploration of the Katinique and Donaldson ore zones at its Ungava Peninsula property. Surface drilling at the Katinique zone increased indicated ore reserves by about 1.5 million tons. At the Donaldson zone shaft sinking to the 750-foot level was completed and stations cut at the 350-, 525- and 700-foot horizons.

ONTARIO

Two of the world's largest nickel producers operate mines, mills and smelters in the Sudbury district of Ontario. The International Nickel Company of Canada, Limited (Inco) operated 12 mines, four mills and two smelters near Sudbury and a refinery at Port Colborne. The company is developing six mines in Ontario, five at Sudbury and a mine and mill at Shebandowan, and a new $80-million concentrator and $85-million pressure-carbonyl refinery at Copper Cliff. Nickel production from the Sudbury plants is scheduled to reach 430 million pounds a year by 1972. Falconbridge Nickel Mines, Limited operated eight mines, four mills, a smelter and a pyrrhotite plant at Falconbridge. The company was developing the Lockerby mine for production in 1975, will reactivate a blast furnace and converter in the old smelter aisle and put a new nickel-iron refinery on stream in 1970. Falconbridge shipped nickel-copper matte to its wholly-owned refinery at Christiansand,

*Mineral Resources Branch.
**Estimate by The International Nickel Company of Canada, Limited.



PRODUCERS

(1) Renzy Mines Ltd.

(2) Sudbury area

Falconbridge Nickel Mines, Ltd. (8 mines, 1 smelter)

The International Nickel Company of Canada, Ltd. (12 mines, 2 smelters)

(3) Consolidated Canadian Faraday Ltd.

(4) Dumbarton Mines Ltd.

(5) The International Nickel Company of Canada, Ltd. (2 mines, 1 smelter)

(6) Sherritt Gordon Mines, Ltd.

(7) Giant Mascot Mines Ltd.

PROSPECTIVE PRODUCERS

(8) Sudbury area

Falconbridge Nickel Mines, Ltd. (1 mine)

The International Nickel Company of Canada, Ltd. (5 mines, 1 refinery)

(9) The International Nickel Company of Canada, Ltd., Shebandowan mine

(10) Falconbridge Nickel Mines, Ltd., Manibridge mine

The International Nickel Company of Canada, Ltd. (2 mines)

REFINERIES

(11) The International Nickel Company of Canada, Ltd. (Port Colborne)

(12) The International Nickel Company of Canada, Ltd. (Thompson)

(13) Sherritt Gordon Mines, Ltd. (Fort Saskatchewan)

TABLE 1

Canada – Nickel Production, Trade and Consumption, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Production[1]				
All forms				
Ontario	203,747	405,168,184	146,838	330,966,930
Manitoba	57,923	117,601,237	64,850	147,713,568
British Columbia	1,658	3,372,225	1,364	3,109,920
Quebec	885	1,800,753	273	622,440
Saskatchewan	145	293,399	–	–
Total	264,358	528,235,798	213,325	482,412,858
Exports				
Nickel in ores, concentrates matte and speiss				
Norway	41,484	74,595,000	35,829	64,992,000
Britain	46,855	92,938,000	35,164	76,757,000
Japan	7,119	12,302,000	5,913	10,752,000
United States	69	126,000	69	93,000
Total	95,527	179,961,000	76,975	152,594,000
Nickel in oxide sinter				
United States	30,510	52,900,000	19,491	38,026,000
Britain	6,346	11,079,000	6,231	11,504,000
West Germany	2,138	4,022,000	1,557	3,013,000
Italy	1,234	2,335,000	937	1,792,000
Australia	851	1,466,000	459	883,000
Sweden	897	1,700,000	301	522,000
Other countries	82	155,000	33	72,000
Total	42,058	73,657,000	29,009	55,812,000
Nickel and nickel alloy scrap				
United States	2,028	1,789,000	2,270	7,028,000
West Germany	1,239	3,072,000	1,663	6,215,000
Netherlands	215	556,000	278	820,000
India	124	393,000	260	990,000
Japan	65	222,000	217	713,000
Other countries	456	1,379,000	350	1,139,000
Total	4,127	7,411,000	5,038	16,905,000
Nickel anodes, cathodes, ingots, rods				
United States	98,251	179,993,000	86,768	178,038,000
Britain	21,186	38,537,000	11,111	21,817,000
Italy	155	346,000	1,712	4,039,000
Australia	1,473	2,866,000	1,420	3,086,000
France	3,161	6,218,000	880	2,033,000
India	648	1,452,000	552	1,208,000
Japan	591	1,200,000	393	854,000
West Germany	249	782,000	298	791,000
Belgium and Luxembourg	–	–	251	513,000
Brazil	293	669,000	234	679,000
Other countries	1,088	2,765,000	624	2,058,000
Total	127,095	234,828,000	104,243	215,116,000

TABLE 1 (Cont'd)

	1968		1969p	
	Short Tons	$	Short Tons	$
Nickel and nickel alloy fabricated materials, n.e.s.				
United States	2,806	7,449,000	2,049	6,590,000
Netherlands	327	1,055,000	303	1,074,000
Japan	128	303,000	171	617,000
India	186	541,000	137	291,000
West Germany	26	74,000	130	616,000
Brazil	39	108,000	124	403,000
Syria	31	135,000	80	398,000
Other countries	357	941,000	294	974,000
Total	3,900	10,606,000	3,288	10,963,000
Imports				
Nickel in ores, concentrates and scrap				
Australia	1,695	2,670,000	4,407	6,408,000
United States	3,713	2,482,000	2,823	4,655,000
French Oceania	8,082	7,527,000	1,861	2,808,000
Britain	2,400	674,000	1,201	776,000
Other countries	92	133,000	99	182,000
Total	15,982	13,486,000	10,391	14,829,000
Nickel anodes, cathodes, ingots, rods				
Norway	11,386	23,841,000	12,388	28,403,000
United States	8	30,000	91	559,000
Other countries	–	–	122	806,000
Total	11,394	23,871,000	12,601	29,768,000
Nickel alloy ingots, blocks, rods and wire bars				
United States	542	2,089,000	509	1,945,000
West Germany	6	24,000	11	47,000
Total	548	2,113,000	520	1,992,000
Nickel and alloy plate sheet and scrap*				
United States	–	–	2,605	9,315,000
Britain	–	–	91	300,000
Other countries	–	–	44	130,000
Total	–	–	2,740	9,745,000
Nickel and nickel alloy pipe and tubing*				
United States	–	–	258	1,148,000
West Germany	–	–	181	1,048,000
Other countries	–	–	16	70,000
Total	–	–	455	2,266,000

TABLE 1 (Cont'd)

	1968		1969p	
	Short Tons	$	Short Tons	$
Nickel and alloy fabricated materials, n.e.s.				
United States	2,300	9,373,000	422	2,455,000
Britain	296	976,000	60	246,000
Other countries	507	2,249,000	20	84,000
Total	3,102	12,598,000	502	2,785,000
Consumption[3]	11,239		12,094	

Source: Dominion Bureau of Statistics.
[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, oxide and salts) as reported by consumers.
*New classes, formerly part of nickel and alloy fabricated materials, n.e.s.
pPreliminary; – Nil; n.e.s. Not elsewhere stated.

Norway and was investigating the feasibility of establishing refinery facilities in Canada. Consolidated Canadian Faraday Limited completed expansion of its mill at Werner Lake to treat ore from the Dumbarton mine in Manitoba and from its own Werner Lake mine. Concentrates were shipped to Copper Cliff for smelting and refining.

MANITOBA

Nickel production continued to increase in Manitoba with the start of production from two new mines. Output in 1969 was 64,850 tons, up 6,927 tons from 1968. Inco brought the Birchtree mine into production near Thompson and was developing the Soab and Pipe Lake mines for production in 1970 and 1972. Dumbarton Mines Limited started production of ore from the Bird River property of Maskwa Nickel Chrome Mines Limited. The ore was trucked to the Werner Lake mill of Consolidated Canadian Faraday for processing. Sherritt Gordon Mines, Limited, at Lynn Lake, continued operation of its mine and mill. Nickel concentrates were shipped to the company's refinery at Fort Saskatchewan, Alberta.

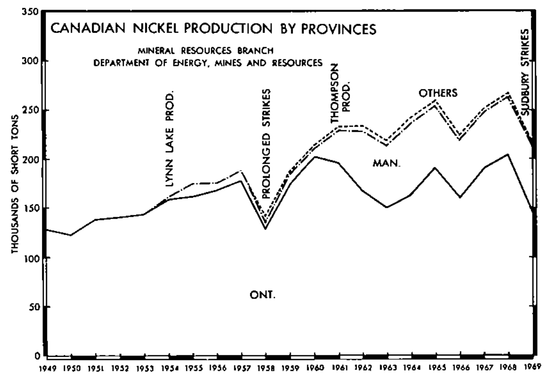


TABLE 2

Nickel – Production, Trade and Consumption, 1960-69
(short tons)

	Production[1]	Exports				Imports[2]	Consumption[3]
		In Matte etc.	In Oxide Sinter	Refined Metal	Total		
1960	214,405	73,910	13,257	108,350	195,517	1,762	4,861
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	5,866r
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

TABLE 2 (Cont'd)

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	11,239
1969p	213,325	76,975	29,009	104,243	210,227	12,601	12,094

Source: Dominion Bureau of Statistics.
[1]Refined metal and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates exported. [2]1960 to 1963 incl., nickel, semi-fabricated, comprising nickel and nickel alloys in ingots, blocks, bars, rods, strip, sheet, etc.; 1960 and subsequent years, refined nickel comprising anodes, cathodes, ingots, rods and shot. [3]After 1959, consumption of nickel, all forms (refined metal, oxide and salts) as reported by consumers.
pPreliminary; rRevised; .. Not available.

BRITISH COLUMBIA

Giant Mascot Mines Limited, near Hope, was the only nickel producer in British Columbia in 1969. Output was 1,364 tons some 295 tons less than 1968. Silver Standard Mines Limited announced that further exploration by diamond drilling would be carried out in 1970 on its Iskut River property.

WORLD DEVELOPMENTS

World production of nickel, as estimated by the United States Bureau of Mines, declined in 1969 to 530,000 tons from the 545,000 tons produced in 1968. Most of this decline was caused by the production interruptions in Canada. The continuing growth in 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 have been discovered and are being explored and/or developed in Africa and Australia but the major exploration and development activity has been directed to the exploration and development of lateritic deposits occurring in semi-tropical or tropical areas. The major areas of interest include Australia, the British Solomon Islands Protectorate, Colombia, Brazil, the Dominican Republic, Indonesia, New Caledonia, the Republic of the Philippines and Venezuela.

AFRICA

Botswana–Bamangwato Concessions Limited continued exploration of the deposits at Selebi-Pikwe. Shaft sinking, underground development and diamond drilling have established reserves of 31.8 million tons averaging 1.25 per cent nickel and 1.32 per cent copper. Bamangwato Concessions Limited is 61 per cent owned by Botswana RST, Ltd., which is, in turn, owned 30 per cent by American Metal Climax, Inc. (Amax) and 30 per cent by Roan Selection Trust Limited. The Botswana government has applied to the World Bank for a loan of $50 million to provide infrastructure for a mining-milling-smelting complex to treat the ores. Initial plans call for a production of 37,000 tons of matte a year containing about 15,344 tons of nickel and 17,696 tons of copper. The matte will be toll refined at Amax's refinery at Braithwaite near Port Nickel, Louisiana, U.S.A. Estimated cost of the mine and plant is $100 million. Anglo-American Corporation was exploring the Tati concession north of the Selebi-Pikwe area. Copper and nickel deposits have been indicated and some diamond drilling done.

AUSTRALIA

There were two nickel producers in Australia in 1969, both in the Kalgoorlie-Kambalda area. Western Mining Corporation Limited at Kambalda continued expansion of its mine and mill. Production was obtained from the Lunnon shoot and development for production continued in the Durkin shoot. Production capacity was increased to 66,000 tons of ore a month. Work continued on Western's nickel refinery at Kwinana and production was expected in the first half of 1970. The refinery was designed to produce 15,000 tons of nickel powder and briquettes a year, together with ammonium sulphate, copper sulphide and nickel-cobalt sulphide. Great Boulder Gold Mines Limited (51 per cent) and North Kalgurli (1912) Ltd. (49 per cent) operated the Scotia mine, 45 miles northwest of Kalgoorlie at 10,000 tons of ore a month. The ore was trucked to the rebuilt Great Boulder gold mill at Kalgoorlie where a flotation concentrate was made. The concentrates will be sold to Western Mining Corporation. Prospecting for nickel continued in many areas of Australia. Great Boulder and North Kalgurli have discovered another deposit at Carr Boyd Rocks about 60 miles northeast of Kalgoorlie. Metals Exploration and Freeport of Australia, Inc. started production from a small deposit at Nepean, in the Kalgoorlie area, and shipped ore to the mill of Western Mining Corporation. The International Nickel Company of Canada, Limited was preparing to sink an exploration shaft at its property at Widgiemooltha.

BRITISH SOLOMON ISLANDS PROTECTORATE

The International Nickel Company of Canada, Limited continued exploration and mineral testing of the lateritic nickel deposits on the islands of Choiseul, Santa Ysabel and San Gorge.

TABLE 3

Producing Companies, 1969

Company and Location	Mill Capacity (tons ore/day)	Ore Produced 1969 (1968) (short tons)	Grade % Ni	Grade % Cu	Developments
QUEBEC					
Renzy Mines Limited, Hainault Township	800	88,049 (–)	0.54	0.57	Production started from the open pit in July at 500 tons of ore a day and was expanded to 800 tons a day. Mill capacity is scheduled for expansion to 1,000 tons a day in 1970.
ONTARIO					
Consolidated Canadian Faraday Limited, Werner Lake Division, Gordon Lake	1,200 (mills ore from Dumbarton)	177,726 (207,417)	0.82	0.39	Routine development. Mill capacity increased to treat ore from Dumbarton mine in Manitoba.
Falconbridge Nickel Mines, Limited, (Falconbridge, East, Hardy, Strathcona, Fecunis Lake, Onaping, North and Longvac mines), Falconbridge.	3,000 (Falconbridge) 1,500 (Hardy) 2,400 (Fecunis) 6,000 (Strathcona)	3,118,000 (3,208,000)	..	..	Operations closed by labour disputes for three months. Development of Lockerby mine continued. Reactivation of one blast furnace and one converter in the old smelter aisle started.
The International Nickel Company of Canada, Limited (Frood, Stobie, Creighton, Garson, Levack, Copper Cliff North, Crean Hill, Totten, Murray and MacLennan mines, Clarabelle and Crean Hill open pits), Copper Cliff.	30,000 (Copper Cliff) 12,000 (Creighton) 6,000 (Levack) 22,500 (Frood-Stobie)	14,578,700 (20,808,500)	..	..	Operations hampered by a strike from July 10 to November 17. Development of four new mines in the Sudbury area delayed. Announcement of construction of new mill and refinery at Copper Cliff.

TABLE 3 (Cont'd)

Company and Location	Mill Capacity (tons ore/day)	Ore Produced 1969 (1968) (short tons)	Grade % Ni	Grade % Cu	Developments
MANITOBA					
Dumbarton Mines Limited, Bird River.	700 (trucked to Consolidated Canadian Faraday mill)	66,395 (–)	0.77	0.26	Mine started production in September. Routine development.
The International Nickel Company of Canada, Limited (Thompson and Birchtree mines), Thompson.	12,000	4,225,000[e] (. .)	. .	. .	Expansion of the mill and smelter at Thompson was completed. Development of SOAB and Pipe mines continued.
Sherritt Gordon Mines, Limited, Lynn Lake	3,500	1,258,193 (1,276,517)	. .	. .	Continued underground exploration by drifting and diamond drilling. Ore reserves maintained.
BRITISH COLUMBIA					
Giant Mascot Mines Limited	1,300	337,056 (338,340)	0.83	0.40	Continued exploration and development. Ore reserves increased by discovery of 4,600 ore zone. Mill capacity will be increased.

Source: Company reports.
. . Not available; [e]Estimated.

TABLE 4

Prospective Producing Companies*, 1969

Company and Location	Type of Ore	Mill Capacity (tons ore/day)	Production to Start	Destination of Concentrates
ONTARIO				
Falconbridge Nickel Mines, Limited, Lockerby mine, Falconbridge	Ni,Cu	..	1975	Own smelter.
The International Nickel Company of Canada, Limited				
Little Stobie	Ni,Cu	6,000 (will be milled at Frood-Stobie)	1972	Own smelter.
Copper Cliff South	Ni,Cu	6,000 (will be milled at Clarabelle)	1972	Own smelter.
Coleman	Ni,Cu	4,000 (will be milled at Clarabelle)	1972	Own smelter.
Kirkwood	Ni,Cu	1,500 (will be milled at Clarabelle)	1972	Own smelter.
The International Nickel Company of Canada, Limited, Shebandowan mine, Shebandowan	Ni,Cu	2,900	1972	Copper Cliff.
MANITOBA				
Falconbridge Nickel Mines, Limited, Manibridge mine, Wabowden	Ni,Cu	1,500^e	1971	Not known.
The International Nickel Company of Canada, Limited, Thompson				
Soab mine	Ni	4,000	1972	Own smelter.
Pipe Lake mine	Ni	16,000 (both will be milled at Thompson)	1	
BRITISH COLUMBIA				
Hudson-Yukon Mining Co., Limited, Wellgreen mine, Kluane Lake	Ni,Cu	600	1972	Japan.

Source: Company reports.
*Only mines with announced production plans.
.. Not available; ^{e}Estimated.

BRAZIL

Nickel production in Brazil was obtained from two properties. Morro do Niquel S.A. at Pratopolis (Minais Gerais) and Companhia Niquel do Brazil S.A. at Liberdads, produced about 1,200 tons of nickel in ferronickel. Exploration of other nickel deposits was carried out during the year.

COLOMBIA

The Hanna Mining Company of the United States has been exploring lateritic nickel deposits at Cerro Matoso in the Montelibano district. The deposits are estimated to contain 80 million tons averaging 2 per cent nickel.

CUBA

The Nicaro and Moa Bay mines produce about 75 million pounds of nickel a year. The Cuban government plans to expand production if financing and technical assistance are available.

DOMINICAN REPUBLIC

Falconbridge Dominicana, C. por A., owned 65.7 per cent by Falconbridge Nickel Mines, Limited and 20 per cent by Armco Steel Corporation, completed financial arrangements necessary to put into production its mine and ferronickel plant in the Boano area. Total cost will be in excess of $180 million for the facility that will produce 63 million pounds of nickel in ferronickel by 1971.

FINLAND

Outokumpu Oy:n was developing the Hitura mine in western Finland for production in 1970. The mine will produce 800,000 tons of nickel-copper ore a year. Outokumpu continued operation of the Kotalahti mine where production was about 450,000 metric tons of nickel-copper ore in 1969.

GREECE

Société Minière et Metallurgique de Larynma-Larco SA produces ferronickel for sale in Europe. A second furnace will be in operation at the ferronickel plant in 1970.

GUATEMALA

Exploraciones y Explotaciones Mineras Izabal S.A. (Exmibal), owned 80 per cent by The International Nickel Company of Canada, Limited and 20 per cent by The Hanna Mining Company, continued mine and plant site development at its property near Lake Izabal. Full scale development awaits completion of arrangements with Guatemalan authorities. Plans for the $205 million project have been revised to increase the projected plant capacity to 30,000 tons of fire-refined nickel a year.

THE REPUBLIC OF INDONESIA

International Nickel continued exploration of lateritic nickel deposits in a 25,000 square-mile area on the island of Sulawesi. Results have been encouraging.

P.T. Pacific Nickel Indonesia formed by Koninblijke Nederlands Hoogovens (22 per cent), Wm. K. Muller N.V. (10 per cent), United States Steel Corporation (43 per cent), Newmont Mining Corporation (15 per cent) and Sherritt Gordon Mines, Limited (10 per cent) continued exploration of low-grade lateritic nickel ores in the Waigeo and Cyclops areas of West Irian.

The Sulawesi Nickel Development Cooperation Co. (Sunedico), a joint venture of Japanese nickel smelting companies, mined ore in the Pomala district. Shipments to Japan in 1969 totalled 250,000 tons of ore averaging 2.6 per cent nickel. Japanese companies have been granted a permit to explore for nickel in the Halmahera area. The agreement includes a clause stating that a smelter will be constructed within six years providing that ore reserves of 50 million tons are established in the area.

JAPAN

No nickel ores are mined in Japan. The smelters and refiners import lateritic ore from Indonesia and New Caledonia, sulphide ores from Australia and Canada, and nickel matte from Canada and New Caledonia. Two Japanese companies produced electrolytic nickel, five produced ferronickel and two nickel oxide sinter. Production of electrolytic nickel in 1969 was estimated at 11,080 tons.

NEW CALEDONIA

Société Le Nickel, the non-communist world's second largest nickel producer, operated mines and smelters in New Caledonia and an electrolytic refinery at Le Havre, France. Production of nickel in ferronickel and matte from New Caledonia was 80 million pounds in 1969. Two new furnaces were installed in 1969 and another was scheduled to start operation in 1970. Le Nickel also exported about 3.5 million tons of lateritic ore to Japan. Le Nickel has announced plans for continuous expansion that will increase production to 150,000 tons of nickel a year. Cofimpac Mining Consortium, a company formed by International Nickel (40 per cent) and a group of French industrial companies, continued exploration of deposits near the south end of the island. A feasibility study will be ready in mid-1970 on the establishment of a facility to produce 25,000 tons of nickel a year. American Metal Climax, Inc. is participating in a joint venture with Société Minière et Metallurgique de Penarroya of France to develop nickel deposits in New Caledonia. Production was scheduled to start in 1975.

REPUBLIC OF THE PHILIPPINES

Marinduque Mining & Industrial Corporation has announced the development of a nickel mine and refinery on Nonoc Island, Surigao. The refinery will use a process developed by Sherritt Gordon Mines, Limited and will have a capacity of 75 million pounds of nickel a year.

USSR

Production from Russia is estimated at 240,000 tons in 1969. The principal producing areas are Monchegorsk, Pechenga, Verkhnii and Norilsk.

VENEZUELA

The lateritic nickel deposit at Loma de Hierro in Aragua State that was originally investigated by International Nickel and latterly by Société le Nickel is presently held by Universal Nickel Corporation of the United States. A local company will be set up with Venezuelan share participation. Exploration and development planning is proposed.

TABLE 5

World – Production of Nickel
(short tons)

	1968	1969p
Canada	264,358	213,325
USSR	105,000	..
New Caledonia	88,018	94,000
Cuba	30,000	40,000
United States	15,154	16,800
Other non-communist countries	25,198	40,000
	527,728	530,000

Source: U.S. Bureau of Mines, Minerals Yearbook Preprint 1968; U.S. Bureau of Mines Commodity Data Summaries, January, 1970 For Canada – Dominion Bureau of Statistics. Total Communist countries for 1969, 124,000 short tons.
pPreliminary; .. Not available.

CONSUMPTION AND 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 was the largest single outlet for nickel followed closely by nickel plating and high-nickel alloys. Stainless steel use 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.

Non-communist world consumption in 1969 was estimated at 820 million pounds compared with 830 million in 1968. Consumption was again limited by supply. In the United States there was a release of 29 million pounds of nickel from the government stockpile. Twenty million pounds of this amount must be returned to the stockpile in 1971 and 1972 in upgraded form.

TABLE 6

Nickel Consumption by Use
(millions of pounds)

	1968	1969e
Stainless steels	307	320
High-nickel alloys	119	131
Nickel plating	124	115
Constructional alloy steels	91	90
Iron and steel castings	81	74
Copper and brass products	27	24
Other	81	66
Total	830	820

Source: The International Nickel Company of Canada, Limited.
eEstimated.

OUTLOOK

Market research, product diversification and a broader supply base will stimulate a continuing growth in nickel consumption. There is a probability of oversupply in the 1974-75 period, particularly if all of the proposed production facilities are activated. However, the possibility of surplus would put downward pressure on prices with a concurrent inhibiting effect on production development. The assurance of adequate supply could stimulate consumption and cause the annual increase to exceed the post-World War II average of 7 per cent a year. A decline in the rate of production increase coupled with an increase in consumption could bring about a balance in the supply-demand equation that might trigger a further round of production increases in the period beyond 1975.

Canada's share of total world production will be reduced by the advent of the development of the lateritic deposits, however it is not thought that the overall development of the Canadian industry will decrease.

PRICES

Prices of nickel in various forms remained stable until November 24 when International Nickel raised its base price in the United States by 25 cents a pound to $1.28. Prices in other markets were adjusted to reflect this increase.

PRICES, 1969

	Canada		United States	
	Jan. 1– Nov. 23	Nov. 24	Jan. 1– Nov. 23	Nov. 24
	(cents a pound)			
Inco, electrolytic, f.o.b. Port Colborne, Ont. and Thompson, Man.	111.25	138.00	103.0	128.0
Falconbridge, electrolytic, f.o.b. Thorold, Ont.	111.25	138.00	103.0	128.0
Sherritt Gordon, briquettes or powder, f.o.b. Niagara Falls, Ont. or Fort Saskatchewan, Alta.	115.0	138.00	107.0	132.0
Inco, nickel oxide sinter 75 (Ni-Co content) points in Ontario (freight allowed)	105.25	131.50		
Points outside of Ontario (less freight allowance of 1.25¢ a pound)	105.25	131.50		
Nickel oxide sinter 75 (Ni-Co content) point of entry			97.5	122.0
Nickel oxide sinter 90 (Ni-Co content), point of entry			98.0	123.0

TARIFFS

Item No.		British Preferential %	Most Favoured Nation %	General %
CANADA				
35500-1	Nickel and alloys consisting of 60% 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, consisting of 90% or more nickel when imported by manufactures 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% by weight of nickel and 12% by weight of chromium for use in Canadian manufactures	free	free	free
35800-1	Anodes of nickel	free	free	10
	Nickel, and alloys containing 60% 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

TARIFFS (Cont'd)

44643-1	Articles or iron, steel or nickel, or of which iron, steel or nickel is the component material 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	10	10	20
37506-1	Ferronickel	free	5	5

UNITED STATES

601.36	Nickel ore and matte	free
620.03	Nickel, unwrought	free
620.04	Nickel waste and scrap (duty suspended to on or before June 30, 1971) On and after Jan. 1 1969 " " " Jan. 1, 1970	 0.7¢ per lb 0.5¢ "
620.30	Nickel flakes On and after Jan. 1, 1969 " " " Jan. 1, 1970	 8¢ per lb 7¢ "
620.32	Nickel powders	free
620.50	Nickel, electro-plating anodes, wrought or cast, of nickel On and after Jan. 1, 1969 " " " Jan. 1, 1970	 8% 7%
419.72	Nickel oxide	free
607.25	Ferronickel	free

Note: – Further tariff reductions on the above United States nickel items will occur on Jan. 1, 1971 and Jan. 1, 1972.

– Various tariffs are in effect on more fabricated forms of nickel and nickel alloys and also on fully manufactured nickel products.

Petroleum

W.G. LUGG*

The Canadian petroleum industry in 1969 was highlighted by an expansion in exploratory drilling and record production levels. Revenue from the sale of oil and gas production exceeded $1,417 million and expenditures by the industry reached $1,409 million. A steadily increasing demand for products in Canada and a notable rise in United States requirements pushed production levels of petroleum and natural gas liquids to a new high of 1,310,000 barrels a day (b/d).

Although no new major reserves were discovered in 1969, exploration was maintained at a high level in the more southern areas and accelerated in the frontier regions as northern Canada continued to dominate the interest in exploration. Exploratory tests of industry-wide interest were drilled off the east coast of Nova Scotia, in Hudson Bay, the Northwest Territories and in Canada's Arctic Islands. Several more excellent prospects were scheduled to be drilled in the same areas in 1970 in the continuing search for major new reserves. The voyage of the tanker S.S. Manhattan through the Arctic seas to Alaska in 1969 demonstrated that it is physically possible for large tankers to operate in Arctic waters. The successful adaptation of this method of transport is likely to have a critical bearing on the development of potential reserves of oil in Canada's Arctic Islands.

In pipeline construction, Lakehead Pipe Line Company, Inc., the United States subsidiary of Interprovincial Pipe Line Company, completed the 30-inch extension from Chicago to Sarnia of its major transmission line. This line, known as the Chicago loop, now extends from Superior, Wisconsin to Sarnia. There were notable gains in refinery capacity this year but no new refineries were built. A small refinery at Brandon, Manitoba, was closed, as part of a company trend to larger, more centralized units on the Prairies.

Exports of crude oil and products to the United States increased to 595,000 barrels a day and exceeded 1968's daily average by 87,000 barrels. Value of exports of crude oil and products was approximately $579,179 million. Although exports reached record proportions, imports of crude oil and products averaged 731,000 barrels daily and exceeded exports by 136,000 barrels a day.

PRODUCTION

Total production of all liquid hydrocarbons–crude oil plus natural gas liquids–increased by almost 9 per cent in 1969 to 477 million barrels. Net production of crude oil averaged 1,119,000 b/d and field and gas-plant production of natural gas liquids reached 187,000 b/d comprised of 105,000 b/d of pentanes plus and condensate, and 82,000 b/d of propane and butane. Alberta's production, at 793,000 b/d, accounted for 71 per cent of the total Canadian crude oil output, 3 per cent greater than last year. Saskatchewan's production, on the other hand, declined for the third consecutive year to 235,000 b/d which is 12,000 b/d less than 1968 and represents only 21 per cent of the Canadian total. British Columbia's production increased by 9,000 b/d to 69,000 b/d and contributed over 6 per cent to the national total. Manitoba's production remained static at about 17,000 b/d in 1969 and did not significantly alter the combined Canadian output. Ontario, the Northwest Territories and New Brunswick together produced 5,402 b/d, representing 0.5 per cent of national production, the same as last year.

*Mineral Resources Branch.

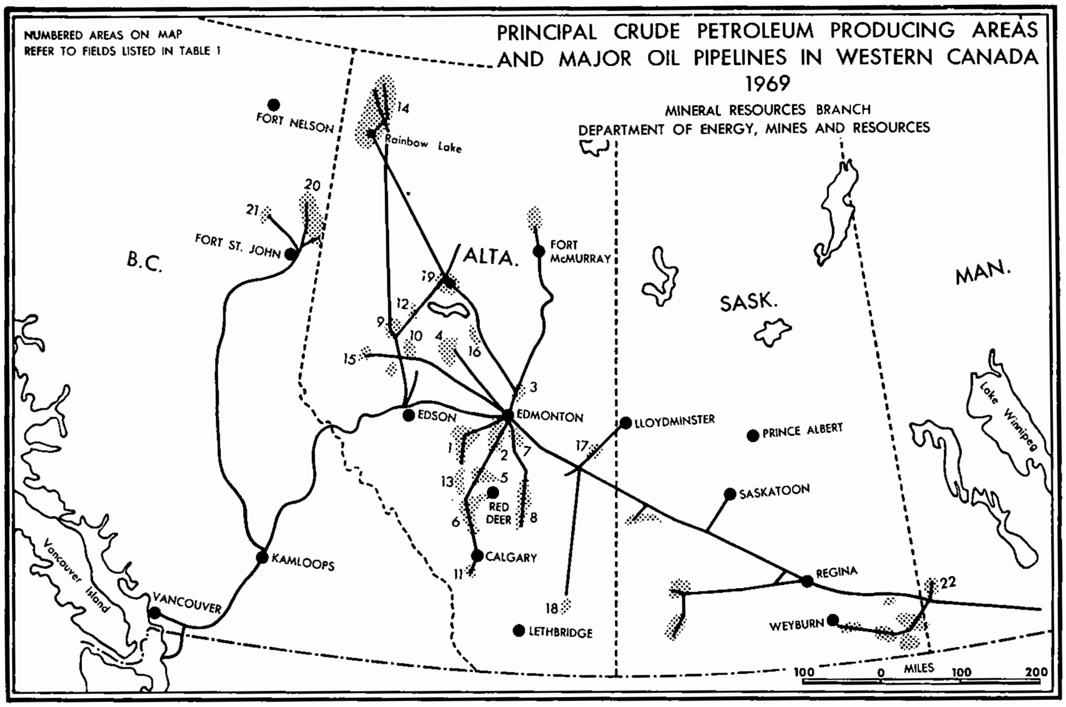


TABLE 1

Production of Crude Oil and Condensate by Province and Field, 1968-69
(number in parentheses gives location of field on the accompanying map)

	1968		1969P	
	Barrels	**Bbl/day**	**Barrels**	**Bbl/day**
Alberta				
Pembina (1)	39,600,957	108,199	43,420,432	118,960
Swan Hills (4)	25,366,620	69,307	26,383,489	72,284
Redwater (3)	15,915,801	43,486	18,850,328	51,645
Rainbow (14)	13,258,160	36,224	17,176,446	47,059
Golden Spike (2)	15,867,588	43,354	14,818,597	40,599
Judy Creek (4)	14,246,333	38,924	13,103,000	35,899
Bonnie Glenn (2)	9,792,005	26,754	11,297,414	30,952
Swan Hills South (4)	10,053,274	27,468	10,436,881	28,594
Mitsue (16)	5,820,410	15,903	9,955,408	27,275
Nipisi (19)	4,762,699	13,013	7,110,930	19,482
Zama (14)	6,110,547	16,695	6,798,233	18,625
Wizard Lake (2)	5,486,543	14,991	6,764,094	18,532
Fenn-Big Valley (8)	5,934,414	16,214	6,387,443	17,500
Virgo (14)	1,141,161	3,118	5,563,792	15,243
Virginia Hills (4)	4,231,064	11,560	4,716,629	12,922
Willesden Green (13)	3,863,933	10,557	3,821,970	10,471
Sturgeon Lake South	3,544,225	9,683	3,698,128	10,132

TABLE 1 (Cont'd)

	1968		1969P	
	Barrels	Bbl/day	Barrels	Bbl/day
Carson Creek North (4)	2,769,446	7,567	3,515,226	9,631
Kaybob (10)	3,496,426	9,553	3,412,578	9,350
Westerose (2)	2,325,437	6,354	2,905,746	7,961
Acheson (2)	2,481,296	6,780	2,752,411	7,541
Rainbow South (14)	2,025,988	5,536	2,595,959	7,112
Bantry (18)	2,017,268	5,512	2,311,517	6,333
Wainwright (17)	2,100,171	5,738	2,273,360	6,228
Snipe Lake (12)	2,266,466	6,193	2,084,995	5,712
Joarcam (7)	2,550,306	6,968	2,061,909	5,649
Harmattan-East (6)	1,654,976	4,522	1,754,277	4,806
Medicine River (13)	2,130,726	5,822	1,752,031	4,800
Joffre (5)	1,718,077	4,694	1,660,536	4,550
Innisfail (6)	1,682,950	4,598	1,584,094	4,340
Harmattan-Elkton (6)	1,482,069	4,049	1,453,028	3,981
Clive	1,504,044	4,110	1,426,068	3,907
Kaybob South (10)	1,614,441	4,411	1,379,733	3,780
Gilby (5)	1,424,550	3,892	1,334,915	3,657
Simonette (15)	1,077,957	2,945	1,269,872	3,479
Red Earth	1,095,134	2,992	1,269,776	3,479
Taber South	965,437	2,638	1,163,535	3,187
Cessford	936,273	2,558	1,115,447	3,056
Other fields and pools	30,634,985	83,702	36,520,840	100,057
Total	257,186,578	702,695	289,985,049	794,480
Total valuc	$660,485,368		$745,895,152	
Saskatchewan				
Total*	91,889,243	251,063	87,342,758	239,295
Total value	$206,942,845		$196,703,751	
British Columbia				
Boundary Lake (20)	7,807,936	21,333	8,915,367	24,426
Peejay (20)	5,458,180	14,913	5,838,825	15,997
Milligan Creek (20)	3,469,743	9,480	3,601,026	9,866
Inga (21)	1,647,144	4,500	2,714,618	7,437
Other fields and pools	3,822,513	10,444	4,239,200	11,614
Total	22,205,516	60,670	25,309,036	69,340
Total value	$50,205,117		$57,221,959	
Manitoba				
North Virden-Scallion (22)	2,866,695	7,832	2,972,664	8,144
Virden-Roselea (22)	1,493,086	4,080	1,540,576	4,221
Other fields and pools	1,845,139	5,041	1,691,411	4,634
Total	6,204,920	16,953	6,204,651	16,999
Total value	$15,569,882		$15,548,929	
Ontario	1,150,779	3,144	1,161,611	3,182
Total value	$3,166,826		$3,196,625	
Northwest Territories	751,592†	2,054	801,341(b)	2,195
Total value	$906,871		$966,898	

TABLE 1 (Cont'd)

	1968		1969p	
	Barrels	Bbl/day	Barrels	Bbl/day
New Brunswick	7,648	21	9,176	25
Total value	$10,707		$12,845	
Total, Canada	379,396,276	1,036,600	410,813,622	1,125,516
Total value	$937,287,616		$1,019,546,159	

Sources: Dominion Bureau of Statistics and provincial government reports.
* Saskatchewan lists production, by formation rather than by fields.
† Net figure after allowing for reinjected products.
p Preliminary.

TABLE 2

Production of Natural Gas Liquids by Province, 1968-69

	1968r		1969p	
	Barrels	Bbl/day	Barrels	Bbl/day
Alberta				
Propane	14,633,683	39,983	16,758,676	45,914
Butane	9,564,976	26,134	10,994,591	30,122
Pentanes plus	31,050,939	84,839	36,412,082	99,759
Condensate	810,862	2,215	722,816	1,980
Total	56,060,460	153,171	64,888,165	177,775
Saskatchewan				
Propane	942,834	2,576	855,041	2,342
Butane	406,489	1,111	347,757	953
Pentanes plus	324,482	886	330,947	907
Total	1,673,805	4,573	1,533,745	4,202
British Columbia				
Propane	400,800	1,095	327,501	897
Butane	527,546	1,441	417,540	1,144
Pentanes plus	960,252	2,624	944,111	2,587
Condensate	54,163	148	78,147	214
Total	1,942,761	5,308	1,767,299	4,842
Canada				
Propane	15,977,317	43,654	17,941,218	49,154
Butane	10,499,003	28,686	11,759,888	32,219
Pentanes plus	32,335,673	88,349	37,687,140	103,252
Condensate	865,025	2,363	800,963	2,194
Total	59,677,018	163,052	68,189,209	186,819
Returned to formation	198,903	543	717,699	1,966
Total net production	59,478,115	162,509	67,471,510	184,853

Source: Provincial government reports.
p Preliminary; r Revised.

TABLE 3

Value of Natural Gas Liquids by Province, 1968-69
($ thousands)

	1968	1969p
Alberta	119,612	129,845
Saskatchewan	2,802	2,557
British Columbia	3,643	3,164
Total, Canada	126,057	135,566
Volume (thousand bbl)	58,613	66,107

Source: Dominion Bureau of Statistics.
pPreliminary.

year began to operate on a full scale basis. Production of synthetic crude oil from the Great Canadian Oil Sands Limited's Athabasca tar sands project in 1969 exceeded 27,000 b/d, the highest since the plant began operating but still far short of the maximum rated output of 45,000 b/d.

In 1969 the Alberta government granted Syncrude Canada Ltd. permission to proceed with construction of its proposed Athabasca tar sand extraction plant near Fort McMurray which has been estimated to cost $190 million. Syncrude is owned jointly by Atlantic Richfield Company, Cities Service Athabasca, Inc., Imperial Oil Limited and Gulf Oil Canada Limited. Syncrude's application called for a daily production of 50,000 barrels of synthetic crude oil, 25,000 barrels of specialty oils and 5,000 barrels of naphtha. In its application, Syncrude agreed to delay start-up time until 1976 from an initial target of 1972-73 in order to gain time in assessing the potential impact that future Prudhoe Bay production would have on prospective markets in the United States.

TABLE 4

Crude Oil – Production, Trade and Refinery Receipts, 1959-69
(barrels)

	Production[1]	Imports[2]	Exports[2]	Refinery Receipts[3]		
				Domestic	Imported	Total
1959	184,778,497	115,288,643	33,362,234	151,507,774	116,342,270	267,850,044
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
1969p	410,813,622	193,124,846	197,340,741	241,977,692	190,473,147	432,450,839

Source: Dominion Bureau of Statistics.
[1]Alberta field condensate is excluded from the statistics for 1960, 1961 and 1962. [2]Trade of Canada (DBS) date. [3]Refinery receipts include condensate and pentanes plus.
pPreliminary.

The Alberta Oil and Gas Conservation Board listed provincial daily developed wellhead capacity at 1.6 million barrels which meant that only about 44 per cent of the province's productive capability was being utilized at the end of 1969. The Pembina field continued to be the province's largest producer and increased production by more than 10,000 b/d to 19,000 b/d. Other notable increases in production occurred in the Rainbow, Zama and Virgo fields of northwestern Alberta as pipeline facilities were extended and secondary recovery projects implemented. Output from the Mitsue and Nipisi fields of north-central Alberta also increased sharply this year as major waterflood projects installed in the previous

RESERVES

According to the estimates of the Canadian Petroleum Association, Canada's recoverable reserves of liquid hydrocarbons, which include conventional crude oil and natural gas liquids, amounted to 10,516 million barrels at the end of 1969. This is comprised

TABLE 5

Reserves of Crude Oil, 1968-69

Province or Region	At end of 1969 (000 barrels)	% of Total		Net Change Since 1968 (000 barrels)
		1968	1969	
Alberta	7,543,195	86.5	87.5	+290,176
Saskatchewan	688,209	8.6	8.0	– 32,294
British Columbia	272,289	3.4	3.2	– 14,957
Northwest Territories	46,105	0.6	0.5	– 854
Manitoba	64,422	0.8	0.7	– 3,291
Eastern Canada	5,585	0.1	0.1	– 588
Total	8,619,805	100.0	100.0	+238,192

Source: Canadian Petroleum Association.

TABLE 6

Reserves of Liquid Hydrocarbons at End of 1969

	Natural Gas Liquids (000 barrels)	Crude Oil Plus Natural Gas Liquids (000 barrels)	Per Cent of Total
Alberta	1,850,125	9,393,320	89.3
Saskatchewan	8,588	696,797	6.6
British Columbia	37,256	309,545	3.0
Other areas	–	116,112	1.1
Total	1,895,969	10,515,774	100.0

Source: Canadian Petroleum Association.
– Nil.

of 8,620 million barrels of crude oil and 1,896 million barrels of natural gas liquids. Of the total increase of 498 million barrels over the 1968 total, 93 million barrels were attributed to new discoveries, 757 million barrels to revisions and another 108 million barrels to extensions of existing fields. At the 1969 level of production of 477 million barrels, the life index for crude oil and natural gas liquids dropped for the third consecutive year to 22 years. Alberta accounted for all of Canada's reserve growth in 1969 with a net gain of 498 million barrels. The reserve position of all other provinces declined, the most notable reduction occurring in Saskatchewan where total reserves dropped by 32 million barrels.

The Canadian Petroleum Association estimated Alberta's remaining recoverable reserves of crude oil at 7.5 billion barrels and natural gas liquids at 1.9 billion barrels. Most of the province's increase was attributed to reserve appreciation in previously discovered fields by the implementation of secondary recovery schemes. The most notable revisions in recoverable reserves were registered in the Nipisi and Mitsue Gilwood sandstone fields.

Estimates of proved non-conventional reserves were again reported as a separate category by the Canadian Petroleum Association 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 deposit currently under development. Ultimate recoverable reserves for the 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

Although exploratory drilling was maintained at a high level in Alberta during 1969, there were no significant oil discoveries made in the province. There has not been a major oil find in Alberta since the Rainbow Lake field was discovered in 1965, nevertheless oil field development remained at about the same level in most areas of the province in 1969 as in the previous year.

TABLE 7

Wells Completed and Footage Drilled

	1955		1960		1968		1969	
	No.	Footage	No.	Footage	No.	Footage	No.	Footage
WESTERN CANADA								
Westcoast – Offshore								
New field wildcats	–	–	–	–	8	80,822	4	36,923
Hudson Bay – Offshore								
New field wildcats	–	–	–	–	–	–	2	5,143
British Columbia								
New field wildcats	34	194,014	60	365,818	55	385,606	41	244,009
Other exploratory	2	13,020	11	55,749	51	271,063	34	182,448
Development	–	–	72	331,740	80	394,199	31	421,426
	36	207,034	143	753,307	186	1,050,868	166	847,883
Alberta								
New field wildcats	307	1,773,980	338	2,078,876	485	2,593,825	421	2,202,319
Other exploratory	105	436,941	223	1,171,079	534	2,446,081	581	2,656,533
Development	1,208	6,219,810	1,131	7,125,856	829	3,747,208	841	3,737,169
	1,620	8,430,731	1,692	10,375,811	1,848	8,787,114	1,843	8,596,021
Saskatchewan								
New field wildcats	312	1,182,727	113	468,507	228	1,009,291	231	772,464
Other exploratory	50	179,511	28	99,203	241	747,363	393	1,151,190
Development	550	1,873,040	461	1,795,968	454	1,536,119	538	1,728,425
	912	3,235,278	602	2,363,678	923	3,292,773	1,162	3,652,079
Manitoba								
New field wildcats	59	174,313	10	30,505	13	33,748	15	39,627
Other exploratory	10	23,743	3	6,370	16	29,568	41	43,002
Development	292	647,379	54	110,073	37	100,003	26	63,318
	361	845,435	67	146,948	66	163,319	82	145,947
Territories								
New field wildcats	9	12,266	32	105,969	33	118,774	56	274,401
Other exploratory	–	–	–	–	1	736	–	–
Development	–	–	–	–	2	3,676	–	–
	9	12,266	32	105,969	36	123,186	56	274,401

TABLE 7 (Cont'd.)

	1955		1960		1968		1969	
	No.	Footage	No.	Footage	No.	Footage	No.	Footage
Total, Western Canada								
New field wildcats	718	3,337,300	553	3,049,675	822	4,222,066	770	3,574,886
Other exploratory	167	653,215	265	1,332,401	843	3,494,811	1,049	4,033,173
Development	2,050	8,740,229	1,718	9,363,637	1,402	5,781,205	1,496	5,950,338
	2,935	12,730,744	2,536	13,745,713	3,067	13,498,082	3,315	13,558,397
EASTERN CANADA								
Eastcoast – Offshore								
New field wildcats	–	–	–	–	–	–	1	13,085
Ontario								
New field wildcats	64	112,246	39	68,393	45	82,021	128	275,074
Other exploratory	57	92,536	55	109,839	52	81,593	26	42,495
Development	266	271,191	213	228,190	79	130,642	64	86,437
	387	475,973	307	406,422	176	294,256	218	404,006
Quebec								
New field wildcats	9	10,226	5	4,287	1	5,990	3	21,023
Other exploratory	–	–	–	–	–	–	–	–
Development	–	–	1	240	–	–	–	–
	9	10,226	6	4,527	1	5,990	3	21,023
New Brunswick								
New field wildcats	1	3,414	2	13,023	–	–	–	–
Other exploratory	–	–	–	–	10	15,876	–	–
Development	7	21,143	–	–	–	–	–	–
	8	24,557	2	13,023	10	15,876	–	–
Nova Scotia								
New field wildcats	–	–	1	9,840	1	4,408	–	–
Other exploratory	–	–	–	–	–	–	–	–
Development	–	–	–	–	–	–	–	–
	–	–	1	9,840	1	4,408	–	–

TABLE 7 (Cont'd)

	1955		1960		1968		1969	
	No.	Footage	No.	Footage	No.	Footage	No.	Footage
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	47	92,419	132	309,182
Other exploratory	57	92,536	55	109,839	62	97,469	26	42,495
Development	273	292,334	214	228,430	79	130,642	64	86,437
	405	512,137	316	433,812	188	320,530	222	438,114
Total, Canada								
New field wildcats	793	3,464,567	600	3,145,218	869	4,314,485	902	3,884,068
Other exploratory	224	745,751	320	1,442,240	905	3,592,280	1,075	4,075,668
Development	2,323	9,032,563	1,932	9,592,067	1,481	5,911,847	1,560	6,036,775
	3,340	13,242,881	2,852	14,179,525	3,255	13,818,612	3,537	13,996,511

Source: Canadian Petroleum Association.
– Nil.

The Rainbow-Zama Lake area of northwestern Alberta continued to retain the industry's interest but little success was experienced in extending the established trends in this area during 1969. However, a significant find appeared to be developing at Bistcho Lake 20 miles to the northeast of Zama Lake and by year-end two Middle Devonian Keg River oil discoveries had been reported. Several follow-up wells have been scheduled for the following winter and when these are completed some indication of the extent of this discovery will become apparent. In north-central Alberta, the Senex Creek, Keg River field appeared to have reached maximum development. Several exploratory and step-out tests drilled in an attempt to extend this field have proven to be unsuccessful.

In the Strachan-Ricinus trend of western Alberta, further exploratory drilling this year resulted in the discovery of several more thick, "wet" gas-bearing, Devonian, D3 pinnacle reefs. Although the primary objective in this area has always been Devonian reefs, several of the exploratory wells that have been drilled have encountered commercial thicknesses of oil-bearing Cardium sandstone at a shallower depth. As a result, exploratory drilling during the past year has established the existence of major reserves of condensate-bearing gas in the Devonian reefs and potentially large scale reserves of oil and gas in the Cardium sandstone but little can be said at this time because much of the information about the wells drilled in this area is still confidential and will not be available until 1970. In southern Alberta exploratory drilling continued to be maintained at a brisk pace and several Lower Cretaceous oil fields were discovered. As in previous years preliminary information indicates that they are limited in respect to reserves.

Most of the oil field development occurred in the Zama and Rainbow Lake fields the same as in the previous two years. By year-end almost all of the established pools in these fields had been completely developed and development drilling began to slacken off. The Red Earth producing region continued to be actively developed despite the unpredictable nature of the subsurface geology and the limits of both the Red Earth and Loon Lake fields were expanded. In central Alberta the Mitsue field was enlarged by the drilling of several successful development wells around the periphery of the established field boundaries. The Ferrier Cardium pool experienced a major expansion by the drilling of several step-out and infill development wells.

Enhanced recovery projects, primarily waterfloods, continued to contribute significantly to the provincial reserve total. In 1969 new projects and the expansion of existing ones are expected to bring additions of about 300 million barrels to secondary recovery reserves beyond what would have been obtained by primary recovery. Performance of enhanced recovery schemes, especially waterfloods, has been excellent, and the cost of installation is relatively low particularly when considered in relation to the increase in recoverable oil. One of the largest single waterflood schemes in Alberta began operating in the Provost field of east-central Alberta late in 1969. Design capacity of this water injection plant is about 15,000 barrels of water a day. Three new waterflood projects were introduced into the Pembina field where an already imposing list is currently operating. Some of the larger additions to existing enhanced recovery schemes include those that began operating in the Goose River, Beaverhill Lake A pool, the Mitsue, Gilwood A pool and the Willesden Green, Cardium A pool. The first sequential production, enhanced recovery scheme was initiated by Banff Oil Ltd. in the Rainbow pinnacle reef pools. This plan calls for a miscible solvent (light hydrocarbons) injection project to be used successively in a series of seven Rainbow pinnacle reef pools in which total ultimate reserves will be increased to 100 million barrels.

SASKATCHEWAN

Saskatchewan experienced an upsurge in both exploratory and development drilling during 1969, but the results in terms of additions to reserves was disappointing. Exploratory drilling at 1,923,000 feet increased by 10 per cent and development footage at 1,728,000 feet was up 12 per cent. The exploratory venture undertaken by Pheasant Exploration Ltd. to assess the unexplored subsurface areas of the Middle Devonian Winnipegosis formation, which trends northwest from the established producing region in the southeastern portion of the province, was abandoned after 48 dry holes had been drilled. Other deep hole drilling projects have also proven to be unsuccessful.

In western Saskatchewan, the area which is adjacent to the Plato Viking oil pool continued to receive much industry attention in 1969, as several wildcat wells were drilled in an attempt to extend this producing trend. Exploratory work is now being concentrated in a 12-township block centred by the Plato field and by year-end there had been over 12 Viking oil discoveries drilled outside the established field boundaries. Another bright spot in Saskatchewan's exploration picture has been the Cretaceous heavy oil belt which is located on the province's western boundary in the Lloydminster area. Several successful wildcats and step-outs in the Waseca and Golden Lake fields have added to already substantial provincial reserves of heavy gravity crude oil.

The Plato field is being developed rapidly and by year-end over 50 successful wells had been drilled within the designated field boundaries. Several more were scheduled for early in 1970. Both the Aberfeldy and the Northminster fields were expanded appreciably in 1969 as the demand for heavy crude oil increased. Oil development in the Mississippian fields of the southeastern corner of the province continued to lag as most of the existing fields in the area have

TABLE 8

Canada, Wells Drilled, by Province, 1968-69

	Oil		Gas		Dry[1]		Total	
	1968	1969	1968	1969	1968	1969	1968	1969
Western Canada								
Alberta	556	464	395	437	897	942	1,848	1,843
Saskatchewan	387	528	47	42	489	592	923	1,162
British Columbia	46	42	34	43	106	81	186	166
Manitoba	28	15	–	–	38	67	66	82
Yukon and N.W.T.	2	–	2	2	32	54	36	56
Hudson Bay – Offshore	–	–	–	–	–	2	–	2
Westcoast – Offshore	–	–	–	–	8	4	8	4
Sub-total	1,019	1,049	478	524	1,570	1,742	3,067	3,315
Eastern Canada								
Ontario	9	5	61	49	106	164	176	218
Quebec	–	–	–	–	1	3	1	3
Atlantic Provinces	–	–	–	–	11	–	11	–
Eastcoast – Offshore	–	–	–	–	–	1	–	1
Sub-total	9	5	61	49	118	168	188	222
Canada	1,028	1,054	539	573	1,688	1,910	3,255	3,537

Source: Canadian Petroleum Association.
[1] Includes suspended wells.
– Nil.

been fully developed and no new fields of any significance have been discovered in recent years. In southwestern Saskatchewan development drilling in the Battrum-Rapdan producing trend of Jurassic age, steadily continued with several fields in this area having their designated boundaries expanded in 1969. Amongst the most noteworthy were the Battrum and Cantuar fields with minor development occurring around the fringes of the Gull Lake and Instow fields.

In the Lloydminster region, the Aberfeldy, Epping and Lashburn waterflood units were all enlarged and in addition the South Aberfeldy Unit was placed under flood this year. In southeastern Saskatchewan, a waterflood scheme was initiated in the Devonian Hummingbird field which is expected to boost ultimate recovery to 25 per cent or 6.2 million barrels.

BRITISH COLUMBIA

Total footage drilled decreased by 19 per cent to 848,000 feet as a slight increase in development drilling was more than offset by sharply reduced exploratory drilling. The lack of significant oil finds in recent years in the province has begun to have a detrimental effect on exploration effort. In the offshore areas, Shell Canada Limited completed its drilling program off the west coast after drilling 14 wells. The program extended from off Pachena Point, Vancouver Island in the south to northern Hecate Strait off Queen Charlotte Island. Although traces of oil and gas were encountered, commercial quantities were not indicated. A test well drilled in the Bowser Basin of the northwestern interior of British Columbia was suspended after encountering gas shows. Further production testing is contemplated for this well in 1970.

Most of the provincial oil development drilling was again confined to the Inga and Boundary Lake fields. This year several wells were drilled along the northeast flank of the Boundary Lake field and as a result the field boundaries were extended in this direction. Additional development drilling was done in the Beatton River West, Cretaceous field and this field's boundaries were also expanded. Waterflood projects increased to nine with the beginning of water injection into the Inga field in February. By the injection of 13,180 barrels of water per day, ultimate recovery is expected to be raised in this field to 56.5 per cent of oil in place or 29.6 million barrels.

MANITOBA

Total footage drilled declined 9 per cent in Manitoba during 1969 to 146,000 feet. There have been no new discoveries made in Manitoba in several years and although there was a notable increase in the number of exploratory wells drilled this year, all of them were unsuccessful. Almost all of the exploratory drilling was confined to formations of Mississippian age. Development drilling declined 37 per cent, reflecting not only the lack of new discoveries but also pointing up the fact that the established fields have been essentially fully developed. Almost all of the development drilling was confined to the peripheries of the Virden, Scallion and Cromer fields as was the case in the last several years.

YUKON TERRITORY, NORTHWEST TERRITORIES AND ARCTIC ISLANDS

Exploration activity continued to increase in Canada's Arctic in 1969 and drilling results tended to confirm the oil industry's belief that this region may eventually become Canada's largest producing area. Panarctic Oils Ltd., the industry-government company which is exploring for oil in Canada's Arctic Islands, has committed a minimum of $30 million towards the drilling of 19 exploration wells. By the end of 1969 three wells had been drilled on Melville Island and one of these is a major gas discovery. The other two tests were both abandoned without significant showings. The successful well at Drake Point tested two separate Triassic sandstone reservoirs with gas flows of 10 million and 13 million cubic feet per day. There is some condensate associated with the gas. Panarctic plans to drill at least one more well on Melville Island and by the end of the year a third rig had been brought in to drill on Ellef Ringnes Island to test a very large domal structure.

Exploration activity was also accelerated in the Mackenzie Delta region of northern Canada and early in 1970 exploratory drilling was rewarded by a discovery made by the well I.O.E. Atkinson H-25, in the Northwest Territories, 50 miles northeast of Tuktoyaktuk. Medium gravity sweet crude oil flowed to surface when a drill stem test was run in Cretaceous sandstones at a depth of 5,700 feet. Preliminary indications are that the discovery is a substantial one but it is too early to evaluate the find in terms of reserves and producibility. Considering the limited amount of drilling that has been done in the Mackenzie River Delta it is apparent that the discovery has major implications for future prospects. At the end of 1969 there were three other wildcat wells being drilled in the same general area with several more scheduled for the coming year.

Research into methods of transportation of oil from the Arctic is being given priority attention and in this connection, Mackenzie Valley Pipe Line Research Limited was formed by a consortium of several oil and pipeline companies to investigate some of the problems that may be encountered in pipeline construction in Arctic regions. At the present time the company is conducting a study on the feasibility of constructing a 48-inch diameter crude oil pipeline from the North Slope of Alaska through the Yukon and Northwest Territories to Edmonton. Actual pipeline tests are being carried out near Inuvik, Northwest Territories on a 2,000 foot section of 48-inch pipeline that has been laid in an area of continuous permafrost.

In September of this year, Humble Oil and Refining Company of the United States sent a specially equipped tanker from the United States east coast through the 'Northwest Passage' to Alaska, in order to assess the feasibility of tanker transportation for crude oil production from the North Slope of Alaska. The 150,000-ton tanker, S.S. Manhattan was equipped with an icebreaking bow and followed a route up the eastern seacoast and through Lancaster Sound, Barrow Strait, Viscount Melville Sound and Prince of Wales Strait. The ship was escorted by the Canadian icebreaker, Sir John A. MacDonald throughout the voyage and returned to New York in November. The voyage proved to be an operational success and analyses of data collected during the voyage and additional tests will be necessary before it can be determined if it is possible to transport oil economically from Alaska by this method. Further tests were, in fact, scheduled for the Manhattan in Arctic waters during the spring of 1970 when ice conditions are expected to be more severe.

EASTERN CANADA

In Ontario, a sharp decrease in development drilling was more than offset by a large rise in exploratory drilling with the net results that over-all drilling footage increased by 37 per cent in 1969. The increase in exploratory drilling was due primarily to an increase in drilling operations in Lake Erie combined with an increased emphasis on Silurian reef exploration in Lambton County. A well drilled near the Kimball-Colinville field encountered oil in a Silurian reef and was the most significant discovery made in eastern Canada during 1969.

In Quebec, three exploratory tests were drilled. None were successful but one of these in the St. Lawrence Lowlands encountered non-commercial amounts of gas. There was no exploratory drilling carried out in the Atlantic provinces during 1969.

In the offshore areas, Shell Canada Limited began a 2-year drilling program off the coast of Nova Scotia and by year-end had drilled one well south of the southern tip of Sable Island and had started drilling a second well farther south. The first well, Shell Onodaga E-84 was abandoned at a depth of 13,085 feet after encountering several minor indications of oil and gas. A second semi-submersible rig was completed in the Halifax shipyards early in 1970 and is scheduled to join the first during the coming year in Shell's drilling program on the Scotian Shelf. Another semi-submersible drilling rig is being built in Halifax for Imperial Oil Limited and is expected to begin drilling on the Grand Banks of Newfoundland in 1970.

The first offshore well in Hudson Bay was drilled in 1969, about 250 miles east of Churchill, Manitoba using a specially reinforced drilling vessel. Because of

TABLE 9

Oil Wells in Western Canada at End of Year 1968-69

	Producing Wells		Wells Capable of Production	
	1968	1969	1968	1969
Alberta	9,114	9,381	13,733	13,897
Saskatchewan	5,788	6,200	6,804	7,095
Manitoba	774	745	926	923
British Columbia	479	515	590	614
Northwest Territories	33	33	66	66
Total	16,188	16,874	22,119	22,595

Source: Provincial and federal government reports.

ice conditions that were building up in Hudson Strait, the drilling vessel had to leave before the projected depth of 6,000 feet was reached. However, although the well reached only a depth of 3,926 feet, it encountered minor indications of oil and gas in separate horizons. A second well, onshore, was drilled in the Hudson Bay Lowlands, near the Manitoba-Ontario border, by a group of oil companies headed by Aquitaine Company of Canada Ltd. This was the first well drilled in a scheduled series of onshore stratigraphic tests which are designed to evaluate the potential of the Hudson Bay Basin. The first well was abandoned at a depth of 3,393 feet and by the end of 1969 the second well in the program was started.

TRANSPORTATION

Oil and product pipeline construction in Canada lagged slightly in 1969 as only 376 miles of new pipeline began operating. Major pipeline construction accounted for most of the new construction. Among the most prominent of these was the addition of 170 miles of 34-inch loop by Interprovincial Pipe Line Company to its main line on the Prairies. Lakehead Pipe Line Company, Inc., Interprovincial's United States subsidiary, completed a 290-mile, 30-inch line from Griffith, Indiana to Sarnia, Ontario. With the completion of these projects, Interprovincial now has three lines in operation between Edmonton and Superior, Wisconsin and two lines in operation between Superior and Sarnia–one via the Straits of Mackinac and one via Chicago. On completion of the 1969 looping and extension program, the combined Canadian system of Interprovincial and United States system of its subsidiary, Lakehead, consisted of more than 5,000 miles of pipeline with main line pumping power of 500,000 horsepower.

In anticipation of deliveries of crude oil to Chicago to begin January, 1970 via the Chicago loop, Interprovincial posted two new tariff schedules. Tariff's from Alberta to the Chicago terminal at Mokema, Illinois varied from 43 cents to 47 cents a barrel depending on the viscosity of the oil. The new rates from Alberta to Stockbridge, Michigan varied between 46 cents to 50 cents per barrel.

Peace River Oil Pipe Line Co. Ltd., which connects with Interprovincial at Edmonton, completed 78 miles of 20-inch pipeline between the Fox Creek pumping station and Edmonton, thereby twinning the line. The new line is of 20-inch pipe and the former is 12-inch. In August, 1969 the 20-inch pipeline began to carry crude oil and the 12-inch pipeline has been converted to handle condensate and liquid petroleum gases from major gas plants in the area. Husky Oil (Alberta) Ltd. completed the third loop of the pipeline system from the Lloydminster fields to the Hardisty pumping station on Interprovincial's main line early in June. This system carries condensate northward for blending with the heavy Lloydminster crude and the resulting mixture is then transported south to Hardisty. The third line was required for flexibility in handling crude oil, condensate for blending and crude-condensate blend in three separate lines, rather than batching two streams in one line as was done before.

A major products pipeline was completed this year for Dome Petroleum Limited when a 186-mile, 8-inch line was constructed from Cochrane, west of Calgary, to Edmonton. The line will carry liquid petroleum gas products from the Alberta Natural Gas Company's extraction plant at Cochrane to Interprovincial's terminal in east Edmonton. From there it will be carried eastward in a mixed stream in batches.

Late in 1969, Rainbow Pipe Line Company Ltd. acquired Mitsue Pipeline Ltd.'s 180-mile system which connects the Mitsue and Nipisi fields to Interprovincial Pipe Line Company's Redwater terminal. As a result of efficiencies attributable to the acquisition, the tariff from these fields to Redwater were reduced from 17 cents to 15 cents a barrel.

TABLE 10

Mileage in Canada of Pipelines for Crude Oil, Natural Gas Liquids and Products

Year-end	Miles	Year-end	Miles
1955	5,079	1962	10,037
1956	6,051	1963	10,607
1957	6,873	1964	11,744
1958	7,148	1965	12,315
1959	7,945	1966	12,995
1960	8,435	1967	14,155
1961	9,554	1968	14,832
		1969p	15,208

Source: Dominion Bureau of Statistics.
p Preliminary.

TABLE 11

Deliveries of Crude Oil and Propane
by Company and Destination, 1968-69
(millions of barrels)

Company and Destination	1968	1969
Interprovincial Pipe Line		
Western Canada	39.1	40.7
United States	99.3	114.3
Ontario	123.9	128.2
Total	262.3	283.2
Trans Mountain Oil Pipe Line		
British Columbia	33.7	30.6
State of Washington	62.6	78.7
Westridge Terminal	2.2	3.3
Total	98.5	112.6

Source: Company annual reports.

In Saskatchewan, Producers Pipelines Ltd. completed a 56-mile pipeline from the Plato oil producing area to the Mid-Saskatchewan Pipe Lines Ltd. terminal at Coleville. The posted tariff on the newly completed line was set at 46 cents a barrel.

PETROLEUM REFINING

Crude oil refining capacity of all plants in Canada at the end of 1969 totalled 1,297,850 b/d–an increase of 75,700 b/d over 1968. This represents a gain of about 6 per cent in the industry's ability to refine crude oil which is 2 per cent more than the demand increase for petroleum products during the year. No new refineries were built in 1969 although modifications to several existing plants resulted in increased capacities. Major refinery projects are scheduled for completion in the early 1970's with the bulk of the proposed construction to take place in the Maritimes and Quebec. The yield patterns of the proposed increased capacity will likely be designed so as to serve the growing domestic demand for light and heavy fuel oils and the foreign markets for jet fuels.

In the Atlantic provinces, the 60,000 b/d refinery that Gulf Oil Canada Limited is building at Point Tupper, Nova Scotia, is proceeding according to schedule and should be completed late in 1970. In order to minimize possible undesirable effects on the eastern Canadian gasoline market, only 20 per cent of the refinery's initial output will be gasoline, 30 per cent will be middle distillates and the remainder bunker fuels. The 100,000 b/d Shaheen-financed, Newfoundland Refining Company Limited plant scheduled for completion in 1970 is behind schedule but progress has been made in the construction of five large storage tanks. Construction has not yet started on Irving Refining Limited's 57,000 b/d expansion to its New Brunswick refinery.

Many of the proposed major refinery projects in Quebec that were announced last year have been slow to materialize. Construction of Irving's proposed 50,000-barrel-a-day refinery at St. Romuald has not yet begun and its status is indefinite. Petrofina Canada Ltd. had originally planned to double the capacity of its 52,000 b/d Montreal East refinery but for the present they have limited construction to the inclusion of a $11.4 million aromatics plant and postponed the bulk of the proposed new expansion to a later date. Shell Canada Limited completed the 38,000 b/d expansion of its Montreal East refinery late in 1969 and at the same time its new 2,500 b/d lubricating oil plant came into operation. Several small additions to other Montreal plants were made in 1969 including BP Canada (1969) Limited's 7,000 b/d expansion to its Montreal East refinery. Golden Eagle Canada Limited is proceeding with the construction of a 100,000 b/d refinery at St. Romuald. The $70 million plant is designed primarily to serve the large eastern Canadian and United States eastern seaboard market for residual fuel oil and distillates. Present plans call for yields of about 13,000 b/d of gasoline, 52,000 b/d of residuals, 29,000 b/d of distillates and 1,000 b/d of propanes and butanes.

TABLE 12

Crude Oil Refining Capacity by Regions

	1968		1969	
	Bbl/day	%	Bbl/day	%
Atlantic Provinces	128,100	10.5	132,600	10.2
Quebec	400,400	32.8	449,600	34.6
Ontario	359,100	29.4	367,000	28.3
Prairies and Northwest Territories	222,150	18.1	236,950	18.3
British Columbia	112,400	9.2	111,700	8.6
Total	1,222,150	100.0	1,297,850	100.0

Source: Department of Energy, Mines and Resources, Petroleum Refineries in Canada (Operator's List 5), January 1970.

TABLE 13

Canada, Crude Oil Received at Refineries, 1968 and 1969[p]
(barrels)

Location of Refineries	COUNTRY OF ORIGIN								
	Year	Canada	Middle East	Trinidad	Venezuela	Africa	Colombia	U.S.A.	Total Received
Atlantic Provinces	1968	–	8,730,047	–	31,238,230	–	–		39,968,277
	1969[p]	–	14,127,172	–	31,469,117	–	–		45,596,289
Quebec	1968	–	39,625,770	4,642,440	90,199,921	3,486,520	–	–	137,954,651
	1969[p]	–	36,995,222	2,531,778	94,452,292	8,396,719	1,871,763	207,513	144,455,287
Ontario	1968	120,013,645	–	–	469,967	–	–		120,483,612
	1969[p]	124,365,267	–	–	421,571	–	–		124,786,838
Prairies	1968	74,549,145	–	–	–	–	–		74,549,145
	1969[p]	77,974,663	–	–	–	–	–		77,974,663
British Columbia	1968	40,593,117	–	–	–	–	–		40,593,117
	1969[p]	38,883,672	–	–	–	–	–		38,883,672
Northwest and Yukon Territories	1968	750,664	–	–	–	–	–		750,664
	1969[p]	754,090	–	–	–	–	–		754,090
Total	1968	235,906,571	48,355,817	4,642,440	121,908,118	3,486,520	–	–	414,299,466
	1969[p]	241,977,692	51,122,394	2,531,778	126,342,980	8,396,719	1,871,763	207,513	432,450,839

Source: Dominion Bureau of Statistics, Refined Petroleum Products.
[p] Preliminary; – Nil.

TABLE 14

Regional Consumption of Petroleum Products, by Province, 1969
(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	2,192	1,382	2,633	2,122	4,428
Maritimes	10,121	2,939	4,733	8,792	14,319
Quebec	39,528	6,876	8,396	35,110	47,734
Ontario	57,566	3,506	10,171	37,777	25,758
Manitoba	7,653	1,080	2,839	1,911	958
Saskatchewan	9,756	1,154	3,876	1,589	544
Alberta	15,302	554	6,301	904	415
British Columbia	15,800	1,668	7,338	6,064	9,121
Northwest and Yukon Territories	265	71	607	319	111
Total	158,183	19,230	46,894	94,588	103,388

Source: Dominion Bureau of Statistics, Refined Petroleum Products monthly reports, 1969.

In Ontario, the growth in plant capacity was negligible with the largest increase being an 8,000 b/d addition to Shell Canada Limited's Corunna refinery. Texaco Canada Limited has selected a new site for its proposed 50,000 b/d Ontario refinery when it was unable to have an area in the Burlington area rezoned for refinery construction. Texaco is now attempting to have a 1,300 acre site near Dunnville, on the shore of Lake Erie, rezoned so that they can proceed with construction there. Present plans call for the refinery to come on stream in the fall of 1972 and the plant design would allow for substantial expansion in subsequent years.

On the Prairies, a new pattern of manufacturing and distribution began to develop in 1969, as Gulf Oil Canada Limited closed its 3,600 b/d plant in Brandon, Manitoba. Gulf also intends to close its small Saskatoon refinery in 1971 and convert its Calgary and Moose Jaw refineries to asphalt plants early in the same year. Capacity of these three refineries total about 30,000 b/d and Gulf will replace this capacity from an 80,000 b/d refinery presently under construction in Edmonton. When this is finished in 1971, Gulf's existing 12,600 b/d refinery will also be closed. Following the completion of centralizing their refinery operations in Edmonton, Gulf will probably serve most of their products market in the major Prairie centres by pipeline. Other Prairie developments include Shell's $6 million expansion of its St. Boniface refinery which increased capacity to 26,500 b/d and Texaco's addition of a 2,000 b/d refinery capacity at its Edmonton facility.

In British Columbia, Gulf is almost doubling the processing capacity of its Port Moody refinery to 32,000 b/d with a completion date scheduled for early in 1970.

Imperial Oil Enterprises Ltd. remained the largest refiner in Canada. The company's nine refineries comprise 32.5 per cent of Canadian refinery capacity. Gulf Oil Canada Limited's eight plants constitute 19.4 per cent of the country's capacity. Shell Canada Limited's six plants accounted for 18.2 per cent of total capacity and made Shell the country's third largest refiner.

MARKETING AND TRADE

Receipts of crude oil and equivalent at Canadian refineries in 1969 totalled 1,185,000 b/d, 4.7 per cent more than in 1968. Foreign suppliers of crude oil benefitted from the increase to a greater extent than did Canadian producers, increasing their input by 7 per cent to 522,000 b/d. Domestic crude oil received at refineries increased by only 2.3 per cent to 664,000 b/d and this constituted 56.0 per cent of the total amount received compared to 57.2 per cent in 1968. Most of the demand increase by refineries occurred in Quebec and the Maritime provinces which depend entirely on imported oil for their source of supply.

Refinery receipts of domestic crude oil in Ontario amounted to 341,000 b/d, 3.5 per cent greater than last year and more than half of all the domestic crude oil consumed in Canada during 1969. Consumption in the Prairie provinces increased by 4.3 per cent to 213,000 b/d in contrast to consumption in British Columbia which decreased 3.5 per cent to 107,000 b/d.

Venezuela was again the main source of imported crude oil, increasing its exports to Canada by 3.5 per cent to 346,000 b/d. The Middle East continued to expand its exports of crude oil to Canada as they exceeded 140,000 b/d in 1969. A significant advance in exports to this country was attained by Nigeria

TABLE 15

Imports of Refined Petroleum Products,1968-69
(millions of barrels)

	1968	1969P
Heavy fuel oil	32.29	33.24
Light fuel oil	13.77	13.09
Stove oil	3.94	2.28
Motor gasoline	4.16	6.01
Aviation gasoline	0.13	0.19
Diesel fuel	6.07	5.15
Lubricating oil	1.66	1.68
Petroleum coke	2.69	3.37

Source: Dominion Bureau of Statistics.
P Preliminary.

which increased its supply to 22,000 b/d. Although this is the largest volume of exports received from Nigeria since the civil strife began in the country in 1967, it still falls short of the record level of 36,000 b/d received in 1966. However, almost all of this country's oil fields were producing at normal rates by the end of 1969 and it is expected that Canada's share of their production will increase appreciably in 1970.

Large volumes of petroleum products were again imported in 1969 but there was no increase from the 1968 average daily level of 200,000 b/d. As in previous years most of the imported products came from Venezuela, United States and the Netherland Antilles and consisted mainly of fuel oil and diesel fuel. Most of the product imports were consumed in Ontario, Quebec and the Maritimes with Ontario being the major importer. Only minor quantities of product imports were absorbed in western Canada.

Exports of Canadian crude oil to the United States was 540,000 b/d in 1969 which represents an increase of 18 per cent over 1968. Of this total, shipments to the United States west coast region (District 5) via Trans Mountain Oil Pipe Line Company averaged 216,000 b/d, which is 25 per cent more than in 1968. Although this is a significant increase, it resulted mainly because Cook Inlet oil, Alaska was not as readily available as had been forecast. Exports to District 5 are not a controversial issue in the United States Import Program because some of these shipments are expected to be displaced by Alaskan North Slope crude oil when it becomes available. Exports to the northern states east of the Rocky Mountains (Districts 1-4) primarily via Interprovincial's main line, amounted to 324,000 b/d in 1969.

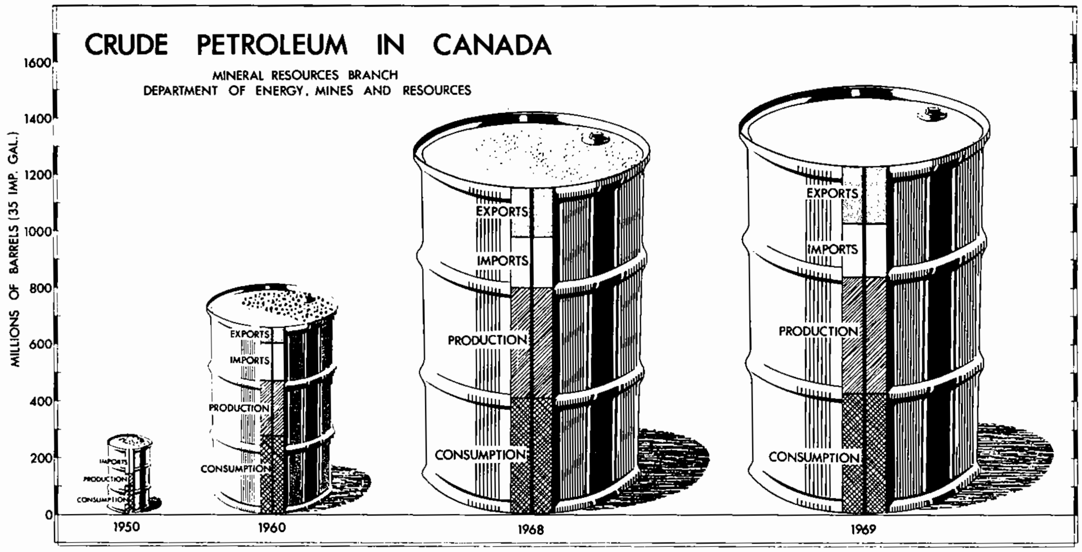
The whole question of import controls is still under review by the United States government. Late in 1969 the United States Cabinet Task Force on Oil Import Controls released its report on the United States oil import program. The task force did not agree unanimously on recommendations regarding the present quota control system which limits oil imports to 12.2 per cent of domestic demand. The majority of the task force wanted this system replaced by a tariff system, while a minority urged that the quota controls be retained. Because of the lack of agreement among the members of the task force, President Nixon ordered another high level interdepartmental committee established to reconcile the task forces recommendations with the view of all parties concerned, including those of foreign governments, and then to make further recommendations.

TABLE 16

Supply and Demand of Oils, 1968-69
(thousand barrels)

	1968r	1969P
SUPPLY		
Production		
Crude oil and condensate	379,396	410,814
Other natural gas liquids	58,613	66,671
Net production	438,009	477,485
Imports		
Crude oil	177,739	193,125
Products	74,422	73,949
Total imports	252,161	267,074
Change in stocks		
Crude and natural gas liquids	− 7,132	− 3,499
Refined petroleum products	− 4,283	− 1,229
Total change	−11,415	− 4,728
Oils not accounted for	+ 2,587	− 2,991
Total supply	681,342	736,840
DEMAND		
Exports		
Crude oil	167,488	197,341
Products	18,128	20,008
Total	185,616	217,349
Domestic sales		
Motor gasoline	152,099	157,932
Middle distillates	164,484	171,377
Heavy fuel oil	97,466	101,360
Other products	47,095	53,752
Total	461,144	484,421
Uses and losses		
Refining	32,004	32,923
Field, plant and pipeline	2,578	2,147
Total	34,582	35,070
Total demand	681,342	736,840

Source: Dominion Bureau of Statistics, and provincial government reports.
r Revised; P Preliminary.



Exports of products increased slightly in 1969 to 54,000 b/d. The main commodities exported were butane, propane, heavy fuel oil and gasoline. Exports of propane to Japan amounted to over 9,000 b/d, 3,000 b/d more than in 1968.

OUTLOOK

Recent estimates indicate that over 50 per cent of Canada's potential recoverable oil reserves are located north of the 60th parallel. The discovery of very large reserves of crude oil at Prudhoe Bay on the North Slope of Alaska has served to intensify interest in these potential reserves. The recent discovery of oil at Atkinson Point in the Mackenzie River Delta by Imperial Oil Limited and the large condensate-bearing gas reservoir discovered by Panarctic on Melville Island have confirmed both industry and government's assessment of the potential of northern Canada. Additional exploratory programs are scheduled for the Arctic Islands in 1970 and amongst the most important of these is the joint venture planned by King Resources Company, Triad Oil Co. Ltd., and BP Oil Limited. They intend to spend $8 million in the next three years on an extensive exploratory program which includes the drilling of two wells in 1970–one on Northwest Melville Island and the other on Bathurst Island. When viewed in the light of existing geological conditions and the substantial effort committed to development, it is a virtual certainty that these regions will eventually become Canada's most important producing area.

The solutions to the problems of transporting production to market will unquestionably influence the rate at which northern areas are developed. Research into oil and gas movement from Arctic regions, including Alaska, is well advanced and currently there are several major pipeline projects under active consideration. From the standpoint of economics, prospects for a Canadian route for some of these pipelines is excellent and since an estimated $5 billion worth of pipeline facilities is involved, the importance to the Canadian economy cannot be overestimated.

The combination of the impact of the Prudhoe Bay discoveries plus the comprehensive review of the import control system currently taking place in the United States poses some uncertainty for the Canadian oil industry in the near term. With the United States heavily involved in developing the huge oil reserves at Prudhoe Bay, production from this area will undoubtedly have an adverse effect on the marketing of Canadian oil in the United States. There is no question that from the point of view of quality and price, Canadian oil is currently competitive, particularly in the northern tier of the United States. However, there are problems relating to the continuing United States concern that Canadian oil is entering the country in quantities in excess of that to which they had formerly agreed on. Therefore, in the short term, the Canadian oil industry can look forward to some increase in exports to the United States if only to meet the seemingly inevitable shortages that have occurred in recent years in areas that can be served by Canadian oil. At the same time, domestic demand for Canadian crude oil should also increase but at a more subdued rate of growth.

Forecast demand for petroleum products in North America during the next decade holds promise of a bright future for the Canadian petroleum industry in the long term. At the present time, Alberta producers have the capacity to supply a larger share of the North American market than they are now doing and we can look forward to the discovery of large new reserves in the traditional producing areas of Canada. Nevertheless, the ability of Canada to serve projected continental market growth in the future will depend to a large degree on the success of exploration and pace of development in Canada's Arctic and offshore regions.

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 then eased considerably as fertilizer inventories began to accumulate. In Canada, a weakening of farm income in the Prairie Provinces resulting from the difficulties in selling wheat has led to a sharp decrease in the use of phosphate fertilizers in that area. Two phosphate fertilizer plants, one in Manitoba and one in Saskatchewan, were closed in 1968 and in 1969 production was suspended at a plant in Alberta. In eastern Canada, fertilizer consumption continued to increase in 1969 but supply outpaced demand and most producers were forced to operate well below their productive capability.

Canada's industrial phosphates industry also experienced considerable difficulties in 1969, but its problems were of a different nature. A new $40-million elemental phosphorus plant was placed on stream at Long Harbour, Newfoundland, late in 1968 but was forced to close from May until July 1969 because it had polluted the waters in Placentia Bay. There is a growing awareness of and concern over the polluting effect of phosphate detergents on the country's rivers and lakes and efforts are being made to eliminate the use of phosphate-bearing compounds in the manufacture of household detergents.

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, 1968-69

	1968		1969	
	Short Tons	$	Short Tons	$
Imports				
United States	2,345,513	18,603,000	2,195,866	14,617,000
Netherlands Antilles	4,467	196,000	5,465	241,000
Total	2,349,980	18,799,000	2,201,331	14,858,000
	1967		1968	
Consumption[1] (available data)				
Fertilizers, stock and poultry feed	2,070,776		2,012,290	
Chemicals	201,442		217,364	
Other[2]	2,877		4,605	
Total	2,275,095		2,234,259	

Source: Dominion Bureau of Statistics.
[1] Breakdown by Mineral Resources Branch; [2] Includes amounts for refractories, food processing, medicinals and pharmaceuticals.

TABLE 2

Canada, Phosphate Rock Imports and Consumption, 1960-69
(short tons)

	Imports	Consumption
1960	941,998	891,894
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	. .

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 AND CONSUMPTION

Canada's phosphate rock imports in 1969 were 2.2 million tons, down slightly from 1968. About two thirds came from Florida with most of the remainder from the western states (Idaho, Montana, Utah and Wyoming). Until recent years, the sedimentary phosphate rock fields in Florida and the western states had supplied approximately equal proportions of Canada's phosphate rock imports from United States, the former supplying rock to markets in eastern Canada and the latter supplying rock to manufacturers in western Canada. In 1965 a system was inaugurated whereby Florida rock is shipped to Vancouver by water and then inland to Alberta by rail and potash is back-hauled from Saskatchewan. Incoming Florida rock shipments through Vancouver amounted to 447,470 tons in 1969.

WORLD PRODUCTION

World production of phosphate rock was 78.6 million metric tons in 1969, a slight decrease from 1968. The decrease reflects a weakening in demand for phosphate fertilizers from 1967 to 1969, particularly in North America, and the accumulation of large inventories of both phosphate fertilizer and phosphate rock during those years. The average annual growth rate for world phosphate rock output was about 12 per cent from 1960 to 1967. World output in 1970 is expected to increase about 6 per cent above the 1969 level.

TABLE 3

World Production of Phosphate Rock 1967-69
('000 metric tons)

	1967	1968	1969[p]
United States	36,079	37,422	36,000
USSR*	15,250	16,210	17,200
Morocco	9,922	10,503	
Tunisia	2,810	3,361	14,450
Algeria	198	361	
Togo	1,139	1,375	
Senegal	1,266	1,270	2,600
South Africa	854	1,087	1,150
Nauru Island	1,795	2,254	
Ocean Island	452	528	4,000
Christmas Island	1,091	1,213	
Egypt	683	600	
Jordan	894	1,162	2,700
Israel	609	850	
Others	606	542	500
Total	73,648	78,748	78,650

Source: The Journal of World Phosphorus and Potassium.
*Includes small quantities from other East European countries.
[p]Preliminary.

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 one ton of phosphorus. Although elemental phosphorus can be used for making fertilizers, it is generally used in the manufacture of chemicals, insecticides, detergents and other industrial compounds.

Electric Reduction Company of Canada, Ltd. (ERCO) uses this process, employing electric furnaces at Varennes, Quebec, and in a newly-opened plant at Long Harbour, Newfoundland. The first of two electric furnaces at ERCO's new $40-million plant at Long Harbour came on stream in December 1968, but was forced to close from May until early July 1969 because phosphorus-bearing discharge water from the plant was polluting the fishing waters in Placentia Bay. Improved anti-pollution measures were adopted and the plant was allowed to reopen; both furnaces were in operation for the remainder of 1969.

About 60 per cent of the phosphorus output from the Long Harbour plant was to be exported and the remainder was to be shipped to ERCO's plants in Buckingham, Quebec, and Port Maitland, Ontario. Much of the export shipments is to be carried in two specially built 5,000-ton vessels to ERCO's parent firm, Albright & Wilson Ltd., in England.

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 one ton of superphosphate, grading 20 per cent P_2O_5 equivalent, are 0.64 ton of phosphate rock (70-72 per cent BPL) and 0.47 ton of sulphuric acid (100 per cent basis).

To produce phosphoric acid, larger quantities of sulphuric acid are added to maintain a 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 one ton of P_2O_5 equivalent produced are 3.1 tons of phosphate rock (74-75 per cent BPL) and 2.6 tons of sulphuric acid (100 per cent basis), 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.

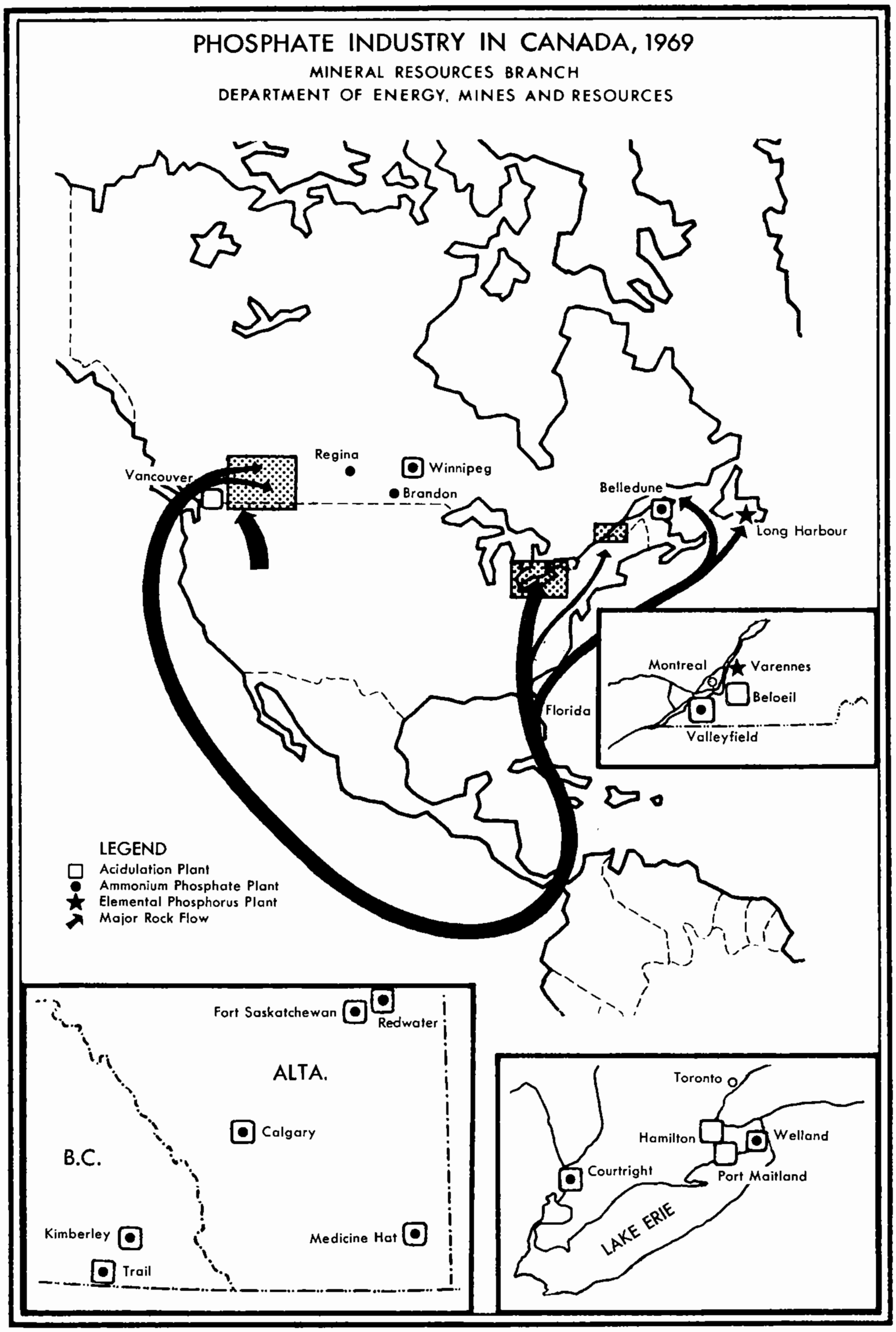
Most of the acid is then neutralized with ammonia to form ammonium phosphate fertilizers. Common grades are 16-20-0 (16 per cent N, 20 per cent P_2O_5 equivalent, and 0 per cent K_2O equivalent), 11-48-0 and 18-46-0. At some plants, phosphoric acid is used to acidulate phosphate rock in which case the end product is triple superphosphate, normally grading 46 per cent P_2O_5 equivalent.

TABLE 4

Canada, Phosphorus and Phosphate Fertilizer Plants, 1969

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 Canada,	Varennes, Que.	20,000	el ph	
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
Border Fertilizer Ltd.	Winnipeg, Man.*	16,000	am ph	sulphur
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.	Regina, Sask.*	. .	am ph	. .
	Kimberley, B.C.	128,000	am ph	SO_2 pyrrhotite
	Trail, B.C.	86,000	am ph	SO_2 smelter gas
Cyanamid of Canada Limited	Welland, Ont.*	13,000	t s, am ph	sulphur
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		1,061,000		

*Plants that were shut down in 1968 and remained closed throughout 1969.
**Production was suspended in 1969 because of poor marketing conditions.
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.


PHOSPHATE INDUSTRY IN CANADA, 1969
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
Regina
Winnipeg
Brandon
Vancouver
Belledune
Long Harbour
Florida
Montreal
Varennes
Beloeil
Valleyfield
LEGEND
Acidulation Plant
Ammonium Phosphate Plant
Elemental Phosphorus Plant
Major Rock Flow
Fort Saskatchewan
Redwater
ALTA.
B.C.
Calgary
Kimberley
Trail
Medicine Hat
Toronto
Hamilton
Welland
Courtright
Port Maitland
LAKE ERIE

There are eleven phosphoric acid plants in Canada with a combined annual productive capacity of 950,000 tons of P_2O_5 equivalent (see Table 4). The balance of Canada's P_2O_5 productive capacity, amounting to 111,000 tons annually, consists of plants that are capable of producing both single and triple superphosphate.

PRODUCTION, TRADE AND CONSUMPTION

Reflecting weaker demand for fertilizers, production of phosphate fertilizers in Canada in the fertilizer year 1968/69 (twelve months ended June 30, 1969) at 523,934 tons P_2O_5 equivalent, was slightly below the levels established in 1966/67 and 1967/68. Canada's phosphate output expanded at an average annual rate of 15 per cent between 1959/60 and 1966/67. As indicated in Table 4, production at three phosphate plants – at Welland, Ontario; Winnipeg, Manitoba; and Regina, Saskatchewan – was suspended in 1968 and all three plants remained closed in 1969. In mid-1969, Sherritt Gordon Mines, Limited, suspended operations in the phosphate section of its fertilizer complex at Fort Saskatchewan, Alberta, and several other producers extended their annual maintenance period in the summer of 1969 in an effort to reduce inventories. Canadian Industries Limited (CIL) suspended production of phosphate fertilizers at Sarnia, Ontario, for several weeks in the latter part of 1969 because a prolonged labour dispute at The International Nickel Company of Canada, Limited's mines and plants at Sudbury resulted in a shortage of sulphuric acid.

In October 1969, Imperial Oil Limited officially opened a new $50-million fertilizer complex at Redwater, Alberta. The plant is designed to produce 140,000 tons P_2O_5 equivalent annually as ammonium phosphates; other fertilizer products include ammonia and ammonium nitrate. Imperial Oil acquires its phosphate rock from Florida.

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 1968/69 were 152,907 tons P_2O_5 equivalent, a slight decrease from the previous twelve months but well above the past ten-year average. Imports of phosphate fertilizer materials in 1968/69 amounted to 24,054 tons P_2O_5 equivalent, down 45 per cent from the previous twelve months, 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 1968/69 were 332,783 tons P_2O_5 equivalent, down 24 per cent from the previous twelve months. 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 151,712 tons in 1968/69, a clear reflection of weaker farm incomes caused by the difficulties in selling wheat. 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 191,893 tons P_2O_5 equivalent, were slightly lower than the year before.

TABLE 5

Canada, Phosphate Fertilizer Production, Years Ended June 30, 1960-69 (short tons P_2O_5 equivalent)

1960	199,570
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

Source: Dominion Bureau of Statistics.

CANADIAN INDUSTRY OUTLOOK

The short-term and long-term production prospects for Canada's phosphate industry are favourable but from a product marketing viewpoint, the outlook is cloudy. Except for the lack of a domestic source of phosphate rock, the Canadian industry is in a particularly favourable position insofar as raw materials are concerned. Rock is readily available from foreign suppliers at competitive prices. Sulphur is relatively cheap and in abundant supply in Canada. Natural gas, which is the key raw material used to manufacture ammonia in North America for the preparation of ammonium phosphate fertilizers, is in abundant supply. Electrical power, necessary for the manufacture of elemental phosphorus, is relatively cheap and plentiful from hydro-electric plants.

Public concern about the pollution of North America's streams, rivers and lakes has been mounting during recent years and phosphate-bearing detergents are being singled out as one of the principal pollutants. Phosphorus is used to manufacture sodium tripolyphosphate, a key ingredient in most household detergents. Proposed amendments to the pending Canada Water Act are geared to limit the phosphate content of detergents to 25 per cent by August 1,

TABLE 6

Canada, Trade in Selected Phosphate Products, 1968-69

	1968		1969	
	Short Tons	$	Short Tons	$
Imports				
Calcium phosphate				
United States	18,199	1,816,000	19,502	2,042,000
Japan	1,605	105,000	1,322	87,000
Belgium and Luxembourg	500	24,000	976	48,000
Total	20,304	1,945,000	21,800	2,177,000
Fertilizers				
Normal superphosphate, 22% P_2O_5 or less				
United States	14,395	384,000	5,378	171,000
Triple superphosphate, over 22% P_2O_5				
United States	30,205	1,565,000	22,422	1,198,000
Chemicals				
Potassium phosphates				
United States	1,447	448,000	1,848	583,000
Sodium phosphate, tribasic				
United States	839	143,000	616	104,000
France	83	7,000	165	12,000
Total	922	150,000	781	116,000
Sodium phosphates, n.e.s.				
United States	6,173	1,246,000	5,617	1,229,000
West Germany	28	9,000	50	12,000
Total	6,201	1,255,000	5,667	1,241,000
Exports				
Nitrogen phosphate fertilizers				
United States		24,397,000		27,157,000
India		1,368,000		1,381,000
Other countries		–		880,000
Total		25,765,000		29,418,000

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

1970, and to eliminate it completely by 1972. Some detergents reportedly contain as much as 50 per cent phosphates. The United States Federal Water Pollution Control Administration has also called for a reduction in phosphates in detergents. The removal of phosphates from detergents eliminates an important market for phosphorus.

Phosphate fertilizer sales in western Canada are expected to decline further in 1970 and there is little evidence to suggest that the situation will improve in 1971 or 1972. The federal government is offering cash bonuses to prairie farmers to reduce their wheat acreage in 1970 in an effort to reduce wheat inventories. Accordingly, a reduction in fertilizer sales is expected. Moderate increases in sales to farmers in eastern Canada are expected in 1970.

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

TABLE 7

Canada, Phosphate Fertilizer Consumption and Trade, Years Ended June 30, 1960-69
(short tons P_2O_5 equivalent)

	Consumption	Imports*	Exports
1960	153,243	45,040	98,318
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	332,783	24,054	152,907

Source: Dominion Bureau of Statistics.
*Excludes nutrient content of mixtures and of orthophosphoric acid.

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 29, 1969, 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 " " "	7.50
70-72 " " "	8.15
74-75 " " "	9.20
76-77 " " "	10.20

Defluorinated phosphate, feed grade, paper bags, carlots (some truckloads), various U.S. points, 18 per cent P, per short ton:
$65.25–$66.00

Phosphoric acid, agricultural, grade, f.o.b. works, per unit-ton, 52-54 per cent a.p.a.
$0.90–$1.10

Superphosphate, run-of-pile, pulverized, bulk, carlots, f.o.b. works, per unit-ton, under 22 per cent a.p.a.
$0.92–$1.12

The price listing for phosphate rock remained unchanged from the previous three years, but phosphoric acid prices were slightly lower than in 1968.

Phosphate rock and phosphate fertilizer materials enter Canada and United States duty fee.

Platinum Metals

A.F. KILLIN*

Canada is the world's third largest producer of the platinum group metals (platinoids). The USSR is the world's largest producer followed by the Republic of South Africa, Canada, United States and Colombia in that order. In Canada the platinoids-platinum, palladium, rhodium, ruthenium, iridium and osmium – are recovered as byproducts from the refining of nickel-copper ores and the volume of recovery varies with the production of these ores. In 1969 production in the Sudbury area was hampered by prolonged labour strikes with a consequent reduction in output to 266,100 troy ounces valued at $26,449,000 compared with 485,891 ounces and $46,199,718 in 1968.

The United States Bureau of Mines estimated world production in 1969 at 3,550,000 troy ounces; 135,000 ounces more than in 1968. The major expansion that brought about the increase in world output, in spite of the Canadian decline, was in the Republic of South Africa where production rose 186,000 ounces to 1.1 million troy ounces. USSR production was estimated at 2,050,000 ounces, United States 30,000 ounces and Colombia 14,000 ounces. There was minor production in Ethiopia and Japan.

The supply shortage in the non-communist world persisted in 1969 and supply was augmented by purchases from the USSR and from metal dealers. The dual pricing formula, consisting of a producers price quoted by Engelhard Industries, Inc. and Johnson, Matthey & Co., Limited and a free market price quoted by merchant dealers and the agents selling for the USSR, persisted throughout 1969. Most of the platinoids produced in the non-communist world were sold at the producers price. Metal reclaimed from scrap and the Russian metal were sold at the free market price.

PRODUCTION

CANADIAN

Canadian nickel-copper ores, principally from the Sudbury area of Ontario, contain most of the platinum metals recovered in Canada. The grade has been estimated at 0.025 troy ounce 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 released are collected from the electrolytic tanks as sludge. This sludge is purified, then shipped to refineries in Britain and the United States for the recovery of the individual platinum metals. Nickel ores containing platinum metals are mined in Ontario, Quebec, Manitoba and British Columbia. No precious metals are recovered in Canada from the British Columbia ores because the concentrates are sold to Japan.

Consolidated Canadian Faraday Limited at Gordon Lake, Ontario, shipped nickel-copper concentrates to The International Nickel Company of Canada, Limited (Inco) at Sudbury for treatment. Dumbarton Mines Limited, formerly Maskwa Nickel Chrome Mines Limited, in the Bird River area of Manitoba started production in September 1969 and shipped ore to the mill of Consolidated Canadian Faraday. Renzy Mines Limited in Hainault Township, Quebec started production from its mine and mill in July and shipped concentrates to Falconbridge for smelting.

*Mineral Resources Branch.

TABLE 1

Canada – Platinum Metals – Production and Trade, 1968-69

	1968		1969p	
	Troy Ounces	$	Troy Ounces	$
Production[1]				
Platinum, palladium, rhodium, ruthenium, iridium	485,891	46,199,718	266,100	26,449,000
Exports				
Platinum metal in ores and concentrates				
Britain	547,174	35,539,000	418,832	31,002,000
Norway	9,716	933,000	10,108	970,000
United States	12,526	527,000	3,157	229,000
Japan	–	–	1,650	131,000
Total	569,416	36,999,000	433,747	32,332,000
Platinum metals				
United States	14,671	911,000	21,237	2,059,000
Japan	–	–	4,125	325,000
Britain	537	91,000	1,897	295,000
Other countries	318	67,000	2,494	295,000
Total	15,526	1,069,000	29,753	2,974,000
Platinum metals in scrap				
United States	10,516	716,000	15,938	1,912,000
Britain	10,550	1,150,000	14,447	1,628,000
Japan	10,975	1,030,000	5,425	416,000
Total	32,041	2,896,000	35,810	3,956,000
Re-Exports[2]				
Platinum metals, refined and semiprocessed	83,228	8,254,753	52,694	5,247,240
Imports				
Platinum lumps, ingots, powder and sponge				
Britain	22,544	3,137,000	9,857	1,355,000
United States	1,759	280,000	8	2,000
Netherlands	6	1,000	–	–
Total	24,309	3,418,000	9,865	1,357,000
Other platinum group metals in lumps, ingots, powder and sponge				
Britain	176,082	13,273,000	90,726	7,176,000
United States	7,204	371,000	18,355	756,000
France	366	15,000		
Total	183,652	13,659,000	109,081	7,932,000
Total platinum and platinum group metals				
Britain	198,626	16,410,000	100,583	8,542,000
United States	8,963	651,000	18,363	758,000
France	366	15,000	–	–
Netherlands	6	1,000	–	–
Total	207,961	17,077,000	118,946	9,300,000

TABLE I (Cont'd)

	1968		1969p	
	Troy Ounces	$	Troy Ounces	$
Platinum crucibles				
United States	15,607	1,719,000	19,267	2,119,000
Platinum metals, fabricated materials, n.e.s.				
United States	14,480	802,000	11,508	843,000
Britain	2,847	343,000	7,594	1,022,000
Netherlands	–	–	42	3,000
Republic of South Africa	7	1,000	–	–
Total	17,334	1,146,000	19,144	1,868,000

Source: Dominion Bureau of Statistics.
[1]Platinum metals, content of concentrates, residues and matte shipped for export. [2]Platinum metals, refined and semiprocessed, imported and re-exported after undergoing no change or alternation.
pPreliminary; – Nil; n.e.s. Not elsewhere specified.

TABLE 2

World Production of Platinum-Group Metals
(troy ounces)

	1967	1968p	1969e
USSR	1,900,000	2,000,000	2,050,000
Republic of South Africa	833,000	914,000	1,100,000
Canada	401,263	485,891	350,000
United States	16,365	14,793	30,000
Other countries	19,092	22,132	20,000
Total	3,169,720	3,436,816	3,550,000

Source: U.S. Bureau of Mines Minerals Yearbook Preprint, 1968; U.S. Bureau of Mines Commodity Data Summaries, January 1970.
pPreliminary; eEstimated.

In the Sudbury area, Inco operated 12 mines, four mills and two smelters for the treatment of platinoid-bearing nickel-copper ores. Nickel-copper matte from the Sudbury smelters 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 mines, a fifth mill, and a nickel refinery in the Sudbury area and a fifth mine at Shebandowan, Ontario for production. Falconbridge Nickel Mines, Limited operated eight mines, four mills and a smelter. Nickel-copper matte containing platinoid metals was shipped from the Falconbridge smelter to the company refinery at Christiansand, Norway for refining. Precious metal sludges were shipped to the United States for refining.

FOREIGN

SOUTH AFRICA

Rustenburg Platinum Mines Limited, the non-communist world's largest platinum producer, expanded production in 1969 to about 1.43 million ounces of platinoids. The company has announced further expansion plans that foresee production of platinoids at 1.59 million ounces in 1970 and 1.91 million ounces by 1972. The smelter in South Africa, jointly owned by Rustenburg and Johnson, Matthey & Co. South Africa (Pty) Limited was expanded in 1969 and a further expansion is planned to match the increased mine output. Impala Platinum Limited, in which Union Corporation Limited has a 50 per cent interest, started production from its Bafokeng mine in July, 1969. The company operated a mine, mill and electric smelter complex at Bafokeng and a refinery at Springs that produced refined platinum, palladium, copper, nickel and gold and will produce other platinoids in the near future. Operating rate in 1969 was: 150,000 ounces of platinum, 50,000 ounces of palladium, 2.5 million pounds of copper, 4 million pounds of nickel and 7,000 ounces of gold. The company has announced plans to expand production to 300,000 ounces of platinum a year with an equivalent increase in associated metals. Lonrho Ltd. and Falconbridge Nickel Mines, Limited have announced plans to develop a mine in the Rustenburg area. The mine is scheduled to produce at the rate of 50,000 ounces of platinum by 1971 and to expand to about 400,000 ounces by 1974. Byproduct production of palladium, nickel, copper and gold is also planned.

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 1969 was estimated by the U.S. Bureau of Mines at 2,050 thousand ounces.

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

Colombian production of platinum metals declined to 14,000 ounces in 1969, 1,000 ounces less than in the previous year. Platinum metals recovery was from the placer deposits of 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 gasolines; 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. Platinum and platinum alloys are used for the cathodic protection of ships' hulls and as inert anodes in electro-deposition. Palladium is used as contacts in automatic electric switching gear and in dentistry. Wear resistance and beauty of finish are the qualities that create a demand for the platinum metals in the manufacture of high-quality jewelry.

TABLE 3

Canada – Platinum Metals – Production and Trade, 1960-69

	Production[1]	Exports		Imports[4]
		Domestic[2]	Re-exports[3]	
	troy oz.	$	$	$
1960	483,604	16,068,728	8,404,563	12,951,420
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[r]	8,254,753	17,077,000
1969[p]	266,100	35,306,000	5,247,240	9,300,000

Source: Dominion Bureau of Statistics.
[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; [r]Revised.

OUTLOOK

There will very probably be a surplus supply of platinoids in the next two years. Platinum, the metal most in demand, will have short-term consumption lags because of the introduction of more efficient industrial catalysts. Over the long-term, platinum consumption should increase, helped by stable supplies and reasonable prices. There will very probably be an increase in platinum use for catalysts with increasing emphasis on pollution prevention. There will be a surplus of palladium and the other platinoids for a number of years because production is increasing at a greater rate than the industry can develop new uses for the material.

In May, the United States government announced a new stockpile objective for platinum. The objective was increased from 335,000 troy ounces to 555,000 ounces. The level of the stockpile in 1969 was 450,000 ounces and there is a deficit of 105,000 ounces. The government has not announced immediate plans to purchase the platinum necessary to reach the new objective.

PRICES

Prices of the platinum metals varied during the year. The following table summarizes the price changes in the United States as quoted by *Metals Week*.

TABLE 4

Price of Platinum-group Metals, 1969

	$/troy** ounce
Iridium	
Jan. 1 – June 15	185–190
Dealers*	179–181
June 16 – Sept. 1	175–180
Dealers*	172–175
Sept. 2 – Nov. 2	165–170
Dealers*	160–165
Nov. 3 – Dec. 31	160–165
Dealers*	160–162
Osmium	
Jan. 1 – June 15	300–450
Dealers*	230–250
June 16 – Nov. 2	225–250
Dealers*	225–250
Nov. 2 – Dec. 31	200–225
Dealers*	200–225
Palladium	
Jan. 1 – Feb. 9	45–47
Dealers*	42–43
Feb. 10 – May 18	43–45
Dealers*	40–40.50
May 19 – July 31	41–43
Dealers*	37–38
Aug. 1 – Nov. 2	39–41
Dealers*	36.50–37
Nov. 3 – Dec. 31	37–39
Dealers*	36.50–37
Platinum	
Jan. 1 – Nov. 2	120–125
Dealers*	206–209
Nov. 3 – Dec. 31	130–135
Dealers*	180–183
Rhodium	
Jan. 1 – Feb. 9	245–250
Dealers*	241–244
Feb. 10 – Apr. 20	240–245
Dealers*	239–241
Apr. 21 – Sept. 1	235–240
Dealers*	233–236
Sept. 2 – Nov. 2	225–230
Dealers*	220–225
Nov. 3 – Dec. 31	220–225
Dealers*	215–220
Ruthenium	
Jan. 1 – Nov. 2	55–60
Dealers*	45
Nov. 3 – Dec. 31	50–55
Dealers*	45

Source: *Metals Week*. *Average; **In U.S.A. currency.

TARIFFS

		British Preferential	Most Favoured Nation	General
CANADA				
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%

TARIFFS (Cont'd)

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, 1969	32%
	" " " Jan. 1, 1970	28%
605.05	Alloys of platinum, semi-manufactured, gold-plated	
	On and after Jan. 1, 1969	40%
	" " " Jan. 1, 1970	35%
605.06	Alloys of platinum, semi-manufactured silver-plated	
	On and after Jan. 1, 1969	19%
	" " " Jan. 1, 1970	16.5%
605.08	Other platinum metals, semi-manufactured including alloys of platinum	
	On and after Jan. 1, 1969	32%
	" " " Jan. 1, 1970	28%

Potash

W.E. KOEPKE*

Canada's potash industry, based entirely in the Province of Saskatchewan, experienced in 1969 the most trying year of its ten-year history. World demand for potash fertilizers expanded at unprecedented rates during the mid-1960's and many mining companies turned to the rich potash deposits in Saskatchewan as one of the few sources to supply rising North American and world needs. As output from Saskatchewan expanded to the point where it became an important market force in the world potash industry, North American and world demand for potash began to slacken and prices weakened to the extent that by 1969, North American prices were at their lowest level on record. As prices declined, corporate profits diminished and the problems of the Saskatchewan potash producers were further compounded by charges of 'dumping' Canadian potash in the United States market. The United States Bureau of Customs launched an anti-dumping investigation in September 1967 that continued until November 1969, when the Tariff Commission announced its finding that the potash industry in United States was being, and was likely to be, injured by reason of less than fair value imports of potassium chloride from Canada, France and West Germany.

The oversupply of potash, accompanied by weak prices and uncertain marketing conditions for Canadian potash, prompted the Province of Saskatchewan to promulgate potash production and marketing controls and to post minimum prices, effective January 1, 1970. One of the immediate effects of the legislation was a rise in world potash prices but the ultimate effect of this action on Canadian potash production remains uncertain.

Reflecting the low prices, the value of Canada's potash shipments in 1969 (preliminary figure) averaged \$21.33 a ton K_2O equivalent (21.3¢ per unit K_2O equivalent, a unit being 20 lbs) compared with \$22.32 in 1968, \$28.28 in 1967, \$31.49 in 1966, and \$37.53 in 1965. In 1965 Canadian and North American potash prices were at their highest point since World War II. During 1969, in Saskatchewan, seven potash mines were in production throughout the year, two new potash mines were brought on stream, and construction of a tenth mine was progressing on schedule for start-up in January 1971. Canada became the world's largest producer of potash in 1969, followed by the USSR.

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 washes, 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 normally 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).

*Mineral Resources Branch.

TABLE 1

Canada – Potash Production, Shipments and Trade, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Production (potassium chloride)				
Gross weight	4,860,000e		6,122,000r	
K_2O equivalent	2,976,000e	..	3,748,000r	..
Shipments (potassium chloride)				
Gross weight	4,763,459		5,755,500	
K_2O equivalent	2,917,611	65,121,399	3,532,000	75,344,000
Imports – Fertilizer potash				
Potassium chloride				
United States	10,185	205,000	11,184	363,000
West Germany	13,761	328,000	5,192	133,000
Britain	2	...	7	2,000
Total	23,948	533,000	16,383	498,000
Potassium sulphate				
United States	23,844	828,000	27,773	1,041,000
Italy	1,100	54,000	3,300	147,000
Britain	–	–	2	1,000
Total	24,944	882,000	31,075	1,189,000
Potash fertilizer, not elsewhere specified				
United States	20,133	378,000	25,574	505,000
Total, potash fertilizer	69,025	1,793,000	73,032	2,192,000
Potash chemicals				
Potassium carbonate	755	144,000	1,001	181,000
Potassium hydroxide	1,919	375,000	1,513	331,000
Potassium nitrate	2,669	310,000	3,836	447,000
Potassium phosphates	1,447	448,000	1,848	583,000
Potassium bitartrate	164	97,000	179	119,000
Potassium silicates	1,167	207,000	1,062	188,000
Total, potash chemicals	8,121	1,581,000	9,439	1,849,000
Exports – Fertilizer potash				
Potassium chloride (muriate of potash)				
United States	..	62,936,000	..	59,909,000
Japan	..	12,440,000	..	12,583,000
Netherlands*	..	10,856,000	..	9,084,000
New Zealand	..	2,613,000	..	1,903,000
South Korea	..	1,412,000	..	1,826,000
Pakistan	..	–	..	1,151,000
Australia	..	462,000	..	981,000
Brazil	..	803,000	..	830,000
Other countries	..	4,634,000	..	2,309,000
Total	..	96,156,000	..	90,576,000

Source: Dominion Bureau of Statistics.
pPreliminary; – Nil; . . . less than $1,000; . . Not available; eEstimated; r Revised.
*Most of the exports to the Netherlands are trans-shipped to Britain.

PRODUCTION AND DEVELOPMENTS IN CANADA

Production of potash in Canada, all from the Saskatchewan mines, rose sharply from an estimated 2,976,000 tons K_2O equivalent in 1968 to 3,748,000 tons in 1969, an increase of 26 per cent. Mine shipments in 1969 totalled 3,532,000 tons K_2O equivalent valued at $75.3 million*, a tonnage increase of 21 per cent and a value increase of 15.7 per cent from the previous years. Potash stocks on hand at the mines at the end of 1969 were at an all time high of 677,000 tons K_2O equivalent. Estimated year-end stocks for previous years were as follows: 1968, 460,000 tons K_2O equivalent; 1967, 402,000 tons; and 1966, 202,000 tons.

DEPOSITS AND OCCURRENCES

Underground potash deposits occur in the prairie provinces of Manitoba, Saskatchewan and Alberta, and in the Malagash-Wallace area of Cumberland County, Nova Scotia. Only those in Saskatchewan have attained commercial importance. The deposits in Nova Scotia 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. Traces of potash minerals have also been found in southwestern Newfoundland.

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 are as much as 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 ($KCl. MgCl_2 6H_2O$). In other areas this mineral is generally lacking but 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 1968, approximately 11 million tons of potash ore were mined by this method.

In the surface plant, the rock is further crushed and the sylvite is separated out 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 about 5,200 feet, 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.

*Statistics for 1969 are revised from earlier figures published by this Branch, but are still preliminary; 'production' statistics published in earlier editions of the Canadian Minerals Yearbook refer to shipments.

TABLE 2

Canada, Potash Production and Trade, Years Ended June 30, 1960-69
(short tons K_2O equivalent)

Year Ended June 30	Production	Imports*	Exports
1960	..	85,820	..
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

Source: Dominion Bureau of Statistics–Fertilizer Trade.
*Includes potassium chloride, potassium sulphate and sulphate of potash magnesia, except that contained in mixed fertilizers.
–Nil; .. Not available.

TABLE 3

Canada, Summary of Potash Mines, 1969

Company	Location*	Initial Production (scheduled)	Capacity Million stpy**		Remarks
			KCl	K_2O eq.	
International Minerals & Chemical Corporation (Canada) Limited	K–1, Esterhazy	1962	2.00	1.20	One 16–ft shaft; mining 7.5–ft bed at 3,148 feet.
	K–2, Esterhazy	1967	1.50	0.90	One 18.5–ft shaft; mining 8–ft bed at 3,150 feet. K–1 and K–2, located 6 miles apart, are connected underground
Kalium Chemicals Limited	Belle Plaine	1964	1.25	0.77	Solution mining from beds about 5,200 feet deep.
Potash Company of America	Saskatoon	1965	0.70	0.42	One 16–ft and one 18–ft shaft, 3,000 feet apart; mining 10–ft bed at 3,315 feet.
Allan Potash Mines	Allan	1968	1.50	0.90	Two 16–ft shafts; mining 10–ft bed at 3,409 feet.
Alwinsal Potash of Canada Limited	Lanigan	1968	1.00	0.60	One 18–ft shaft; mining 11–ft bed at 3,280 feet.
Duval Corporation of Canada	Saskatoon	1968	1.20	0.72	Two 16–ft shafts; mining 10–ft bed at 3,315 feet.
Cominco Ltd.	Vanscoy	1969	1.20	0.72	One 18.5–ft and one 16–ft shaft; mining 10–ft bed at 3,532 feet.
Noranda Mines Limited	Viscount	1969	1.50	0.90	Two 16–ft shafts; mining 10–ft bed at 3,354 feet.
Hudson Bay Mining and Smelting Co., Limited	Rocanville	(1971)	1.00	0.60	Sinking two 16–ft shafts to a depth of about 3,300 feet.
Total			12.85	7.73	

*All in the Province of Saskatchewan; **Calculations based on conversion factor of 1.0 KCl equals 0.60 K_2O equivalent for conventional mines and 0.62 for solution mine.

CURRENT OPERATIONS

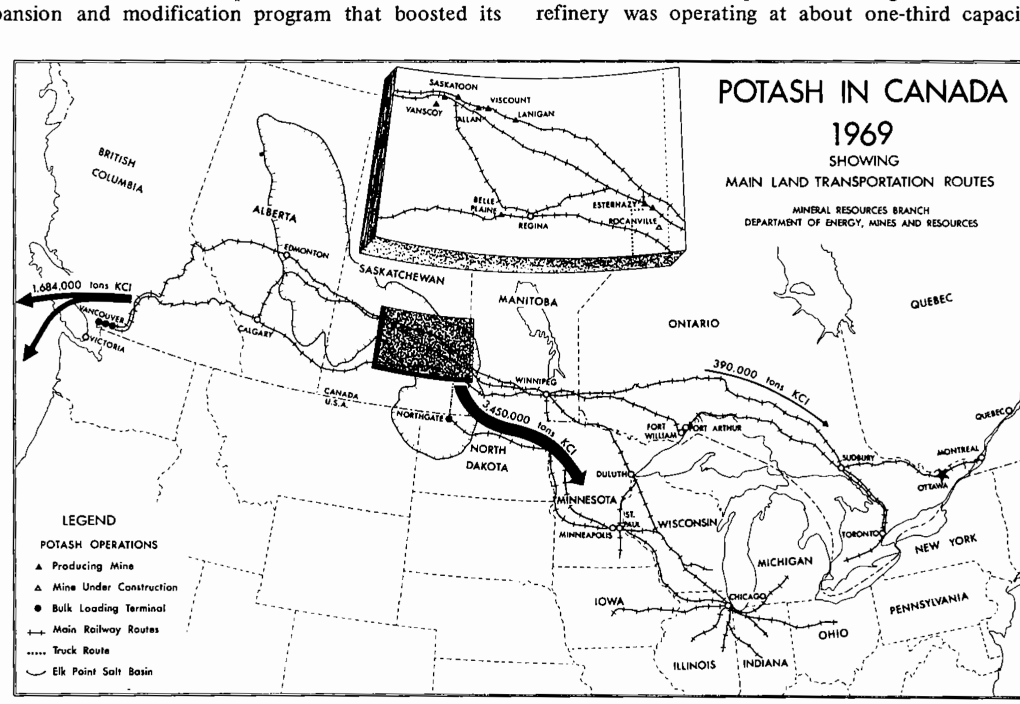
Although potash permits have been issued in all three prairie provinces and extensive drilling has been done in the area around St. Lazare, Manitoba, most exploration work has been concentrated in a belt 120 miles wide that extends southeasterly from just west of Saskatoon to the Manitoba border. This 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 1969 there were outstanding in Saskatchewan, 13 potash leases comprising 964,499 acres, one 99,840-acre lease pending, and 14 permits totalling 1,065,511 acres.

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, one of which is still under construction. 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 3, nine mines with an installed annual productive capacity of 11.85 million tons of potassium chloride (7.13 tons K_2O equivalent), were operating at the end of 1969. Kalium Chemicals Limited completed a $10–million expansion and modification program that boosted its annual productivity capacity to 1.25 million tons of potassium chloride; Potash Company of America completed the sinking of a second mine shaft in February 1969, at a cost of $12 million. The new shaft, 18 feet in diameter, is being used for ventilation and supply purposes but has been designed to allow mine expansion to 3 million tons of potash product annually should markets improve. Early in 1969, Texas Gulf Sulphur Company acquired from Homestake Mining Company a 40–per cent financial interest in Allan Potash Mines; the remaining interest is shared, 40 per cent by United States Borax & Chemical Corporation and 20 per cent by Swift Canadian Co., Limited. Allan Potash Mines was renamed APM Operators Ltd., effective January 1, 1970.

In January 1969, Cominco Ltd. officially opened its $65 million potash mine at Vanscoy, 20 miles southwest of Saskatoon. The production and service shaft was completed to a depth of 3,750 feet and the base of the potash being mined is at 3,537 feet. A downcast ventilation shaft, 500 feet from the production and service shaft, was bottomed at 3,575 feet. Cominco's mine and refinery has been designed to produce 1.2 million tons of potassium chloride annually.

In August 1969, Noranda Mines Limited started up its potash mine at Viscount, 45 miles east of Saskatoon, and by year-end, three continuous mining machines were in operation underground and the refinery was operating at about one-third capacity.



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. Output from Noranda's operation was scheduled to reach designed capacity of 1.5 million tons of potassium chloride annually by mid-1971. Noranda has a contract with a large U.S.-based co-operative, Central Farmers Fertilizer Company, for the sale of all or nearly all of its potash and the latter also has an option to acquire a 49-per cent interest in Noranda's mine. The mine and refinery, built at a cost of $89 million, is being operated under the name, Central Canada Potash Limited.

Sylvite of Canada Division of Hudson Bay Mining and Smelting Co., Limited was developing a $70-million potash mine near Rocanville, about 25 miles southeast of Esterhazy. Twin shafts, 515 feet apart, were being sunk to a depth of about 3,300 feet. The mine and refinery will have an annual productive capacity of 1.0 million tons of potassium chloride annually and is expected to begin operation in January 1971.

Other companies, notably Scurry-Rainbow Oil Limited, Canberra Oil Company Ltd., Kerr-McGee Corporation, Southwest Potash Corporation, Lynbar Mining Corporation Limited, and Great Canadian Potash Corporation Limited, have been conducting feasibility studies in anticipation of mine development but none have made firm commitments.

CANADIAN 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 and Quebec. Potash fertilizer consumption in Canada in the fertilizer year 1968/69 (twelve months ended June 30, 1969) was 200,531 tons K_2O equivalent, up 10 per cent from the previous twelve months. Deliveries of potash salts for agricultural purposes in Canada for the calendar year 1969 were 262,938 tons K_2O equivalent, consisting of 242,585 tons as potassium chloride supplied almost entirely from Saskatchewan, and 20,353 tons as potassium sulphate and potassium magnesium sulphate imported from the United States. Deliveries in 1969 were 45 per cent higher than in 1968, some of the increase being attributed to year-end stockpiling of potash by fertilizer distributors, pending a rise in prices in January 1970. Potash deliveries for industrial purposes (such as for soaps, cleansers, gypsum products and medicinals) in Canada were 5,013 tons K_2O equivalent in 1969.

The United States is Canada's leading export market for potash, followed by Japan and Britain. In 1969, about 2,263,000 tons K_2O equivalent, representing about 64 per cent of Canada's potash output went to the United States. The bulk of these shipments were carried by railway from the mines to market outlets in the central and midwestern states; some shipments were carried by a truck-railway system, the trucks operating from Esterhazy to the International Boundary, thence by railway to marketing outlets in Wisconsin and Illinois. A substantial quantity of the shipments to United States go by railway to Vancouver, thence by ocean-going vessels to the southeastern states, and still others have been shipped by rail to the Lakehead and then by boat to lower Great Lakes ports.

Almost all of Canada's overseas potash sales are channelled through the Vancouver port area, some 1,100 railway miles from the potash mines. In 1969, the three bulk-loading terminals–Vancouver Wharves Ltd., Pacific Coast Bulk Terminals Ltd., and Neptune Terminals Ltd.–in the Vancouver area, handled 1.68 million tons of potash product for export markets. The three terminals collectively provide storage for 350,000 tons of potash product and a loading capacity of about 11,000 tons an hour. Deep-sea berthing facilities at these terminals can accommodate vessels up to 65,000 dead-weight tons.

TABLE 5

Canada, Consumption of Potash Fertilizers, Years Ended June 30, 1960-69
(short tons K_2O equivalent)

Year Ended June 30	In Materials	In Mixtures	Total
1960	4,387	84,888	89,275
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	58,944	141,587	200,531

Source: Dominion Bureau of Statistics.

The railway freight rate for transporting potash in bulk from the mines in Saskatchewan to the Vancouver terminals for export is $9 a short ton (the rate was increased to $9.54 a short ton effective February 19, 1970). Although there are no posted shipping rates for ocean transport, the following reported tramp charterings are regarded as indicative of ocean freight costs for potassium chloride from Vancouver to various world ports (all figures are given in US dollars a long ton on free in and out terms): $4.20 to $5.50 a ton for 18,000 to 45,000-ton bulk cargoes to Rotterdam, Netherlands; $4.50 a ton for 24,000-ton bulk cargoes to Ulsan, South Korea; $4 to $5 a ton for 20,000 to 30,000-ton bulk cargoes to US Gulf and

TABLE 4

Canada, Potash Deliveries by Product and Area, 1968-69
(short tons K_2O equivalent)

		Agricultural						Industrial
		Potassium Chloride				Potassium Sulphates	Total Agricultural	
		Standard	Coarse	Granular	Soluble			
Atlantic Provinces	1968	7,136	15,623	–	..	935	23,694	–
	1969	5,873	27,910	–	–	1,105	34,888	–
Quebec	1968	14,903	24,803	171	..	1,760	41,637	248
	1969	19,768	38,119	1,994	50	3,197	63,128	273
Ontario	1968	25,943	64,397	3,666	..	13,278	107,284	4,416
	1969	16,819	78,797	5,193	4,157	15,634	120,600	4,511
Prairie Provinces	1968	1,558	1,325	1,617	..	–	4,500	134
	1969	7,767	2,707	2,027	17,702	103	30,306	92
British Columbia	1968	781	2,257	825	..	351	4,214	25
	1969	4,053	8,153	1,122	374	314	14,016	137
Totals	1968	50,321	108,405	6,279	..	16,324	181,329	4,823
	1969	54,280	155,686	10,336	22,283	20,353	262,938	5,013

Source: American Potash Institute
–Nil; . . Not available for 1968.

Atlantic ports; \$8.25 to \$10 a ton for 10,000 to 16,000-ton bulk cargoes to Santos and Rio Grande, Brazil; \$8 to \$8.25 for 12,000-ton bulk cargoes to New Zealand ports; and \$12.85 a ton for 11,500-ton bulk cargo to east coast ports in India.

As indicated in Table 2, 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 24,600 in 1968/69. Imports during the last few years consisted largely of potassium sulphate, potassium magnesium sulphate and potassium nitrate, none of which are produced in Canada.

WORLD HISTORY AND REVIEW

Germany was the centre of the world's potash industry prior to World War I but with the restoration of Alsace-Lorraine to France, the Alsatian potash deposits came under French control. After a brief period of competition, a cartel consisting of German and French producers was organized and beginning in 1924, agreements were made to share foreign potash markets on the basis of 70 per cent for Germany and 30 per cent for France. Potash prices at North American ports remained fairly constant at roughly 62¢ per unit K_2O equivalent from 1924 to 1933.

In the meantime, potash deposits were developed and brought into production in Poland (1920), Spain (1926), United States (Carlsbad, New Mexico, 1931), Palestine (1932) and Russia (1932). Although production from these new sources remained fairly small during early years, pressure on the German-French cartel gradually increased and in 1934 potash prices at United States ports were slashed 50 per cent. As the 1930's progressed, potash output in United States expanded quite rapidly and began penetrating European markets. To avoid market disruption, a Potash Export Association was formed in United States in 1938 and an arrangement was made with the cartel for a share of the European market. By that time, potash prices at United States ports had rallied to about 47¢ per unit K_2O equivalent. Also by that time, United States had become the chief supplier for Canada's potash needs, accounting for about 72 per cent of Canada's potash fertilizer imports of about \$1.33 million in 1939.

During World War II, United States became self-sufficient in potash and continued to supply most of Canada's needs. With the division of Germany, United States emerged as the world's leading potash producer, followed by West Germany, East Germany, France and USSR. Their respective positions remained unchanged until 1964 and from 1950 to 1964, world potash production and consumption experienced an average annual growth rate of about 7 per cent. Prices were fairly steady with the average value of United States potash producer shipments ranging from a low of 33.9¢ per unit K_2O equivalent in 1958 to a high of 41.3¢ in 1965.

TABLE 6

World Potash Production, 1968-69
('000 metric tons K_2O equivalent)

	1968	1969p
Canada*	2,700	3,400
USSR	3,120	3,200
United States	2,469	2,544
Germany, East	2,293	2,400
West	2,220	2,260
France	1,719	1,800
Spain	592	633
Israel	366	400
Italy	266	259
Congo	–	50
Chile (nitrate)e	20	20
Total	15,765	16,966

Source: U.S. Bureau of Mines, Dominion Bureau of Statistics, and The Journal of World Phosphorus and Potassium.
*Production figures in previous editions of the Canadian Minerals Yearbook referred to shipments.
pPreliminary; eEstimated.

Regular production of potash in Canada began in 1962 and by the end of 1965 three mines were in operation and another six were under construction. In 1965, world potash consumption jumped sharply and for the three-year period 1965 to 1967, world consumption increased at an average annual rate of 10 per cent, but with the new production from the rich deposits in Canada and greater output from the USSR, world potash production increased at a greater rate. Prices began to weaken in 1966 and the trend continued throughout 1967 and 1968 and in 1969 North American prices reached the lowest level on record. In 1967, the USSR became the world's leading potash producer, only to be displaced by Canada in 1969.

As indicated in Table 6, potash production in 1969 remained relatively unchanged from the previous year in most countries with the exception of Canada, the Congo, and the United States. In May 1969, Compagnie des Potasses du Congo shipped the first potash from its \$US 82 million mine near Saint Paul, Republic of Congo (Brazzaville), some 30 miles inland from the Port of Pointe Noire. The mine is designed to produce 500,000 metric tons of K_2O equivalent annually, but that level of output is not expected for several years.

In the United States, potash production in 1969 regained slightly from its 1968 low. A Carlsbad, New Mexico, mine that had been closed down in 1967 was reactivated at a modified rate in the latter part of 1968 and operated throughout 1969 by United States Potash and Chemical Co. Elsewhere in the United States, Great Salt Lake Minerals & Chemical Corp., a subsidiary of Gulf Resources & Chemical Corporation and a German Company, Salzdetfurth, is apparently proceeding with plans to construct a brine recovery plant at Great Salt Lake, Utah. The complex is to include a 220,000-ton-a-year potassium sulphate plant and is scheduled to begin operation in 1971. Also at Great Salt Lake, a similar complex is planned by National Lead Company and Hogle-Kearns Co.

Potash production in USSR increased only slightly in 1969, apparently because of processing interruptions that became necessary in order to reduce mine inventories, which had accumulated as a result of transportation problems. Output is expected to rise considerably in the next few years with the completion in late 1969 of the first sections of two potash combines, Berezniki II in the northern Urals and Soligorsk III in the Minsk area; second sections are scheduled to begin operation in 1970. Additional combines are under construction at both locations.

Potash output in both France and West Germany, although up slightly in 1969 from the previous year, remained at approximately the same levels as the past few years but considerably lower than the peaks established in 1965. The potash industries in both countries have been introducing major programs of rationalization and modernization during the past few years in an effort to reduce operating costs and stabilize output. In East Germany, the potash industry has also been modernized during the past few years and production has been increasing steadily; output in 1969 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 1970, followed by a substantial rise in 1971 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 is believed to have begun operation late in 1968 to process some low-grade potash deposits near Klodawa, central Poland. The potash beds apparently are highly folded and irregular and this operation would appear to be marginally economic. Output in 1969, although not included in world production statistics, is estimated to have been about 15,000 tons K_2O equivalent.

The Spanish potash industry has been steadily increasing its output during the past five years and has become a significant supplier of potash for the rest of Europe; further 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, Dead Sea Works, Ltd. completed an expansion of processing facilities in 1969, to bring its productive capacity to 720,000 metric tons K_2O equivalent annually. The company depends entirely on export markets and as a result of depressed potash prices and a continuation of hostilities in the Middle East, has apparently suffered some financial losses and has had some difficulty in moving its products to market.

Construction has started 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., are seeking approval from local authorities to proceed with their plans to construct a second and third mine in the same area. The Yorkshire deposits occur at a depth of 3,200 to 4,000 feet and grade 26 to 30 per cent K_2O equivalent.

Potash and magnesium salts have been discovered in the Netherlands and in 1969 plans were drawn up by a newly formed subsidiary of Royal Dutch Shell for further drilling and exploration in anticipation of outlining an exploitable deposit; the beds are at a depth of about 6,000 feet and would presumably be mined by solution methods. In Australia, Texada Mines Pty. Ltd. proceeded in 1969 with development of a salt-potash project at Lake McLeod, a few miles from Cape Ciwier, Western Australia; salt production is expected to begin in 1970 and potash recovery is to follow in a year or so.

Although there is scarcely any data available with respect to potash operations in Mainland China, there have been reports that production from a surface deposit in west-central China began about ten years ago. On the basis of potash consumption figures published by the United Nations, it is estimated that annual output from Mainland China is in the order of 75,000 metric tons K_2O equivalent.

TARIFFS AND QUOTAS

For the most part, potash as produced at the mine, whether it be in Saskatchewan or elsewhere or whether the product be potassium chloride or potassium sulphate, has in recent years moved freely in international trade and has not been subject to tariffs and quotas. When applicable, tariffs have generally been confined to potassium-bearing chemicals imported for industrial purposes rather than agricultural purposes. The French potash industry, by virtue of having a central marketing agency that handles both domestic and export sales, is reputed to have effective control over potash imports, but this has been regarded as one of the few examples of trade barriers for potash in recent years.

The highly competitive conditions that have developed in the world potash industry since Canada emerged as a prominent producer have had a strong impact on international potash trade, particularly with respect to the United States. For example, Canada supplied about one-half the potash consumption in the United States in 1969, which is in sharp contrast to 1960 when imports accounted for less than 10 per cent of that country's needs. In 1967, one potash mine in the United States was temporarily closed and production was cut back at another, and as the miners were laid off, charges were made that Canadian potash was being 'dumped' in the United States market. In September 1967, an anti-dumping investigation was launched by the United States Bureau of Customs and in June 1968, withholding of appraisement notices for potassium chloride from Canada, France and West Germany were posted. On August 20, 1969, the United States Treasury Department announced its finding that potassium chloride was being and is, likely to be, sold at less than fair value within the meaning of Anti-dumping Act, 1921, as amended, and on November 21, 1969, the United States Tariff Commission, announced its finding that the potash industry in United States is being, and is likely to be, injured by reason of less than fair value imports of potassium chloride from Canada, France, and West Germany. As a result of the Tariff Commission's determination, potash from Canada, France and West Germany sold at less than fair value became subject to special dumping duties.

Also, in the United States, a bill was placed before the Senate in September 1969 seeking a 40 per cent ad valorem tariff on imports into United States on potassium chloride in excess of 30 per cent of that country's potash needs. Introduction of the bill followed a series of earlier bills dating back to October 1967 that had called for the imposition of quotas to limit imports to 25 per cent of United States potash consumption.

PRICES AND REGULATIONS

Potash prices for the period January 1, 1969, to June 30, 1969, were listed by producers in Canada as follows (Storage allowances of $1.94 to $2 a ton were to be deducted for shipments during the month of January):

Muriate of Potash, bulk, carload lots, f.o.b. mine, per unit (20 lbs) K_2O

	60% K_2O Min.	62% K_2O Min.
Standard	31.3¢	31.9¢ to 33.5¢
Coarse	35.6¢	36.2¢
Granular	37.8¢	38.3¢

The posted prices for that period were a poor reflection of what potash was actually being sold for and at mid-year new price lists were posted for the period July 1, 1969 to December 31, 1969. The new prices were as follows:

Muriate of Potash, bulk, carload lots, f.o.b. mine, per unit (20 lbs) K_2O

	60% K_2O Min.	62% K_2O Min.
Standard	21.1 to 22.6¢	21.6 to 24.8¢
Coarse	24.3 to 25.8¢	24.8¢
Granular	26.5 to 28.0¢	27.0¢

The oversupply of potash accompanied by weak prices and uncertain marketing conditions for Canadian potash prompted the Province of Saskatchewan to promulgate on November 17, 1969, potash production and marketing controls under the Mineral Resources Act, 1959. The regulations, cited as "The Potash Conservation Regulations, 1969" became effective January 1, 1970, and require potash producers in Saskatchewan to obtain production licences and disposal licences. Under the regulations, the Minister of Mineral Resources may determine, on the guidance of a three-member Potash Conservation Board, productive capacities, rates of production, the demand for potash, fair and reasonable prices, and other matters. In this regard, a Ministerial Order was posted by the Province stating that a fair and reasonable price shall be not less than 33.75¢ per unit K_2O equivalent. A formula has been established whereby production rates for the various mines can be set on the basis of their individual mine and plant capacities, individual market needs, and inventory positions.

OUTLOOK

Since January 1, 1970, Canada's potash producers have been subject to production and marketing controls under The Potash Conservation Regulations set up by the Province of Saskatchewan. Under the regulations, for the first two quarters of 1970 the various mines have been allowed to operate at from 40 to 66 per cent of productive capacity, the average for the industry being about 54 per cent. The minimum price of 33.75¢ per unit K_2O equivalent established by a Ministerial Order did not apply to potash held in inventory on January 1st, hence from January to March 1970, Canadian potash prices reportedly ranged from about 21¢ to 37¢ per unit depending largely on the grade and availability of potash. By April, prices were in line with the Ministerial Order. For the most part, United States potash producers have followed Saskatchewan's price leadership, hence North American potash prices are about the same for Canadian and United States produced potash. Other world potash producers have welcomed the price increases and have boosted their own prices but apparently not to the same extent as the increases for Canadian potash. A price differential is of deep concern when Canadian potash is competing in offshore markets. If a price differential exists, and continues to exist, Canadian potash producers are likely to suffer a loss of export markets.

Offshore markets have accounted for about one third Canada's potash exports from 1967 to 1969. This proportion of offshore markets to total exports should be maintained or even improved if Canada's potash industry is to strengthen. North American potash consumption in 1969 amounted to an estimated 4.6 million tons K_2O equivalent and in 1970 it is expected to rise to 5.0 million tons. According to the United States Bureau of Mines, potash consumption in that country is expected to rise from 3.3 million tons K_2O equivalent in 1965 to 7.7 million tons in 1980 for an average annual growth rate of 5.8 per cent. On the basis of the foregoing estimates one might predict that North American potash consumption in 1975 will be 6.4 million tons K_2O equivalent. Judging by the recent performance of the United States potash industry, Canada's share of the North American potash market will be about 2.9 million tons K_2O equivalent in 1970, rising to 4.4 million tons in 1975. Canada's offshore sales in 1969 amounted to about 850,000 tons K_2O equivalent; unless that export level is substantially improved in 1970, Canadian potash producers will be faced with even greater inventories in spite of the fact that they are currently operating at about half their productive capacity.

Rare Earths

ROBERT J. SHANK*

The rare earths are the top 17 metals in Group III B of the periodic table. They are:

Element No.	Name	Abbre-viation	Abundance in Igneous Rocks – parts per million
21	Scandium	Sc	5.0
39	Yttrium	Y	28.0
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
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
			153.0

On this basis, cerium is more abundant than tin or cobalt and almost three times as abundant as lead; thulium is more abundant than silver. Thus, the rare earths are not "rare" and they are not "earths" but metals. "Earth" is the old chemical term for "oxide" and the rare-earth elements were discovered as oxides.

Those elements from lanthanum to gadolinium, inclusive, are known as the "light" rare earths, while those from terbium to lutetium are the "heavy" rare earths. Scandium is usually associated with the light rare earths and yttrium with the heavies.

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 occurred in the last six years. 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 markets in the future.

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CANADIAN INDUSTRY

Uranium mines in the Elliot Lake district of Ontario have been the major source of yttrium-bearing concentrate in the world for the past four years. All rare earths, except promethium, have been detected in these ores which contain the minerals uraninite, uranorthite, brannerite and monazite. The rare earths and thorium can be recovered from effluent solutions following uranium extraction. Variable recoveries are possible depending upon the method used. Under current conditions of supply and demand, the yttrium oxide content is the only constituent of value. The Elliot Lake ores contain about 0.11 per cent uranium oxide (U_3O_8), 0.028 per cent thorium oxide (ThO_2), and 0.057 per cent rare earth oxides (REO). The distribution of the individual rare earths in the REO is variable but approximates 20 to 40 per cent yttrium oxide, 20 per cent cerium oxide, 10 to 20 per cent neodymium oxide, with the others seldom exceeding 5 per cent.

There are no facilities in Canada for the separation of the individual rare earths and all output is exported. Denison Mines Limited continued to be the only producer of rare earth concentrate in 1969. Rio Algom Mines Limited phased-out production of thorium and the rare earths at its Nordic mill at the end of 1967 and did not resume production when the milling of uranium ores was transferred to the Quirke mill.

Shipments of rare earth concentrate for the past five years are summarized in the table below.

Year	Y_2O_3 in Concentrate – pounds	Value
1969	86,127	$ 675,549
1968	113,330	936,067
1967	172,551	1,594,298
1966	20,724	130,223
1965	–	–

This reduction in shipments reflects the oversupply situation existing in markets for yttrium and the heavy rare earths. There is some indication that research into new uses for the heavy rare earths is increasing. Success in this field could lead not only to greater demand for Canadian supplies but also to more advanced separation and treatment facilities in Canada.

Besides the large potential of the Elliot Lake uranium ores, rare earths are also associated with uranium deposits at Agnew Lake, 40 miles east of Elliot Lake, where the REO content is about twice that of Elliot Lake ores, in the Bancroft area of Ontario, and at one deposit in British Columbia; the distribution of rare-earth elements in these deposits is not known. Phosphorite formations in western Canada contain small quantities of rare earths as do Florida phosphates imported into Canada for the production of phosphoric acid. Other potential sources include the rare earth content of apatite or pyrochlore associated with carbonatite rocks.

Few laboratories are equipped to analyze samples containing rare earth elements. Assay results can be misleading unless the laboratory is provided with information on the mineralogy or chemistry of the test material.

WORLD INDUSTRY

The minerals monazite and bastnasite are the main sources of cerium group rare earths. These may be processed to recover mixed rare earths for low value products such as mischmetal or may be further processed at much higher cost to separate individual rare earths. The two methods of recovery, for higher purity compounds, are solvent extraction and ion exchange, or combinations of these.

Australia is the main source of monazite. Recovery is a byproduct of mining beach sands for rutile and zircon. In the United States, there is some recovery from beach sands in Georgia and from molybdenum mining in Colorado. Some Indian beach sands are mined; the concentrates being treated either domestically or in Japan. Brazilian production is processed domestically. Small parcels from a number of other countries do not add materially to supply. As monazite of placer origin is relatively low cost, lode deposits are currently uneconomic.

The mine of Molybdenum Corporation of America (Molycorp), at Mountain Pass, California is the main source of concentrates for cerium group rare earths and, unlike monazite, concentrates from this unusual deposit in carbonatite do not contain thorium. The ore, mined by a small, low cost, open pit, grades 8 to 10 per cent rare earth oxides. The rare earth distribution in per cent is cerium 48, lanthanum 32, neodymium 13.1, praseodymium 4.5, samarium 0.5, gadolinium 0.2, europium 0.1, other-yttrium group 0.3.

The adjacent mill produces a flotation concentrate grading 60 per cent rare earth oxide, a leached concentrate grading 70 per cent and a calcine grading 90 per cent. A chemical and solvent extraction plant makes intermediate rare-earth products and separates a number of rare earths including europium. Further processing is carried out at Louviers, Colorado and York, Pennsylvania.

During 1969 Molycorp made arrangements with Republic Steel Corporation to treat tailings dumps at Republic's iron mining operation at Port Henry, New York, for their heavy rare earth content. Molycorp has until June 30, 1972 to make its final decision whether or not to proceed on the project. That decision will hinge largely on further market development for the heavy rare earths.

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. Other sources of phosphate rock, such as those from Florida, contain lesser amounts with a different rare earth distribution.

Xenotime, valuable for its yttrium content, is recovered from heavy mineral rejects in concentrating placer tin in Malaysia and from retreatment of monazite concentrate, itself a byproduct, from western Australia. Such concentrates are usually treated in Europe or Japan.

A few uranium mines have rare earths as a potential byproduct not in the form of a mineral concentrate but as a chemical precipitate from treating barren liquors following uranium extraction. While such precipitates are free of thorium, the thorium content must be removed prior to rare earth recovery. Canadian production is of this type. Potential sources in Australia are Mary Kathleen Uranium Limited and Field Metals and Chemicals Pty. Limited. The latter, in re-opening the Port Pirie uranium extraction plant, may recover scandium oxide among other possible products. Should markets for scandium develop, thorveitite, a mineral found in Norway, is a possible source. This element is mainly used in basic research. Commercial applications have been negligible but a market may develop from an improved mercury arc light now being tested which contains scandium as well as mercury, thorium and sodium.

Other rare earth minerals such as euxenite, samarskite, and fergusonite are occasionally available but they are difficult to treat and markets for these yttrium group rare earths are limited.

It is worth noting that promethium isotopes have half lives ranging from seconds to 18 years. Accordingly, its natural occurrence is extremely minute. The commercial source of promethium 147 is from waste fission products in atomic reactors. Its radioactive properties are attractive as a power source in space research as well as in luminescent paints.

The main world processors of rare earth ores and concentrates include: in the United States, 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 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.

USES

Rare earths are consumed mainly as oxides, the form in which they are produced by chemical extraction from the mineral concentrates. The purity of the various REO mixtures is usually expressed in terms of total REO content; the individual rare earths being present in about the same proportions as they occur in the originating concentrates. Mixtures are used in glass-polishing compounds, for the production of mischmetal, and as alloying agents in nodular iron, steel, and magnesium. Mischmetal, which is mostly cerium, lanthanum and neodymium, has a stable use in lighter flints. Refined rare earth chlorides of lanthanum, neodymium and praseodymium are used in petroleum refineries to increase the yield of gasoline during the distillation process.

The main metallurgical uses are those involving cerium in the preparation of nodular iron, and yttrium and neodymium as hardeners in magnesium alloys. In marine turbine applications, corrosion rate may be reduced by a factor of ten by the addition of 0.1 to 0.2 per cent yttrium to cobalt-base alloys, and of lanthanum or cerium to nickel-base alloys. Samarium-cobalt permanent magnets are now in use that have twice the strength of any conventional permanent magnets. These magnets can be formed by melting the constituents as metals and casting, or by pressing the constituents as metal powders to shape. Gadolinium and europium are used in control rods in nuclear reactors.

Artificial garnets containing yttrium and gadolinium are used in microwave devices. One very new application of yttrium-aluminum-garnets (YAGs) is in the jewelry trade replacing spinel crystals. YAGs have slightly less lustre than spinel but are harder, being about 8.9 on Mohs scale. The demand is reported to be large and growing.

Varied and growing applications are evident in the glass industry, ranging from the use of cerium to neutralize the effects of iron impurities to the absorption of ultra-violet rays in bottles by additions of cerium and praseodymium to coloured glass. Praseodymium imparts a yellow-green colour, neodymium a lilac-purple, europium an orange-red, and erbium a pink. Lanthanum is a major component of optical glass and cerium glass has application as windows in atomic reactors.

The main demand in the electronics industry is for high-purity red phosphors for use in colour television tubes. Technical improvements led to a decrease in consumption to 5 grams per tube. Brighter phosphors have been developed such as europium activated yttrium oxysulphide. Gadolinium oxide activated with europium is under development. Terbium can be used as a glaze stain, but will not colour glass.

A range of phosphors that convert infra-red radiation to visible light have recently been discovered. The source of infra-red radiation is a silicon-doped gallium arsenide diode. Ytterbium absorbs the radiation and passes it to other rare earth ions in the phosphor. Red, green and blue light can be produced by using various combinations of holmium, erbium and thulium.

A lamp that changes colour as the electric power supplied to it is varied has also been developed. The phosphor, which uses oxychlorides host crystals containing ytterbium, erbium and holmium, produces light that varies from red to green as the power is reduced.

The number of compounds that theoretically can be made from mixtures of the rare earths with each other and with the other 86 elements is somewhat staggering. Research to date has been sufficient to examine only a small portion of these. An effort is being made to use computers to indicate what compounds might form. A follow-up to this would be to use computers to forecast what properties these compounds might have. This would aid in designing new compounds for specific purposes.

PRICES

Metals Week in April 1970 quoted a nominal value of \$180 to \$200 a long ton for monazite sand, c.i.f. United States ports. Unleached bastnasite concentrates, f.o.b. California, were quoted at 30 cents a pound for material grading 55 to 60 per cent rare earth oxide. Leached concentrate sells for 35 cents a pound for a grade of 68 to 72 per cent. Calcined oxide from this source assaying 88 to 92 per cent rare earth oxide was quoted at 45 cents a pound.

The grade of concentrates originating from Canada is not published, but sales made in 1969 had a value of \$7.84 Canadian per pound contained Y_2O_3 as compared to \$8.39 in 1968. Concentrates are best sold on a contract basis and odd lots may be difficult to sell.

Refined products have a wide range in price depending upon purity, demand, and whether in the oxide or metal state. Some typical prices, as quoted in the *American Metal Market,* are given here to illustrate the ranges involved. Metallurgical or glass grades of cerium oxide are available at 40 cents a pound while other grades range up to \$7.50 a pound. Yttrium oxide, phosphor grade, is worth \$38 a pound, europium oxide \$519, samarium oxide \$40, lanthanum oxide \$4.50, neodymium oxide \$25, and praseodymium oxide \$38. Mischmetal sells for \$3 a pound, yttrium metal for \$260, and thulium for \$6,000.

Salt

W.E. KOEPKE*

Salt production in Canada in 1969 declined slightly from the previous year largely as a result of temporary closures that were brought about by labour disputes at a rock salt mine and an evaporator plant. Demand for salt and its chemical derivatives in Canada remained strong in 1969 but, in spite of the decline in output, there were no severe shortages of salt. Some of the decrease in output for 1969 was attributed to the cessation of brine exports to the United States in 1968, which was also reflected in a decrease in the value of Canada's exports. Solar salt from Mexico and the San Francisco Bay area to supply west coast markets constituted the greater portion of imports, which reached an all time high of 696,000 tons in 1969.

Developments in Canada's salt industry in 1969 were highlighted by the completion of a salt processing plant based on byproduct brines from a potash mine in Saskatchewan. Other developments in the year included: partial completion of a $2.4 million expansion program at an evaporator plant at Unity, Saskatchewan; initiation of brining to develop a liquid petroleum gas storage cavern near Sarnia, Ontario; the start of a two phase expansion program of the rock salt mine at Goderich, Ontario; and a continuation of exploration for salt deposits in the Atlantic Provinces, particularly in Nova Scotia.

PRODUCTION AND DEVELOPMENTS IN CANADA

Canadian salt production falls into three statistical classes: (1) mined rock salt, (2) fine vacuum salt, and (3) salt content of brines used or shipped and salt recovered in chemical operations. Total salt production (shipments) in Canada in 1969 was 4,629,000 tons valued at $32.3 million. The tonnage was down slightly from 1968 while the value increased slightly. Much of the decline in output is attributed to the shutdown of The Canadian Rock Salt Company Limited's rock salt mine at Ojibway, Ontario, from April to September 1969, which came about as a result of a labour dispute. Production of mined rock salt accounted for two-thirds of Canada's total salt output and was an estimated 3,080,000 tons in 1969 compared with 3,230,305 tons in 1968. Output of fine vacuum salt also decreased in 1969 because of a labour dispute at The Canadian Salt Company Limited's salt plant at Windsor, Ontario, that kept operations closed from January to August. Salt brine production was also down in 1969, a decrease brought about by the cessation in mid-1968 of brine exports from Canadian Brine Limited's operations at Windsor. This decrease was partially offset by the output from Dow Chemical of Canada, Limited's brine-based caustic soda-chlorine plant at Fort Saskatchewan, Alberta, which came on stream late in 1968. Brine output also increased in the Sarnia, Ontario area in 1969, where in mid-year Dome Petroleum Limited and Amoco Canada Petroleum Company Ltd. began developing a liquid petroleum gas storage cavern; the salt brines obtained from the cavity are piped to Dow Chemical's nearby caustic soda-chlorine plant.

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 our salt requirements.

*Mineral Resources Branch.

TABLE 1

Canada, Salt Production and Trade, 1968-69

	1968		1969P	
	Short Tons	$	Short Tons	$
Production (shipments)				
By type				
Mine rock salt	3,230,305	16,710,723	. .	. .
Fine vacuum salt	553,280	11,121,103	. .	. .
Salt content of brines used or shipped and salt recovered in chemical operations	1,080,739	3,338,266	. .	. .
Total	4,864,324	31,170,092	4,629,000	32,340,000
By provinces				
Ontario	4,143,759	21,605,938	3,762,000	21,068,000
Nova Scotia	473,584	5,243,697	500,000	5,348,000
Alberta	120,381	1,776,359	231,000	3,029,000
Saskatchewan	99,480	1,928,108	92,000	1,944,000
Manitoba	27,120	615,990	44,000	951,000
Total	4,864,324	31,170,092	4,629,000	32,340,000
Imports				
Total, salt and brine				
Mexico	215,777	366,000	321,043	477,000
United States	280,969	2,138,000	290,670	2,192,000
Spain	33,647	136,000	40,363	159,000
Bahamas	101,840	415,000	23,173	105,000
Bermuda	–	–	12,000	88,000
Britain	9,450	39,000	6,959	32,000
Other countries	2,470	25,000	1,430	34,000
Total	644,153	3,119,000	695,638	3,087,000
Exports				
United States	. .	5,818,000	. .	5,050,000
Jamaica	. .	63,000	. .	18,000
Leeward and Windward Islands	. .	8,000	. .	10,000
Bermuda	. .	10,000	. .	9,000
New Zealand	. .	5,000	. .	7,000
Other countries	. .	17,000	. .	13,000
Total	. .	5,921,000	. .	5,107,000

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

In Canada, underground salt deposits have been found in all provinces except Quebec and British Columbia. They have also been fround 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 was recovered from brine springs in Nova Scotia, New Brunswick, Ontario, Manitoba, Saskatchewan and Alberta. Salt springs are also common in southwestern Newfoundland and in certain parts of British Columbia.

TABLE 2

Canada, Salt Production and Trade, 1960-69

	Production*	Imports	Exports
	(short tons)		$
1960	3,314,920	191,940	3,461,366
1961	3,246,527	199,365	2,829,138
1962	3,638,778	245,836	3,987,668
1963	3,721,994	332,581	3,701,356
1964	3,988,598	405,574	3,618,569
1965	4,584,096	441,601	4,996,509
1966	4,492,034	509,548	3,588,000
1967	5,361,463	567,012	5,926,000
1968	4,864,324	644,153	5,921,000
1969P	4,629,000	695,638	5,107,000

Source: Dominion Bureau of Statistics.
*Producers' shipments.
PPreliminary.

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, between 900 and 2,700 feet below surface can be identified and traced from drilling records; maximum bed thickness is 300 feet with aggregate thicknesses reaching as much as 700 feet. They occur in the Salina Formation of Upper Silurian age. The beds are relatively flat-lying and undisturbed, permitting easy exploitation.

In 1969, 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. Developments in Ontario's salt industry during 1969 included the start-up of a brining operation near Sarnia by Dome Petroleum Limited and Amoco Canada Petroleum Company Ltd. to develop a storage cavern for liquid petroleum gas. In mid-year, Domtar Chemicals Limited started work on the first phase of a two-phase expansion program which will boost the productive capacity of its Goderich salt mine to 2.25 million tons of salt annually by 1972. The first phase involves 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 called for the small plant to produce flake salt for local markets.

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 1969 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 exploration of salt deposits under mainland Nova Scotia and Cape Breton Island. Although no new salt or brine producing operations have been announced for the area, Canso Chemicals Limited, an associated company of Canadian Industries Limited and two pulp and paper companies, has been constructing a chlor-alkali plant at Abercrombie Point, near New Glasgow, Nova Scotia; completion was expected in April 1970.

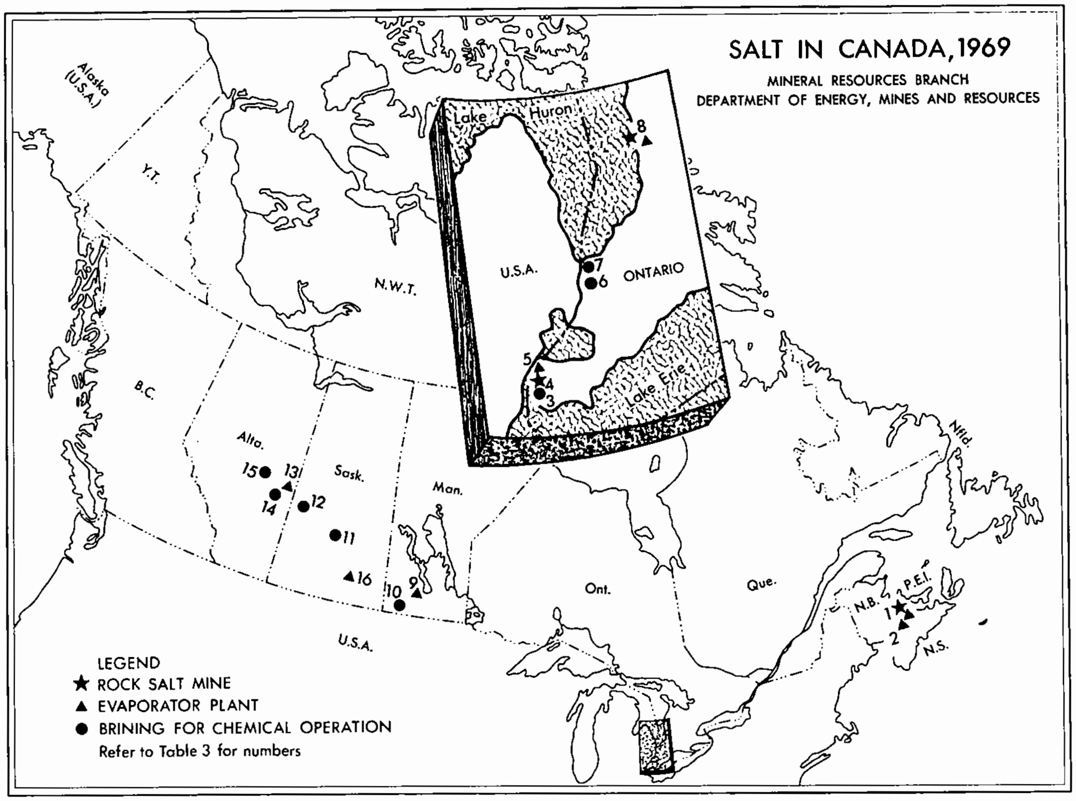
Prairie Provinces

Salt beds underlie a broad belt of the Prairie Provinces extending from the extreme southwestern corner of Manitoba, northwestward across Saskatchewan and into the north-central part of Alberta. Most of the salt deposits occur within the Prairie Evaporite Formation, which constitutes the upper part of the Middle Devonian Elk Point Group, with thinner beds occurring in Upper Devonian rocks. Depths range from 600 feet at Fort McMurray, 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.

TABLE 3

Canada, Summary of Salt Producing and Brining Operations, 1969
(refer to map for numbers)

Company	Location	Initial Production	Remarks
1. The Canadian Rock Salt Company	Pugwash, N.S.	1959	Rock salt mining at a depth of 630 feet.
Limited	Pugwash, N.S.	1962	Dissolving rock salt fines for vacuum pan evaporation.
2. Domtar Chemicals Limited	Amherst, N.S.	1947	Brining for vacuum pan evaporation.
3. Allied Chemical Canada, Ltd.	Amherstburg, Ont.	1919	Brining to produce soda ash.
4. The Canadian Rock Salt Company Limited	Ojibway, Ont.	1955	Rock salt mining at a depth of 980 feet.
5. The Canadian Salt Company Limited	Windsor, Ont.	1892	Brining, vacuum pan evaporation and fusion.
6. Dome Petroleum Limited	Sarnia, Ont.	1969	Brining to develop storage cavity.
7. Dow Chemical of Canada, Limited	Sarnia, Ont.	1950	Brining to produce caustic soda and chlorine.
8. Domtar Chemicals Limited	Goderich, Ont.	1959	Rock salt mining at a depth of 1,760 feet.
	Goderich, Ont.	1880	Brining for vacuum pan evaporation.
9. The Canadian Salt Company Limited	Neepawa, Man.	1932	Pumping natural brines for vacuum pan evaporation.
10. Dryden Chemicals Limited	Brandon, Man.	1968	Pumping natural brines to produce caustic soda and chlorine.
11. Interprovincial Co-Operatives Limited	Saskatoon, Sask.	1968	Brining to produce caustic soda and chlorine.
12. Domtar Chemicals Limited	Unity, Sask.	1949	Brining, vacuum pan evaporation and fusion.
13. The Canadian Salt Company Limited	Lindbergh, Alta.	1948	Brining, vacuum pan evaporation and fusion.
14. Chemcell Limited	Two Hills, Alta.	1953	Brining to produce caustic soda and chlorine.
15. Dow Chemical of Canada, Limited	Fort Saskatchewan, Alta.	1968	Brining to produce caustic soda and chlorine.
16. The Canadian Salt Company Limited	Belle Plaine, Sask.	1969	Producing fine salt from byproduct brine from potash mine.



These rock salt deposits were being tapped at five locations in the Prairie Provinces in 1968 – Saskatoon and Unity, Saskatchewan; Lindbergh, Two Hills, and Fort Saskatchewan, Alberta. In addition, naturally occurring subsurface salt brines in Manitoba were being used to produce caustic soda and chlorine at Brandon, and fine salt at Neepawa. The Neepawa plant was closed in January 1970, following the start-up in October 1969 of The Canadian Salt Company's new $3-million salt processing and packaging plant at Belle Plaine, Saskatchewan, one mile from the potash mine of Kalium Chemicals Limited. Kalium mines potash from beds at a depth about 5,200 feet using solution methods and, by a sequence of multiple-effect evaporation and crystallization, the potassium chloride is separated from the brine. Some of the brine, rich in sodium chloride, is then pumped to The Canadian Salt Company's plant for final processing, drying and packaging; the salt plant is designed to produce 200,000 tons of salt annually.

RECOVERY METHODS

Canadian producers employ two methods for the recovery of salt from depth, the method used depending 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 salt or can be used directly in the manufacture of sodium-bearing chemicals. A third 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 in Canada 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 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 ranges from 40 to 60 per cent.

TABLE 4

World Salt Production
('000 short tons)

	1968p
United States	41,274
China	16,500
USSR	12,125
Britain	. .
West Germany	7,980
India	5,560
France	5,070
Canada	4,864
Italy	4,299
Other countries	26,746
Total	124,418

Source: U.S. Bureau of Mines Minerals Yearbook Preprint 1968.
p Preliminary; . . Not available.

The mining operation consists of undercutting, drilling, blasting, loading and primary crushing. Underground haulage is by 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 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 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 solution. At the surface, the brine is either evaporated to produce dry fine 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 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 1969 was for snow and ice control on highways and city streets. By comparison to other uses, this market is new, having expanded in Canada from less than 100,000 tons in 1954 to an estimated 1.8 million tons in 1969.

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. About 1.6 tons of salt is required to produce one ton of caustic soda and a proportionate amount of chlorine. In 1969, 22 caustic soda-chlorine plants with a combined annual productive capacity of about 1 million tons of caustic soda and 860,000 tons of chlorine were operating in Canada and one new plant was being built. 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 1969 was 943,189 tons of caustic soda (as 100% NaOH) and 834,818 tons of chlorine compared with 844,266 tons and 741,281 tons, respectively, in 1968. The pulp and paper and petrochemical 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 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.

TABLE 5

Canada, Available Data on Salt Consumption, 1966-69
(short tons)

	1966	1967e	1968e	1969e
Industrial chemicals	1,322,284	1,400,000	1,500,000	1,650,000
Snow and ice control	1,200,000e	1,400,000	1,600,000*	1,800,000
Slaughtering and meat packing	50,312	57,000	65,000	70,000
Food processing	65,777	68,000	70,000	75,000
Starch, glucose, malt	13,912	14,000	14,500	15,000
Breweries	626	650	650	700
Pulp and paper	64,427	66,000	68,000	70,000
Leather tanneries	5,747	6,000	6,000	6,500
Soaps and cleaning compounds	2,870	3,000	3,000	3,200
Dyeing and finishing textiles	1,542	1,600	1,600	1,700
Artificial ice	267	300	300	300
Fishing industry	75,000e	75,000	75,000	80,000
Farm stock	46,000e	48,000	50,000	55,000

Source: Dominion Bureau of Statistics.
*Salt Institute; eEstimated by Author.

OUTLOOK

The outlook for Canada's salt industry is favourable. Demand for salt for snow and ice control on city streets and on highways has increased sharply in the past few years and the trend is expected to continue. Likewise, demand for salt-based chemicals has been strong and is expected to be even stronger in 1970 and 1971. With the start-up of a new plant at Belle Plaine, Saskatchewan, the completion of expansions at Unity, Saskatchewan, and Goderich, Ontario, and continued exploration to develop salt deposits in the Atlantic Provinces, Canada's salt production is expected to keep pace with rising demand.

TARIFFS

The Kennedy Round of the General Agreement on Tarriffs 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:

CANADA	British Preferential	Most Favoured Nation	General
Common salt (including rock salt)			
Jan. 1, 1968 to Dec. 31, 1968			
– per 100 lb	free	2¢	5¢
Jan. 1. 1969 to Dec. 31, 1969			
– per 100 lb	free	1 1/2¢	5¢
Jan. 1, 1970 to Dec. 31, 1970			
– per 100 lb	free	1¢	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, 1968 to Dec. 31, 1968			
– per 100 lb	5%	9%	15%
Jan. 1, 1969 to Dec. 31, 1969			
– per 100 lb	5%	8%	15%

Jan. 1, 1970 to Dec. 31, 1970 – per 100 lb	5%	7%	15%
Salt liquors and sea-water	free	free	free

UNITED STATES

Salt, in brine	
Jan. 1, 1968 to Dec. 31, 1968	9%
Jan. 1, 1969 to Dec. 31, 1969	8%
Jan. 1, 1970 to Dec. 31, 1970	7%
Salt, in bulk	
Jan. 1, 1968 to Dec. 31, 1968	1.5¢ per 100 lb
Jan. 1, 1969 to Dec. 31, 1969	1.3¢ per 100 lb
Jan. 1, 1970 to Dec. 31, 1970	1.15¢ per 100 lb
Salt, other	
Jan. 1, 1968 to Dec. 31, 1968	2.5¢ per 100 lb
Jan. 1, 1969 to Dec. 31, 1969	2¢ per 100 lb
Jan. 1, 1970 to Dec. 31, 1970	1¢ per 100 lb

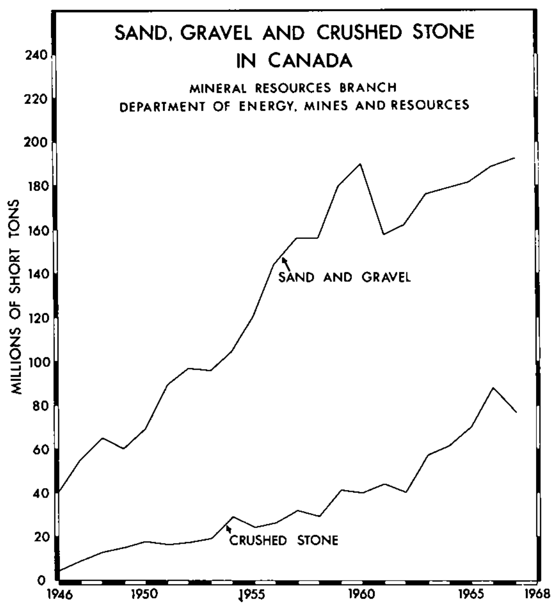
Further tariff reductions will come into effect on January 1, 1971, and January 1, 1972.

Sand, Gravel and Crushed Stone

D.H. STONEHOUSE*

The volume of sand, gravel, crushed gravel and crushed stone produced annually in Canada is in direct proportion to the amount of construction activity in progress. The general upward trend in output experienced prior to 1966 was sharply increased during 1966 in support of major requirements initiated by the Expo '67 construction surge. The demand fell off during 1968 and 1969 and is tending to stabilize to a more normal annual increment. The effects of work stoppages in many regions and the general high costs of construction will undoubtedly have a limiting effect on production of all mineral aggregates.

Total sand and gravel production is estimated at 204,060,000 tons for 1969, valued at $130.6 million, representing 2.8 per cent of the total value of mineral production in Canada. Total stone production, of which crushed stone represents about 80 per cent, is estimated to be about 70 million tons for 1969, valued at $88.2 million. Detailed statistics, available only up to 1967, appear in Tables 1 and 2.



SAND AND GRAVEL

Sand and gravel deposits are widespread in Canada and large producers have established permanent plants as close as possible to major markets. Urban development has created the major demand for sand and gravel and at the same time has tended to overrun operating pits and quarries. It has become necessary for producers to move farther from the consuming centres resulting in increased transportation costs being passed on to the construction industry. Land values have generally increased in urban areas to more than offset costs of rehabilitation of all quarry sites. 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. Large producers are not automatically blameless in this recently-recognized disruption of our environment. It is evident that a co-operative, planned land-use program must be designed and followed to provide the best possible use of our mineral resources and the most acceptable urban development.

*Mineral Resources Branch.

TABLE 1

Sand, Gravel and Crushed Stone, 1966-1967

	1966		1967	
	Short Tons	$	Short Tons	$
Production				
By provinces				
Sand and Gravel[1]				
Newfoundland	3,327,216	3,406,721	2,894,199	2,946,811
Prince Edward Island	660,726	1,162,513	796,685	959,217
Nova Scotia	8,084,412	10,743,785	5,979,632	3,841,946
New Brunswick	719,442	726,968	7,045,597	4,021,097
Quebec	41,110,007	20,172,395	40,653,245	20,028,976
Ontario	83,039,157	61,730,806	81,280,963	60,784,446
Manitoba	8,952,396	5,382,531	9,409,152	5,613,996
Saskatchewan	7,998,574	4,836,205	9,047,750	5,260,955
Alberta	11,885,541	9,719,584	13,331,345	11,195,561
British Columbia	22,285,372	20,503,576	21,408,403	19,782,387
Total	188,062,843	138,385,084	191,846,971	134,435,392
Crushed Stone[2]				
Newfoundland	131,893	233,572	240,000	300,496
Prince Edward Island	200,000	200,000	725,383	619,149
Nova Scotia	543,101	1,524,974	276,968	576,831
New Brunswick	3,194,379	2,010,821	3,136,449	2,830,722
Quebec	56,181,342[r]	46,085,562[r]	46,013,176	45,219,256
Ontario	23,466,872	28,166,429	23,245,138	26,622,487
Manitoba	1,948,547	2,087,931	1,663,161	1,907,036
Saskatchewan	–	–	–	–
Alberta	–	–	6,712	5,762
British Columbia	2,641,252	3,809,464	1,898,965	3,417,835
Total	88,307,386	84,118,753	77,205,952	81,499,574
Total Sand and Gravel and Crushed Stone				
Newfoundland	3,459,109	3,640,293	3,134,199	3,247,307
Prince Edward Island	860,726	1,362,513	1,522,068	1,578,366
Nova Scotia	8,627,513	12,268,759	6,256,600	4,418,777
New Brunswick	3,913,821	2,737,789	10,182,046	6,851,819
Quebec	97,291,349[r]	66,257,957[r]	86,666,421	65,248,232
Ontario	106,506,029	89,897,235	104,526,101	87,406,933
Manitoba	10,900,943	7,470,462	11,072,313	7,521,032
Saskatchewan	7,998,574	4,836,205	9,047,750	5,260,955
Alberta	11,885,541	9,719,584	13,338,057	11,201,323
British Columbia	24,926,624	24,313,040	23,307,368	23,200,222
Total	276,370,229[r]	222,503,837[r]	269,052,923	215,934,966

Source: Dominion Bureau of Statistics.
[1]Includes total sand and gravel less that for fill, mine backfill and other special uses. [2]Includes crushed stone for: concrete aggregate, railway ballast, road metal, rubble and riprap, terrazzo, stucco and artificial stone, other miscellaneous uses.
[r]Revised; – Nil.

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

TABLE 2

Sand, Gravel and Crushed Stone, 1966-1967

	1966		1967	
	Short Tons	$	Short Tons	$
Production				
By Type				
Sand and Gravel				
For roads (roadbed surface)	96,416,278	63,584,170	102,510,254	56,572,332
Concrete aggregate	26,152,005	25,144,138	23,502,396	24,998,376
Asphalt aggregate	3,809,321	3,459,475	6,574,510	6,460,704
Railroad ballast	2,545,155	887,246	2,277,509	1,059,244
Mortar sand	2,190,420	2,120,513	1,776,634	1,768,683
Total	131,113,179	95,195,542	136,641,303	90,859,339
Crushed Gravel				
For roads (roadbed surface)	42,656,612	28,979,956	41,583,887	28,070,493
Concrete aggregate	6,106,694	7,241,244	5,461,912	7,046,094
Asphalt aggregate	2,390,426	2,956,834	3,318,370	3,806,151
Railroad ballast	1,292,134	1,134,421	1,748,419	1,800,682
Other uses	4,503,798	2,877,087	3,093,080	2,852,633
Total	56,949,664	43,189,542	55,205,668	43,576,053
Total Sand, Gravel and Crushed Gravel	188,062,843	138,385,084	191,846,971	134,435,392
Crushed Stone				
Concrete aggregate	18,138,461	19,605,453	17,835,912	19,889,819
Railway ballast	2,548,798	3,020,274	3,073,924	3,730,633
Road metal	49,843,699[r]	48,467,485[r]	41,718,342	43,038,346
Rubble and riprap	11,905,428[r]	6,548,897[r]	12,608,629	11,926,538
Terrazzo, stucco and artificial stone	126,116	1,131,950	81,156	850,035
Other uses	5,744,884	5,344,694	1,887,989	2,064,203
Total	88,307,386	84,118,753	77,205,952	81,499,574
Total Sand, Gravel, Crushed Gravel and Crushed Stone	276,370,229[r]	222,503,837[r]	269,052,923	215,934,966

Source: Dominion Bureau of Statistics.
[r]Revised.

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.

Non-construction uses for sand and gravel (not included in Table 2) account for an additional 15 per cent by volume. The use of sand and gravel as backfill in mines continues along with increasing use of cement and mill tailings for this purpose. Abrasive

TABLE 3

Imports and Exports – Sand, Gravel and Crushed Stone

	1968		1969	
	Short Tons	$	Short Tons	$
Exports				
United States	496,230	535,000	457,760	625,000
St. Pierre-Miquelon	45	1,000	76	1,000
West Germany	220	1,000	55	11,000
Other countries	30	1,000	27	3,000
Total	496,525	538,000	457,918	640,000
Imports				
United States	683,490	642,000	859,898	737,000

Source: Dominion Bureau of Statistics.

TABLE 4

Canada, Total Sand, Gravel and Stone Production 1968, 1969
(by province)

	1968		1969p	
	Short Tons	$	Short Tons	$
Sand and Gravel				
Prince Edward Island	383,165	563,142	770,000	900,000
Newfoundland	3,812,003	3,632,018	3,600,000	3,400,000
Nova Scotia	9,380,262	8,078,650	8,520,000	7,700,000
New Brunswick	6,361,658	2,139,790	3,800,000	1,650,000
Quebec	42,955,933	17,613,824	43,000,000	18,000,000
Ontario	84,095,642	55,094,706	85,000,000	55,500,000
Manitoba	9,563,927	5,951,628	9,500,000	6,000,000
Saskatchewan	9,167,702	5,149,600	8,500,000	4,500,000
Alberta	13,600,098	10,739,614	13,700,000	10,800,000
British Columbia	25,914,119	20,537,581	27,670,000	22,200,000
Total	205,234,509	129,500,553	204,060,000	130,650,000
Stone				
Prince Edward Island	439,775	413,600	150,000	150,000
Newfoundland	876,768	1,097,848	705,000	935,000
Nova Scotia	819,788	2,340,640	825,300	2,348,300
New Brunswick	2,137,748	2,934,769	1,730,000	3,505,000
Quebec	34,952,128	39,422,561	33,230,000	37,825,000
Ontario	28,636,257	37,733,856	25,749,000	32,565,000
Manitoba	2,305,900	3,021,925	2,212,000	2,835,000
Saskatchewan	–	–	–	–
Alberta	220,523	695,872	253,000	697,200
British Columbia	5,550,880	7,997,004	5,442,500	7,334,000
Total	75,939,767	95,658,075	70,069,100	88,194,500

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

sands, glass sand, foundry sands and filter sands are also produced.

CRUSHED STONE

Many quarries producing 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. However, by volume, crushed stone accounts for over 80 per cent of the total stone production. Quarries removing solid rock, requiring drilling, blasting and crushing, are not so liable to be operated for small, local needs as are gravel pits and are therefore usually operated by large companies associated with the construction industry. Rehabilitation of a stone quarry to provide subsequent land-use is probably more difficult and more costly than for gravel pits and because of the blasting they are not encroached upon as readily. They do provide the same disruptions to environment and to urban development and are therefore included in recent studies to plan efficient land-use.

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.

Crushed stone uses included in "other uses" in Table 2 include granite and marble used to manufacture roofing granules, granite and limestone used to produce poultry grit and limestone and sandstone used in the production of rock wool.

Pulverized stone not included in Table 2 is produced 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.

MARKETS OUTLOOK AND TRADE

Markets for sand, gravel and crushed stone will continue to grow as construction expenditures continue to increase. Of particular influence is activity in the engineering construction sector in which a 12 per cent increase to $5.7 billion is forecast for 1970. 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.

The possibility of substitutes for aggregates is not too pressing 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 likely the main reason for use of a foreign material.

Selenium and Tellurium

A. F. KILLIN*

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 smelting.

Non-communist world production is distributed among the copper-refining nations including Canada, United States, Japan, Australia, Belgium and Luxembourg, Finland, Mexico, Zambia, Peru and Sweden. There is also production in the USSR and other communist nations. Selenium supply is dependent upon copper production and, because of this, it fluctuates with the rate of copper output and not in response to demand.

Canada's selenium production in 1969 was 710,618 pounds valued at $4,375,563 an increase of 75,108 pounds and $1,293,340 from 1968. Refined production, from anode slimes and stockpiled material, rose to 820,277 pounds from 620,033 pounds in 1968. Domestic consumption fell by 5,868 pounds to 15,572 pounds in 1969. The remainder of the refined production was exported, principally to the United States and Britain.

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% Se), high-purity metal (99.9% 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 a minus 200-mesh selenium powder (99.5%).

CONSUMPTION AND USES

Selenium is used in the glass, rubber, chemical, plastics, steel and electronics industry. 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

*Mineral Resources Branch.

TABLE 1

Canada - Selenium Production, Exports and Consumption, 1968-69

	1968		1969p	
	Pounds	$	Pounds	$
Production				
All forms[1]				
Quebec	413,038	2,003,234	486,435	3,162,000
Manitoba	54,788	265,722	88,522	477,130
Ontario	127,500	618,375	82,000	447,200
Saskatchewan	40,184	194,892	53,661	289,233
Total	635,510	3,082,223	710,618	4,375,563
Refined[2]	620,033		820,277	
Exports (metal)				
United States	508,400	3,009,000	525,800	3,469,000
Britain	225,000	1,215,000	266,900	1,525,000
Republic of South Africa	6,100	28,000	19,600	105,000
Argentina	11,500	54,000	15,100	83,000
Brazil	7,100	32,000	10,000	51,000
France	400	2,000	7,900	44,000
Spain	5,500	28,000	7,500	32,000
Other countries	23,100	97,000	19,500	106,000
Total	787,100	4,465,000	872,300	5,415,000
Consumption[3] (selenium content)	21,440		15,572	

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.

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 decolourizer 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.

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.

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.

Canadian consumption of selenium in 1969 was 15,572 pounds of which over 80 per cent was reported used in the glass manufacturing industry.

TABLE 2

Canada-Selenium Production, Exports and Consumption, 1960-69
(pounds)

	Production		Exports Metals and Salts[3]	Consumption[4]
	All Forms[1]	Refined[2]		
1960	521,638	524,659	404,410	14,461
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[p]	710,618	820,277	872,300	15,572

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]1960, exports of selenium metal and compounds; from 1961, exports of metal, metal powder, shot, etc. [4]Consumption (selenium content), as reported by consumers.
[p]Preliminary.

TABLE 3

Non-Communist World Production of Selenium 1967-69
(pounds)

	1967	1968	1969[e]
United States	598,000	633,000	1,200,000
Canada	724,573	635,510	710,618
Japan	422,000	394,000	450,000
Sweden	158,000[r]	154,000	170,000
Zambia[e]	58,000	58,000	. .
Belgium and Luxembourg	90,000	54,000	100,000
Other countries	40,000	44,000	100,000
Total	2,090,573	1,972,510	. .

Source: U.S. Bureau of Mines Minerals Yearbook, Preprint 1968, and U.S. Bureau of Mines Commodity Data Summaries, January 1970.
[e]Estimated; . . Not available; [r]Revised.

TABLE 4

Canada – Industrial Use of Selenium, 1967-69
(pounds of contained Selenium)

	1967	1968	1969
By end-use			
Glass	10,226	10,787	12,624
Other*	10,791	10,653	2,948
Total	21,017	21,440	15,572

Source: Dominion Bureau of Statistics – Consumers' reports.
*Electronics, rubber, steel, pharmaceuticals.

OUTLOOK

There has been a persistent increase in the consumption of selenium since 1968. The limitation on supply because of selenium's byproduct production role has brought about competition for supplies between the major consuming areas. Producers' stocks have been depleted and supply is likely to revert to the production capacity geared to copper output. Producer prices have reacted to the demand for metal and there were reports of merchant sales of commercial grade selenium at $28 a pound.

There will probably be a continuing increase in demand and it remains to be seen if the consequent increase in price will stimulate substitution in selenium's major uses.

PRICES

The strong demand for selenium in 1969 caused prices to rise sharply during the year. The prices per pound of selenium in the United States in 1969 were quoted by *Metals Week* as follows:

Period	Commercial Grade	High purity
	$	$
January 1 – March 9	4.50	6.00
March 10 – June 30	5.00	6.25
July 1 – October 5	5.50	6.75
October 6 – November 30	6.00	7.25
December 1 – December 31	7.00	8.50

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General
CANADA				
92804-4	Selenium metal	5%	10%	15%
UNITED STATES				
632.40	Selenium metal, unwrought, waste and scrap		free	
632.84	Selenium metal alloys, unwrought			
	On and after Jan. 1, 1969		14%	
	" Jan. 1, 1970		12.5%	
420.50				
420.52	Selenium dioxide and salts		free	
420.54	Other compounds of selenium			
	On and after Jan. 1, 1969		8%	
	" Jan. 1, 1970		7%	

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 production in 1969 was 103,777 pounds, 32,786 pounds more than in 1968. Refined tellurium production rose to 72,664 pounds from the 65,926 pounds in 1968. Because tellurium is a co-product of selenium refining, the increased production in 1969 was related to the increase in refined selenium output.

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.

TABLE 5

Canada-Tellurium–Production and Consumption, 1968-69

	1968		1969p	
	Pounds	$	Pounds	$
Production				
All forms[1]				
Quebec	54,592	352,664	87,240	567,000
Manitoba	5,654	36,525	7,120	46,000
Ontario	6,600	42,636	5,100	30,700
Saskatchewan	4,145	26,777	4,317	27,888
Total	70,991	458,602	103,777	671,588
Refined[2]	65,926		72,664	
Consumption[3] (refined)	4,605		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.

TABLE 6

Canada-Production and Consumption of Tellurium, 1960-69 (pounds)

	Production		Consumption
	All Forms[1]	Refined[2]	Refined[3]
1960	44,682	41,756	4,238
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[r]	1,870
1966	72,239	72,745	862
1967	73,219	70,105	981
1968	70,991	65,926	4,605
1969[p]	103,777	72,664	3,532

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; [r]Revised.

TABLE 7

Non-Communist World Production of Tellurium (pounds)

	1967	1968	1969[e]
United States	135,000	121,000	125,000
Canada	73,219	70,991	103,777
Peru	37,000	53,000	40,000
Japan	30,000	31,000	30,000
Other countries	–	–	–
Total	275,219	275,991	298,777

Source: U.S. Bureau of Mines Minerals Yearbook, Preprint 1968 and U.S. Bureau of Mines Commodity Data Summaries, January, 1970.
[e]Estimated; – Nil.

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.

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, as 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.

OUTLOOK

The limited supply of tellurium available because of its co-product relationship to copper will inhibit its growth in industrial applications. A slow but steady increase in consumption is forecast.

PRICES

The price of tellurium in the United States as quoted by *Metals Week* was $6.00 a pound throughout 1969.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General
CANADA				
92804-5	Tellurium metal	5%	10%	15%
UNITED STATES				
632.48	Tellurium metal unwrought, waste and scrap (duty on waste and scrap temporarily suspended)			
	On and after Jan. 1, 1969		6%	
	" Jan. 1, 1970		5.5%	
421.90	Tellurium compounds			
	On and after Jan. 1, 1969		8%	
	" Jan. 1, 1970		7%	
427.12	Tellurium salts			
	On and after Jan. 1, 1969		8%	
	" Jan. 1, 1970		7%	

Further tariff reductions on the above United States tellurium items will occur on Jan. 1, 1971 and Jan. 1, 1972

Silica

P.R. COTE*

Silica production in Canada in 1969 amounted to 2,368,481 tons valued at $6,116,884, representing a decrease in output of 7.3 per cent and an increase in value of 7.2 per cent over 1968. As in previous years, most of this production was low-grade lump silica and low-grade silica sand for use as metallurgical flux.

Canada imports high-grade silica sand for use in glass manufacture and substantial quantities of sand suitable for foundry castings. In 1969, imports amounted to 1,285,228 tons valued at $4,986,000, a tonnage increase of 16 per cent and a value increase of 17 per cent over 1968. Almost all imports were from the United States.

Silica sand suitable for glass manufacture is produced by two companies in Canada. Indusmin Limited, the largest, operates two quarries in Quebec. The Winnipeg Supply and Fuel Company, Limited operates a high-grade silica sand deposit on Black Island in Lake Winnipeg.

Silica (SiO_2) occurs in the earth's crust as the mineral quartz in unconsolidated sands, sandstones, quartzite and as vein quartz. The mineral is very abundant but seldom does it occur 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; abrasive 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, began producing silica in 1968 from a newly developed 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 newly built $40-million phosphorus plant requires about 200,000 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 are imported from the United States.

Union Carbide Canada Mining Ltd. quarries quartzitic sandstone at Melocheville, Beauharnois

*Mineral Resources Branch.

TABLE 1

Canada–Silica, Production and Trade, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Production, quartz and silica sand[1]				
By province				
Ontario	1,205,796	564,430	873,000	468,700
Quebec	796,966	3,755,214	790,614	3,919,465
Manitoba	308,507	803,288	389,925	1,033,697
Saskatchewan	186,830	168,745	167,152	167,152
British Columbia	44,955	294,973	31,903	154,609
Newfoundland	–	–	104,887	263,261
Nova Scotia	11,511	117,096	11,000	110,000
Total	2,554,565	5,703,746	2,368,481	6,116,884
By use				
Flux	1,961,094	1,943,824		
Ferrosilicon	181,197	918,287		
Silicon carbide	76,129	470,080		
Glass	167,732	1,133,063		
Other uses[2]	168,413	1,238,492		
Total	2,554,565	5,703,746	2,368,481	6,116,884
Imports				
Silica sand				
United States	1,104,312	4,233,000	1,263,035	4,856,000
Belgium and Luxembourg	–	–	17,214	42,000
Sweden	2,688	30,000	4,968	88,000
West Germany	–	–	11	...
Total	1,107,000	4,263,000	1,285,228	4,986,000
Silex and crystallized quartz				
United States	112	115,000	33	67,000
Brazil	4	103,000	2	30,000
Britain	–	–	....	7,000
Total	116	218,000	35	104,000
	1968		1969p	
	Thousands	$	Thousands	$
Firebrick and similar shapes, silica				
United States	1,150	973,000	935	876,000
West Germany	2	3,000	14	4,000
Belgium and Luxembourg	1	1,000	–	–
Total	1,153	977,000	949	880,000
	Short Tons	$	Short Tons	$
Exports				
Quartzite				
United States	64,086	181,000	81,471	222,000
Dominican Republic	–	–	17	...
Total	64,086	181,000	81,488	222,000

Source: Dominion Bureau of Statistics.

[1] Producers' shipments, including crude and crushed quartz, crushed sandstone and quartzite, and natural silica sand. [2] Includes foundry uses, sand blasting, silica brick, concrete products, chemical manufacture and building products.

pPreliminary; – Nil; ... Less than $1,000; .... Less than one short ton.

TABLE 2

Canada–Silica–Production and Trade, 1960-69
(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
1960	2,260,766	720,826	10,521	1,232	13,057	2,709,669
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	3,677,261
1969p	2,368,481	1,285,228	35	. .	81,488	

Source: Dominion Bureau of Statistics.
[1]Includes silica to make silica brick.
pPreliminary; . . Not available.

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 also 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.

Armand Sicotte & Sons Limited quarries silica near Howick, Quebec for use in elemental phosphorus production at Varennes.

ONTARIO

In mid-1968, Indusmin Limited announced plans to construct a $1.5 million silica grinding and processing plant at Midland. Feed material for the mill will come from a high-grade silica deposit on Badgeley Island, near Killarney, about 120 miles north across Georgian Bay. The deposit consists of very pure Precambrian Lorraine quartzite and has an economic life expectancy of 20 years. Expenditures on the total operations including both the Midland plant and Badgeley Island facilities are now estimated at $5.6 million. Construction began early in 1969 and completion date is scheduled for May 1970. The Badgeley Island operation will have an initial capacity of approximately 3,000 tons a day of washed lump and fine material.

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 both directly to manufacturers of ferrosilicon and silicon metal and 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.

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.

TABLE 3

Chemical Specifications for Glass-Grade Silica Sand

Quality	Minimum $\%SiO_2$	Maximum $\%Al_2O_3$	Maximum $\%Fe_2O_3$	Maximum $\%CaO + MgO$
First quality, optical glass	99.8	0.1	0.02	0.1
Second quality, flint glass containers and tableware	98.5	0.5	0.035	0.2
Third quality, flint glass	95.0	4.0	0.035	0.5
Fourth quality, sheet glass rolled, polished plate and window glass	98.5	0.5	0.06	0.5
Fifth quality, sheet glass rolled, polished plate and window glass	95.0	4.0	0.06	0.5
Sixth quality, green glass containers	98.0	0.5	0.3	0.5
Seventh quality, green glass	95.0	4.0	0.3	0.5
Eighth quality, amber glass containers	98.0	0.5	1.0	0.5
Ninth quality, amber glass	95.0	4.0	1.0	0.5

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. As 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, ¾ to 5 inches in size, obtained by crushing quartzite or indurated sandstone, is used in the manufacture of ferrosilicon. Chemical specifications are: silica, 98.0 per cent; alumina, (Al_2O_3) less than 1.0 per cent; iron (Fe_2O_3) plus alumina not over 1.5 per cent; lime and magnesia, each less than 0.2 per cent. Phosphorus and arsenic should be absent.

Silica Brick

Quartz and quartzite crushed to minus 8 mesh are used in the manufacture of silica brick for high temperature refractory furnaces. Chemical specifications for this use are: silica, 96 to 98 per cent; alumina, less than 0.1 per cent; combined iron and alumina, less than 1.5 per cent. Other impurities such as lime and magnesia should be low.

Aggregate

Crushed and sized quartz and quartzite are used as exposed aggregate in precast concrete panels for buildings, slabs, sidewalks and for other decorative landscape purposes. Colour and texture are important. Some architects prefer a white, opaque quartz, while others prefer a shiny, translucent variety.

Other Uses

Lump quartz and quartzite are used as lining material in ball and tube mills and as lining and packing for acid towers. In some instances, naturally occurring quartzitic pebbles are used as grinding media in the crushing of various nonmetallic ores.

SILICA SAND

High-purity naturally occurring sand or material produced by crushing quartzite or sandstone is used in the manufacture of glass. Generally accepted chemical specifications for silica sand used to manufacture various glass grades, are shown in Table 3.

Minor amounts of certain elements are particularly objectionable as they act as powerful colourants. For example, chromium should not exceed 6 parts per million; cobalt not over 2 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 are 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 feed material to the cement plant.

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 of 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 of at least 4 to 1 over natural quartz crystal.

There is only a small demand for quartz crystal in Canada and virtually no production, domestic requirements being 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.

TABLE 4

Canada, Available Statistics on Consumption of Silica by Industries, 1967 and 1968

	1967	1968
	Short Tons	Short Tons
Smelter flux*	1,818,810	1,961,094
Glass manufacture (incl. glass fibre)	478,910	366,484
Foundry sand	670,108	748,948
Artificial abrasives	152,166	169,849
Ferrosilicon	99,270	147,495
Metallurgical use	80,220	87,195
Concrete products	22,706	23,738
Gypsum products	42,968	32,431
Asbestos products	30,975	38,614
Chemicals	23,114	21,925
Fertilizers, stock, poultry feed	32,230	30,488
Other	49,709	49,000[e]
Total	3,501,186	3,677,261

Source: Dominion Bureau of Statistics for source data. Classification by Mineral Resources Branch.

*Producers' shipments of quartz and silica for flux purposes.

[e]Estimated.

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 $8 to $10 per ton in Montreal and Toronto.

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General
CANADA				
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, 1969		40¢ per long ton	
	On and after Jan. 1, 1970		35¢ per long ton	
513.14	Sand, other		free	
514.91	Quartzite, whether or not manufactured		free	
523.11	Silica, not specially provided for		free	

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, and in making ferrosilicon, silicon carbide and other abrasive products, and in various silicon alloys for domestic and export markets. The more important silicon alloy exports in 1969 were: 103,500 tons of silicon carbide valued at $14,974,000 and 48,499 tons of ferrosilicon valued at $5,257,000.

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 sands 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 semi-conduction 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 semiconductors for use in transistors, diodes, and rectifiers.

SILICON IN STEEL AND IRON

Silicon, introduced 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 ferro-alloy silicomanganese can be used to introduce both elements at the same time.

*Mineral Resources Branch.
†See 1969 Silica preprint.

TABLE 1

Canada, Ferrosilicon, Silicon Carbide, and Some Other Ferroalloys*, Exports and Imports, 1968-69

	1968		1969	
	Short Tons	$	Short Tons	$
Exports				
Ferrosilicon				
Britain	25,778	3,112,000	28,170	3,266,000
United States	11,564	804,000	18,394	1,756,000
Australia	105	25,000	394	70,000
New Zealand	–	–	242	36,000
Philippines	–	–	248	31,000
West Germany	24	5,000	257	6,000
Other countries	9,744	1,479,000	794	92,000
Total	47,215	5,425,000	48,499	5,257,000
Silicon carbides, crude and grains				
United States	102,444	14,586,000	103,500	14,974,000
Britain	480	104,000	–	–
Total	102,924	14,690,000	103,500	14,974,000
Ferroalloys, n.e.s.				
United States	281	85,000	2,176	587,000
Britain	–	–	554	138,000
Venezuela	50	5,000	416	67,000
Sweden	–	–	22	56,000
Other countries	309	93,000	52	17,000
Total	640	183,000	3,220	865,000
Imports				
Ferrosilicon				
United States	8,753	2,454,000	7,994	1,770,000
Norway	1,060	160,000	920	213,000
Republic of South Africa	–	–	106	20,000
Other countries	3	1,000	30	7,000
Total	9,816	2,615,000	9,050	2,010,000
Silicomanganese incl. Silico spiegel				
Republic of South Africa	–	–	3,519	546,000
Norway	38	11,000	920	139,000
United States	199	32,000	120	34,000
USSR	547	61,000	–	–
Other countries	560	56,000	–	–
Total	1,344	160,000	4,559	719,000
Ferroalloys, n.e.s.				
United States	3,576	1,743,000	2,860	2,279,000
Britain	101	254,000	147	354,000
France	104	46,000	771	232,000
West Germany	–	–	660	210,000
Brazil	17	44,000	11	34,000
Norway	697	138,000	30	10,000
Other countries	7	12,000	–	–
Total	4,502	2,237,000	4,479	3,119,000

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.

TABLE 2

Ferrosilicon Consumption and Steel Production in Canada, 1960-69

	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

Source: Dominion Bureau of Statistics.

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, 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 titamium. 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: killed, semikilled, 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.

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.

TABLE 3

Canada, Consumption, Exports, and Imports of Ferrosilicon, 1960-69

	Consumption	Exports		Imports	
	Short Tons	Short Tons	$	Short Tons	$
1960	18,002	52,903	4,851,795	6,671	1,067,798
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

Source: Dominion Bureau of Statistics.

TABLE 4

Canada, Ferrosilicon Consumption in the Steel Industry, 1960-68
(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

Source: Dominion Bureau of Statistics annual report, Iron and Steel Mills.

TABLE 5

Canada, Ferrosilicon Production, 1962-68
(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

Source: Dominion Bureau of Statistics.

* Principally abrasives industry byproducts.

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 infra-red 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 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 6

Canada, Manufacturer's Shipments of Silicon Carbide, 1959-68

	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

Source: Dominion Bureau of Statistics.

TABLE 7

Canada, Exports of Silicon Carbide, 1960-69

	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

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.

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	30-33% 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

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.

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.

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.

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

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.

PRICES

The following prices were published by *Metals Week* in United States currency in December of 1969:

Ferrosilicon: pound contained silicon f.o.b. shipping point, freight equalized to nearest main producer, carload lots, lump bulk

High-purity 75% Si	17.3¢
85% Si	18.0¢
90% Si	18.6¢
Regular 50% Si	14.1¢
65-70% Si	16.2¢

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¢
0.50% " " "	18.85¢
1.00% " " "	17.65¢

Magnesium Ferrosilicon 44/48 Si:

9% Mg	20.9¢
9% Mg 0.5% Ce	23.2¢
5% Mg 0.5% Ce	17.25¢
12-15 zirconium silicon	10.90¢
35-40 " "	31.95¢

Silicon Metal: per pound, f.o.b. producer,

Semiconductor grade	$130-$355
Solar grade	$ 70

The following prices were published by *American Metal Market* in United States currency in December 1969:

SMZ Alloy: 60-65% Si, 5-7% Mn, 5-7% Zr, 15 ton lots, per pound of alloy 20.8¢

Calcium – Silicon and Calsibar alloy f.o.b. producer, 15 ton lots, per pound 23.75¢

Electric Furnace Silvery Pig Iron
f.o.b. Niagara Falls, 15% Si, per ton $82.00
" " " 22% Si, per gross ton $99.00

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 thereof, on the silicon contained 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 1969	1970
607.50	Ferrosilicon containing over 8% but not over 60% by weight of silicon, per pound Si content	0.4¢	0.2¢
607.51	Ferrosilicon containing over 60% but not over 80% by weight of silicon, per pound Si content	0.7¢	0.6¢
607.52	Ferrosilicon containing over 80% but not over 90% by weight of silicon, per pound Si content	1.6¢	1.4¢
607.52	Ferrosilicon containing over 90% by weighing of silicon, per pound Si content	3.2¢	2.8¢
607.55	Ferrosilicon chromium	10%	10%
607.57	Ferrosilicon manganese per pound Mn content	0.84¢ plus 6.5%	0.84¢ plus 6.5%

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 1969, at 43,092,976 troy ounces, was about 2 million ounces lower than the all-time high of 1968. The decrease was due mainly to lower output at several base-metal mines in British Columbia, and at the silver-copper property of Echo Bay Mines Ltd. near Port Radium in the Northwest Territories. Although its output was only slightly higher than in 1968, 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. The value of Canadian production was $83 million, or about 20 per cent less than in 1968, partly due to decreased output, but more particularly because of lower silver prices.

Base-metal ores continued to be the main source of Canada's mine output of silver, accounting for almost 90 per cent of total production. Almost 10 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 Canadian silver producers 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 about 50 per cent of total Canadian silver production. Largest producer in the Cobalt-Gowganda area of northern Ontario was Silverfields Mining Corporation Limited with output of 1,143,018 ounces.

The silver refinery of Kam-Kotia Mines Limited, Refinery Division, at Cobalt, Ontario, became Canada's largest producer of refined silver. It recovered a total of 19,970,876 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. Canadian Copper Refiners Limited at Montreal East, Quebec, was the second largest producer, recovering 12,360,000 ounces from the treatment of anode and blister copper. 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.

Canada's exports of silver in ores and concentrates and as refined metal totalled 56,541,965 ounces in 1969, or almost 7 million ounces greater than the corresponding amount in 1968. The United States continued to be our major market, importing almost 86 per cent of Canada's total exports. Canadian imports of refined silver in 1969 at 19,168,785 ounces were more than 5 million ounces greater than in 1968. Virtually all of the imports came from the United States with very minor quantities coming from Britain and Mexico. Much of the imports from the United States was lower grade silver bullion and coins sent to Canada for refining and subsequent return to the United States.

*Mineral Resources Branch.

TABLE 1

Canada, Silver Production, Trade and Consumption, 1968-69

	1968		1969p	
	Troy Ounces	$	Troy Ounces	$
Production*				
By province and territories				
Ontario	21,844,592	50,526,541	22,033,095	42,523,873
British Columbia	7,121,250	16,471,451	5,431,267	10,482,345
New Brunswick	3,654,079	8,451,884	4,172,200	8,052,346
Quebec	3,986,371	9,220,476	4,103,420	7,919,600
Yukon	2,077,987	4,806,384	2,990,056	5,770,808
Northwest Territories	3,751,563	8,677,365	2,026,513	3,911,170
Newfoundland	895,706	2,071,768	963,100	1,858,783
Saskatchewan	695,893	1,609,601	636,906	1,229,229
Manitoba	616,954	1,427,015	489,345	944,436
Nova Scotia	368,389	852,084	247,064	476,834
Alberta	13	30	10	19
Total	45,012,797	104,114,599	43,092,976	83,169,443
By sources				
Base-metal ores	40,289,380		38,437,862	
Gold ores	379,398		488,144	
Silver-cobalt ores	4,342,698		4,165,500	
Placer gold ores	1,321		1,470	
Total	45,012,797	104,114,599	43,092,976	83,169,443
Refined silver	30,764,934r		38,204,527	
Exports				
In ores and concentrates				
United States	12,138,547	23,364,000	15,141,088	23,976,000
Belgium and Luxembourg	3,299,029	5,645,000	2,720,379	4,611,000
Japan	3,524,213	8,509,000	1,919,768	2,959,000
West Germany	1,092,274	1,351,000	1,547,458	1,589,000
Britain	263,041	416,000	333,866	402,000
Italy	124,479	141,000	69,414	130,000
Sweden	199,226	379,000	64,365	119,000
Other countries	861,213	1,222,000	86,690	128,000
Total	21,502,022	41,027,000	21,883,028	33,914,000
Refined metal				
United States	25,965,955	60,709,000	33,400,033	63,816,000
Belgium and Luxembourg	1,704,628	3,347,000	825,342	1,682,000
West Germany	119,031	123,000	396,055	836,000
Trinidad–Tobago	2,490	5,000	19,892	40,000
Brazil	6,424	17,000	6,429	13,000
Jamaica	1,316	3,000	6,093	13,000
Other countries	304,718	730,000	5,093	15,000
Total	28,104,562	64,934,000	34,658,937	66,415,000

TABLE 1 (Cont'd)

	1968		1969p	
	Troy Ounces	$	Troy Ounces	$
Silverware and goldware n.e.s.				
United States		124,000		150,000
Britain		95,000		123,000
Republic of South Africa		30,000		60,000
Australia		31,000		36,000
New Zealand		14,000		22,000
Bahamas		17,000		16,000
Trinidad–Tobago		3,000		16,000
Other countries		51,000		47,000
Total		365,000		470,000
Imports				
Refined metal				
United States	13,403,461	31,551,000	19,130,769	34,720,000
Britain	5,992	12,000	25,937	56,000
Mexico	651,182	1,396,000	11,619	22,000
Bolivia	–	–	460	1,000
Total	14,060,635	32,959,000	19,168,785	34,799,000
Silverware and goldware, n.e.s.				
United States		961,000		776,000
Britain		311,000		337,000
West Germany		291,000		273,000
Netherlands		24,000		42,000
Italy		45,000		40,000
Other countries		190,000		173,000
Total		1,822,000		1,641,000
Consumption by use				
Coinage	7,352,359		–	
Silver salts	2,313,346		496,506	
Silver alloys	763,833		572,954	
Sterling	841,603		889,956	
Wire and rod	16,666		22,222	
Other**	2,310,551		3,765,430	
Total	13,598,358		5,747,068	

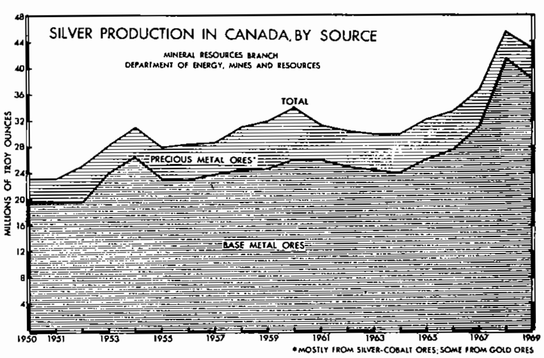
Source: Dominion Bureau of Statistics.
*Includes: (a) recoverable silver in ores, concentrates and matte shipped for export; (b) silver in crude gold bullion produced; (c) silver in blister and anode copper produced at Canadian smelters; (d) silver in base bullion produced from domestic ores; (e) silver bullion produced from treatment of domestic silver-cobalt ores at Cobalt, Ontario.
**Includes sheet and miscellaneous uses.
pPreliminary; – Nil; n.e.s. Not elsewhere specified; rRevised.

TABLE 2

Canada, Silver Production, Trade and Consumption, 1960-69
(troy ounces)

	Production		Exports			Imports	Consumption**
	All Forms*	Refined Silver	In Ores and Concentrates	Refined Silver	Total	Refined Silver	Refined Silver
1960	34,016,829	22,564,397	8,897,402	12,761,063	21,658,465	3,849,115	11,742,064
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	30,765,934r	21,502,022	28,104,562	49,606,584	14,060,635	13,598,358
1969p	43,092,976	38,204,527	21,883,028	34,658,937	56,541,965	19,168,785	5,747,068

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.
pPreliminary; rRevised.



Reported consumption of silver in Canada totalled 5,747,068 ounces, almost 7.9 million ounces less than in 1968.

WORLD PRODUCTION AND CONSUMPTION

Non-communist world production of silver in 1969, according to an estimate of Handy and Harman*, was 245.8 million ounces, or 10.1 million ounces more than in 1968. The increase was attributed

The Silver Market 1969, compiled by Handy and Harman.

TABLE 3

World Production of Silver 1968-69
(troy ounces)

	1968	1969e
Canada	45,621,000*	43,000,000
Mexico	40,031,000	42,000,000
United States	32,729,000	40,000,000
Peru	36,020,000	37,000,000
Russiae	35,000,000	..
Australia	21,618,000	..
Japan	10,713,000	..
Bolivia	5,180,000	..
East Germanye	4,800,000	..
Honduras	4,397,000	..
Chile	3,757,000	..
Sweden	3,524,000	..
Republic of South Africa	3,337,000	..
Other countries	25,780,000	116,000,000
Total	272,507,000	278,000,000

Sources: 1968 statistics from U.S. Bureau of Mines Minerals Yearbook, 1968. 1969 statistics from U.S. Bureau of Mines Commodity Data Summaries, January 1970.
*This figure has since been revised to 45,012,797 by the Dominion Bureau of Statistics.
eEstimated; .. Not available.

mainly to higher output in the United States and Mexico. In 1969, non-communist world consumption for both industrial and coinage uses, excluding requirements for United States coinage which are supplied from Treasury stocks, was 386.7 million ounces. The gap between production and consumption, not including United States coinage requirements, was some 141 million ounces, or somewhat more than in 1968.

Consumption of silver for coinage in the non-communist world, excluding the United States, was 24.3 million ounces or about half that in 1968. No silver was used in 1969 in the production of Canadian coinage; and sharp reductions in France and other countries also contributed to the decline. The continuing trend toward using non-silver coins, or ones of lower silver content, has brought about reduced demand for this purpose.

Based on preliminary figures, Canada in 1969 retained its position as the world's largest mine producer of silver; other leading producers were Mexico, the United States and Peru.

New production of silver in the United States increased substantially from 32.7 million ounces in 1968 to an estimated 40 million ounces in 1969. The nationwide strike in the nonferrous industry in 1968 had restricted silver refining capacity. In the United States, the world's largest silver consumer, consumption for industrial uses and coinage was 147.0 and 19.4 million ounces, respectively, in 1969. 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 were reduced during 1969 from 70.9 to 62.0 million ounces, excluding 165 million ounces held in the strategic stockpile. The United States Mint used 19.4 million ounces of silver for coinage in 1969 compared with 36.8 million ounces in 1968.

Among the more important developments affecting the silver market in 1969 was an announcement on May 12 by the United States Treasury Department that, effective immediately, the ban was removed on the private melting and exporting of silver coins. At the same time, the Treasury Department announced that, effective with the offering made May 27, 1969, the amount of silver offered for sale through the General Services Administration (GSA) at GSA's weekly auctions, would be reduced from 2 to 1½ million ounces. Furthermore, the auctions were opened up to all competitive bidders, foreign as well as domestic. On October 15, the United States Senate passed a bill authorizing the minting of 300 million 40 per cent silver Eisenhower dollars, whereas the House of Representatives voted to mint cupro-nickel (silverless) Eisenhower dollars and to cease minting the 40 per cent silver Kennedy half-dollars. The question of whether or not the Eisenhower dollars would contain any silver was still not settled at year-end.

The New York silver price fluctuated considerably during 1969 but not as widely as in 1968. It ranged between a high of $2.025 a troy ounce on January 15 and a low of $1.540 on June 27, and thereafter it rose to close the year at $1.800.

OUTLOOK

Canada's mine production of silver in 1970 is forecast to be some 45 million ounces and, from 1971 to 1975, it could range between 45 and 50 million ounces annually.

Despite recent declines in world consumption of silver, it is expected that demand will continue to exceed supply 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.

Assuming that sales of U.S. Treasury stocks of silver are maintained at 1.5 million ounces a week, the remaining stocks are expected to be exhausted by late 1970, and they could be used up sooner depending on whether or not any additional silver is allocated for coinage. When the Treasury has ceased to be a seller, silver prices may tend to rise. However, even in the absence of Treasury sales, market observers believe there will not be a shortage for industrial requirements, since sufficient quantities of speculative holdings and hoarded silver coins will eventually find their way into the market. At what price such silver will be attracted to the market, is still an unknown factor.

Over the next five years, a reasonably good domestic and foreign demand is expected to obtain for silver-bearing base-metal ores and concentrates. Therefore, little difficulty is anticipated in selling in foreign markets the substantial portion of Canadian output of both refined silver and silver contained in ores and concentrates that will be surplus to domestic requirements.

CANADIAN DEVELOPMENTS

The continuing good demand and favourable price for silver and the major base-metals acted as a spur to exploration and development of silver-bearing ores in 1969, especially in major producing areas in Ontario, British Columbia, the Yukon Territory and Northwest Territories.

YUKON TERRITORY AND NORTHWEST TERRITORIES

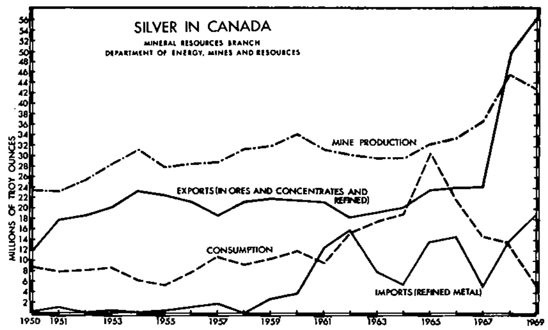
A substantial increase in silver output in 1969 in the Yukon Territory resulted mainly from the greater quantity and better recovery of ore milled by United Keno Hill Mines Limited. At the company's Husky mine, crosscuts are being driven toward the favourable mineralized zone. United Keno Hill has also increased its activity in general exploration work in the Yukon. Also contributing to the Yukon Territory's increase was some byproduct output by Anvil Mining Corporation Limited which began tune-up operations in September 1969 at the new 5,500-ton-a-day concentrator at its lead-zinc-silver property near Ross River. A 20 per cent increase in the mill capacity to 6,600 tons daily was planned for the spring of 1970. The ore contains about one ounce of silver a ton and, when the mill reaches full capacity, annual silver production could amount to some 2.5 million ounces. Operations at the 400-ton-a-day mill of Mount Nansen Mines Limited near Carmacks, were temporarily suspended early in January 1969. The concentrator had been in operation since September 1968.

Venus Mines Ltd. planned to bring into production its gold-silver-lead-zinc property on the west shore of the Windy Arm of Tagish Lake, about 17 miles south of Carcross. A 300-ton-a-day concentrator was under construction with operations expected to begin by the summer of 1970. Hart River Mines Ltd. continued exploration work at its silver-base-metals property in the Yukon some 85 air miles northeast of Dawson City. Hudson Bay Mining and Smelting Co., Limited collared a portal at its silver-lead-zinc "Tom" claims on the Canol Road near the Yukon-Northwest Territories border. The company planned to drive an adit in 1970. It will provide access for underground exploration of the deposit.

In the Northwest Territories silver production was substantially reduced in 1969 mainly because of decreased output by Echo Bay Mines Ltd. which operates a silver-copper property near Port Radium on the east shore of Great Bear Lake. Texas Gulf Sulphur Company continued exploration and development work on its zinc-lead-silver deposit on the shores of Strathcona Sound on Baffin Island, about 500 miles north of the Arctic Circle. Some 2,000 feet of development work was done and additional work on the project was planned for 1970. Cadillac Explorations Ltd. continued diamond drilling and exploration work on its Prairie Creek silver-lead-zinc property in the Nahanni Mining District some 110 miles due west of Fort Simpson. Further adit work and underground drilling were planned for 1970.

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. Utica Mines Ltd. and Mastodon-Highland Bell Mines Limited each produced over one-half million ounces of silver at their properties near Keremeos and Beaverdell, respectively.



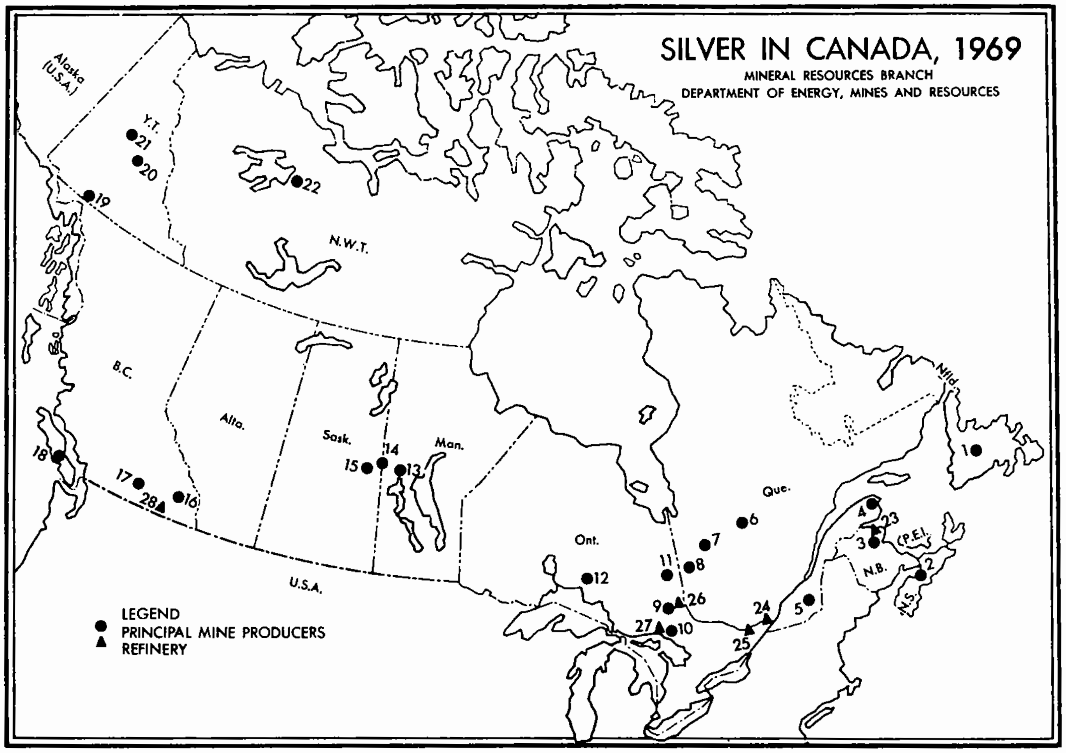
Development work continued at the Ruth-Vermont lead-zinc-silver property of Columbia River Mines Ltd. in the East Kootenay district near Golden. The company planned to bring its mine and a 500-ton-a-day mill into production about mid-1970. Dolly Varden Mines Ltd. was considering bringing into production in 1970 its silver-lead-zinc property near Alice Arm. Further exploration and development work were done at the silver-lead property of Interprovincial Silver Mines Ltd. northeast of Atlin near the Yukon border.

MANITOBA-SASKATCHEWAN

In Manitoba and Saskatchewan most of the silver continued to come from six base-metal mines operated by Hudson Bay Mining and Smelting Co., Limited, near Flin Flon and Snow Lake, Manitoba. In July 1969, operations were suspended at the Par zinc-lead-copper-silver mine and 350-ton-a-day mill of Western Nuclear Mines, Ltd., at Hanson Lake in northern Saskatchewan. The property had been in operation since mid-1967.

ONTARIO

Ontario was again, by far, the leading silver-producing province with its output accounting for more than 51 per cent of Canadian mine production. The largest producer was again Ecstall Mining Limited that recovered almost 14 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 4 million ounces were again 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.



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. Sullivan Mining Group Ltd. (Cupra Division), formerly Cupra Mines Ltd.
   Sullivan Mining Group Ltd., (Solbec Division), formerly Solbec Copper Mines, Ltd.
6. Campbell Chibougamau Mines Ltd.
   Opemiska Copper Mines (Quebec) Limited
7. Mattagami Lake 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
   Deer Horn Mines Limited
   Glen Lake Silver Mines Limited
   Hiho Silver Mines Limited
   Silverfields Mining Corporation Limited
   Siscoe Metals of Ontario Limited
10. The International Nickel Company of Canada, Limited
11. Ecstall Mining Limited
12. Noranda Mines Limited (Geco Division)
    Willecho Mines Limited
    Willroy Mines Limited
13. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake, Stall Lake, and Osborne Lake mines)
14. Hudson Bay Mining and Smelting Co., Limited (Flexar, Flin Flon, and Schist Lake mines)
15. Western Nuclear Mines, Ltd.
16. Cominco Ltd. (Sullivan and Bluebell mines)
17. Mastodon-Highland Bell Mines Limited
    Utica Mines Ltd.
18. Western Mines Limited
19. Arctic Gold and Silver Mines Limited
20. Anvil Mining Corporation Limited
21. United Keno Hill Mines Limited
22. Echo Bay Mines Ltd.

REFINERIES

23. East Coast Smelting and Chemical Company Limited
24. Canadian Copper Refiners Limited
25. Royal Canadian Mint
26. Kam-Kotia Mines Limited (Refinery Division)
27. The International Nickel Company of Canada, Limited
28. Cominco Ltd.

As a result of the continuing good demand for silver and the higher silver prices that have obtained since mid-1967, some of the companies operating in the Cobalt-Gowganda district processed old mill tailings. Underground development work continued at the silver property of Manridge Mines Limited, about 12 miles from the Siscoe mine in the Gowganda area. An old shaft has been rehabilitated and it was expected that the property would be brought into production in 1970. Operations at the property are being managed by Siscoe Metals of Ontario Limited under a leasing agreement with Manridge. The ore will be custom-treated at the Siscoe mill.

Selco Exploration Company Limited, a subsidiary of Selection Trust Limited of London, England, planned to bring into production by 1971 its copper-zinc-silver property in the Uchi Lake area of northwestern Ontario. Diamond drilling to a depth of 425 feet on the main sector of the ore zone has indicated sufficient ore to justify a 500-ton-a-day mill. Diluted grade of the deposit, discovered in 1968, was reported to average about 2.24 per cent copper, 14.11 per cent zinc, and 3.64 ounces of silver a ton. Exploration work and diamond drilling continued at the new zinc-copper-silver-lead discovery of Mattagami Lake Mines Limited on the south side of Sturgeon Lake in northwestern Ontario about 45 miles southeast of Sioux Lookout. Mattagami holds 60 per cent interest in the property and the remaining 40 per cent is held by Abitibi Paper Company Ltd. The results of the first 26 drill holes indicated an ore zone which is expected to contain between 10 and 15 million tons of ore within a depth of 600 feet from surface. The company is considering bringing the property into production in 1972. Open-pit mining appears to be possible for the first few years. The discovery made late in 1969 by an aerial geophysical survey, sparked a major staking rush and intensive exploration work in the area by many other mining companies.

QUEBEC

Silver output in the province, derived almost entirely from gold and base-metal ores, was slightly higher in 1969 than in 1968. Mattagami Lake Mines Limited, near Matagami Lake, was the leading mine producer with byproduct output of almost two-thirds of a million ounces. Because of the depletion of its copper ore reserves, Manitou-Barvue Mines Limited planned to increase mill capacity for treating its zinc-silver ore. Late in 1969, Delbridge Mines Limited brought into production its silver-base-metals mine in the Noranda area. After completion of shaft sinking, a major development program, to open up the ore, was started at the silver-base-metals property of D'Estrie Mining Company Ltd. adjacent to the Cupra mine of Sullivan Mining Group Ltd. (Cupra Division) at Stratford Centre. The company was considering bringing the property into production in 1970, with the ore to be custom-milled at the Cupra concentrator.

NEW BRUNSWICK

Operations were shut down during the second half of 1969 at the zinc-copper-lead-silver property of Heath Steele Mines Limited near Newcastle. The shutdown permitted the company to expand its mine and concentrator facilities, which almost doubled capacity to 1 million tons of ore annually. Construction and installation of equipment were completed in December and it was planned to begin production at full capacity in January 1970. Mine ore reserves were reported to be sufficient to sustain operations at present capacity rates for at least 20 years.

Restigouche Mining Corporation, Ltd. was considering bringing into production its lead-zinc-silver property about 50 miles west of Bathurst. Negotiations were still in progress regarding the sale of concentrates and, if these are concluded satisfactorily, it was expected that the deposit would be brought into production about mid-1971 at a rate of 1,000 tons a day, using open-pit mining methods. The orebody contains 3,270,000 tons grading 4.6 per cent lead, 5.9 per cent zinc, and 2.5 ounces silver a ton. Chester Mines Limited, an affiliate of the Sullivan Mining Group, did further diamond drilling and other exploration work on its copper-lead-zinc property in Northumberland County in the Newcastle area.

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 43.7 million ounces in 1969. 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

TABLE 4

Principal Silver Producers in Canada, 1969

Company and Location	Mill Capacity (short tons ore/day)	Type of Ore Milled	Silver Grade 1969 (1968) (oz/ton)	Ore Produced 1969 (1968) (short tons)	Contained Silver Produced 1969 (1968) (troy ounces)	Remarks
YUKON TERRITORY-NORTHWEST TERRITORIES						
Anvil Mining Corporation Limited, Ross River, Y.T.	5,500	Pb,Zn,Ag	1.2 (–)	. . (–)	273,500 (–)	Mill tune-up operations began in September 1969. Mill capacity being increased to 6,600 tons a day.
Arctic Gold and Silver Mines Limited, Carcross, Y.T.	300	Ag,Au	5.633 (8.35)	21,263 (30,811)	119,887 (185,637)	Mill ceased operations in October 1969.
Echo Bay Mines Ltd., Port Radium, N.W.T.	150	Ag,Cu	67.99 (68.12)	34,797 (36,985)	2,404,637 (2,669,880)	Plans an additional 750 feet of shaft sinking in 1970.
United Keno Hill Mines Limited, Calumet and Elsa mines, Mayo District, Y.T.	500	Ag, Pb,Zn	27.98 (33.93)	87,483 (60,800)	2,405,615 (1,981,777)	Husky mine being developed and prepared for production.
BRITISH COLUMBIA						
Cominco Ltd., Sullivan mine, Kimberley	10,000	Pb,Zn,Ag	. . (. .)	2,157,522 (2,155,749)	3,039,430 (3,140,650)	Cominco's total output of silver in 1969 was 5,705,130 troy ounces.
Bluebell mine, Riondel	700	Pb,Zn,Ag	. . (. .)	230,956 (251,497)	. . (. .)	
Mastodon-Highland Bell Mines Limited, Beaverdell	115	Ag,Pb,Zn	13.74 (15.45)	37,120 (36,413)	510,149 (562,560)	
Utica Mines Ltd., Keremeos	350	Ag,Au,Pb,Zn	. . (. .)	74,915 (128,652)	555,943 (1,067,971)	
Western Mines Limited[1], Myra Falls, Vancouver Island	1,000	Zn,Cu,Pb,Ag	1.54 (2.2)	373,850 (330,223)	. . (. .)	Development at Paramount property was seriously curtailed by very heavy snowfalls followed by snow and rock slides.

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Type of Ore Milled	Silver Grade 1969 (1968) (oz/ton)	Ore Produced 1969 (1968) (short tons)	Contained Silver Produced 1969 (1968) (troy ounces)	Remarks
MANITOBA-SASKATCHEWAN						
Hudson Bay Mining and Smelting Co., Limited	6,000 (treated at central mill at Flin Flon)	Cu,Zn,Pb,Ag	0.6 (0.7)	1,701,000 (1,614,100)	735,649 (942,200)	Flexar mine went into production April 1, 1969.
Flexar mine, Flin Flon, Man.		Cu,Zn,Ag	0.1 (–)	93,400 (–)		
Flin Flon mine, Flin Flon, Man.		Cu,Zn,Ag,Pb	0.8 (0.8)	622,400 (806,500)		
Schist Lake mine, Flin Flon, Man.		Cu,Zn,Ag	0.9 (1.4)	122,600 (121,000)		
Chisel Lake mine, Snow Lake, Man.		Zn,Cu,Pb,Ag	0.8 (1.1)	282,400 (278,400)		
Osborne Lake mine, Snow Lake, Man.		Cu,Zn,Ag	.. (0.1)	376,100 (177,400)		
Stall Lake mine, Snow Lake, Man.		Cu,Zn,Ag	0.6 (0.4)	204,100 (230,800)		
Western Nuclear Mines, Ltd., Hanson Lake mine, Hanson Lake, Sask.	350	Zn,Pb,Cu,Ag	.. (2.89)	59,718 (60,789)	.. (159,557)	Operations ceased in July 1969.
ONTARIO						
Ecstall Mining Limited (Texas Gulf Sulphur Company), Kidd Creek mine, Timmins	9,000	Zn,Cu,Ag,Pb	.. (5.19)	3,617,226 (3,614,860)	13,822,000 (13,396,190)	Planning program of underground development work including shaft sinking.
Noranda Mines Limited (Geco Division), Manitouwadge	4,000	Cu,Zn,Ag,Pb	2.34 (2.20)	1,320,000 (1,495,369)	2,351,000 (2,452,360)	Mine and mill struck from November 22, 1969 to February 2, 1970.

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Type of Ore Milled	Silver Grade 1969 (1968) (oz/ton)	Ore Produced 1969 (1968) (short tons)	Contained Silver Produced 1969 (1968) (troy ounces)	Remarks
Willecho Mines Limited, Lun-Echo mine, Manitouwadge	ore custom-milled	Zn,Cu,Ag,Pb	2.13 (2.15)	318,149 (402,680)	443,858 (402,680)	Ore treated at Willroy mill.
Willroy Mines Limited, Manitouwadge	1,700	Cu,Zn,Ag,Pb	0.61 (0.77)	127,300 (174,336)	51,077 (71,898)	Company continued to prepare the Big Nama Creek orebody for mining operations using trackless mining methods.
The International Nickel Company of Canada, Limited, Sudbury, Ont., and Thompson, Man.	76,500	Ni,Cu	.. (..)	18,800,000 (24,900,000)	1,111,000[2] (1,607,000)[2]	Combined capacity and output for Sudbury and Thompson mills. Production at company's Ontario facilities was substantially reduced by a 128-day labour strike during the second half of 1969.
Agnico Mines Limited, 407 mine, 96 shaft mine and Penn-Canadian mine, Cobalt District	400	Ag,Co	17.14 (14)	35,525[3] (33,384)[3]	573,511 (581,466)	
Deer Horn Mines Limited, Cross Lake property, Cobalt District	100	Ag,Co	10.3 (8.4)	13,447 (21,881)	138,089 (184,351)	Milling operations temporarily suspended about mid-1969, but company continuing underground development work.
Glen Lake Silver Mines Limited, Bailey mine, Cobalt District	250	Ag,Co	.. (7.59)	72,180[4] (48,999)[4]	52,344 (48,999)	Plans diamond drilling exploration of claims in South Giroux Lake area.
Hiho Silver Mines Limited, Cleopatra, Giroux Lake, Kerr Lake and Crown Reserve properties in Cobalt District	150	Ag,Co	17.57 (11.63)	47,015 (97,704)	826,062 (1,137,126)	
Silverfields Mining Corporation Limited, Cobalt District	250	Ag,Co	14.4 (12.6)	79,556 (80,705)	1,143,018 (996,960)	

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Type of Ore Milled	Silver Grade 1969 (1968) (oz/ton)	Ore Produced 1969 (1968) (short tons)	Contained Silver Produced 1969 (1968) (troy ounces)	Remarks
Siscoe Metals of Ontario Limited, Gowganda District	275	Ag,Co	19.78 (20.92)	41,808 (47,544)	. . (963,564)	Routine underground development at main mine and Castle property.
QUEBEC						
Campbell Chibougamau Mines Ltd., Chibougamau District	3,500	Cu,Au,Ag	0.2557 (0.2375)	1,196,849 (739,270)	204,895 (134,736)	
Delbridge Mines Limited, Noranda	Ore custom-milled	Zn,Cu,Ag	3.25 (–)	57,494 (–)	103,380 (–)	Production began October 1, 1969.
Gaspé Copper Mines, Limited, Gaspé mine, Murdochville	11,250	Cu,Mo	. . (. .)	2,997,800 (3,933,745)	345,066 (370,628)	Mine, mill and smelter closed by strike from May 13 to August 19, 1969.
Lake Dufault Mines, Limited, Noranda	1,300	Cu,Zn,Ag	0.77 (1.24)	405,790 (415,009)	236,600 (400,038)	Sinking 4,000-foot shaft to explore new ore zone.
Manitou-Barvue Mines Limited, Golden Manitou mine, Val d'Or	1,300	Cu,Zn,Au,Ag	2.27 (0.81)	198,605[5] (181,250)[5]	380,538 (127,481)	Continued to concentrate on exploration and development work.
Mattagami Lake Mines Limited, Mattagami Lake mine, Matagami	3,850	Zn,Cu,Ag,Au	1.02 (0.80)	1,413,651 (1,363,705)	664,795 (. .)	Development heading driven on 750-foot level to check copper-nickel zone on north side of No. 1 orebody.
Noranda Mines Limited, Horne mine, Noranda	3,200	Cu,Au	. . (0.382)	754,365 (773,765)	. . (142,491)	Routine mining of remaining ore reserves.
Normetal Mines Limited, Normetal	1,000	Zn,Cu,Ag	1.48 (1.79)	355,495 (358,557)	348,380 (436,352)	Operations confined to mining remainder of known ore reserves.
Opemiska Copper Mines (Quebec) Limited, Chapais	2,000	Cu,Au,Ag	0.37 (0.39)	792,549 (744,466)	243,583 (248,230)	Robitaille mine brought into production. Will increase mill rate.

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Type of Ore Milled	Silver Grade 1969 (1968) (oz/ton)	Ore Produced 1969 (1968) (short tons)	Contained Silver Produced 1969 (1968) (troy ounces)	Remarks
Quemont Mines Limited, Noranda	2,300	Cu,Zn,Au,Ag	0.74 (0.79)	334,432 (429,309)	148,771 (210,109)	Routine development of remaining ore reserves.
Sullivan Mining Group Ltd. (Cupra Division), formerly Cupra Mines Ltd., Stratford Centre	1,500	Cu,Zn,Pb,Ag	1.07 (1.21)	246,009 (225,702)	217,051 (198,533)	Opening three new underground levels from internal shaft.
Sullivan Mining Group Ltd. (Solbec Division), formerly Solbec Copper Mines, Ltd., Stratford Centre	Ore custom-milled	Cu,Zn,Pb,Ag	2.086 (1.85)	185,288 (262,076)	260,149 (269,968)	Mine on salvage basis.
NEW BRUNSWICK						
Brunswick Mining and Smelting Corporation Limited, No. 12 mine, Bathurst	5,000	Zn,Pb,Cu,Ag	2.13 (1.92)	1,696,408 (1,724,465)	1,706,447 (2,023,148)	Cut-and-fill mining methods, utilizing modern trackless mining equipment, are being introduced.
No. 6 mine, Bathurst	2,500	Zn,Pb,Cu,Ag	1.87 (1.53)	1,134,224 (984,280)	961,370 (901,180)	Construction work continued on the gyratory crusher installation.
Heath Steele Mines Limited, Newcastle	3,000	Zn,Cu,Pb,Ag	1.71 (. .)	321,403 (391,363)	224,477 (373,454)	Mill capacity increased to 3,000 tons a day.
Nigadoo River Mines Limited, Bathurst	1,000	Pb,Zn,Cu,Ag	3.85 (3.33)	328,709 (284,867)	952,575 (694,486)	
NOVA SCOTIA						
Dresser Minerals, Division of Dresser Industries, Inc., Walton	125	Ag,Pb,Zn,Cu	5.5 (7.10)	49,870 (49,786)	227,822 (270,832)	Carrying out exploration work at lower levels.

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Type of Ore Milled	Silver Grade 1969 (1968) (oz/ton)	Ore Produced 1969 (1968) (short tons)	Contained Silver Produced 1969 (1968) (troy ounces)	Remarks
NEWFOUNDLAND						
American Smelting and Refining Company (Buchans Unit), Buchans	1,250	Zn,Pb,Cu,Ag	4.01 (3.93)	371,000 (378,000)	1,300,784 (1,354,860)	

Source: Company reports.

[1]Production for fiscal years ending September 30. [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. [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.

– Nil; . . Not available.

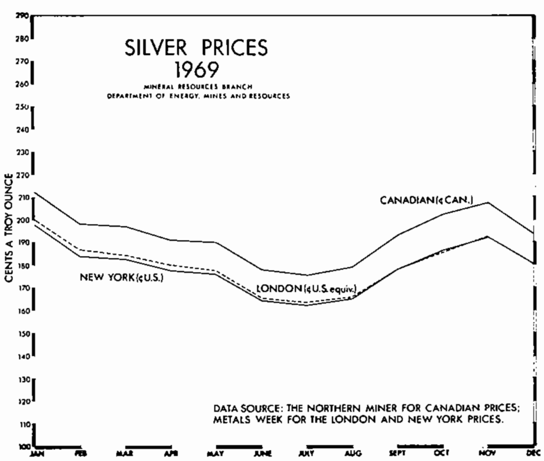
ability to take a fine finish. The photographic industry, in which the use of silver is based on the light sensitivity and ease of reduction of certain silver compounds, has now become the metal's greatest single use.

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 rechargability 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 of such batteries serviced the command module and two of them were located in the lunar excursion module.

PRICES

In 1969, the New York silver price again followed an erratic pattern but the range of price fluctuations was narrower than in 1968. The year opened with the price at $1.945 a troy ounce, with a brief upward trend carrying it to $2.025 on January 15 and which was the high for the year. Beginning in February and continuing until about mid-year, the price displayed a downward trend. A low for the year of $1.540 was reached on June 27. During the second half of the year the price trend was generally upward, and at year-end the price was $1.800. The London price ranged between a high of 205.5 pence an ounce, equivalent to $2.042 (US) on January 10, a low for the year of 156.5 pence, equivalent to $1.559 (US) on June 27, and at year-end it was 179.0 pence, equivalent to $1.791 (US).



In 1969, the Canadian silver price closely followed its United States counterpart with the essential difference being the exchange rate; it fluctuated between a high of $2.178 a troy ounce on January 15 and a low of $1.670 on June 27. Average for the year was $1.931.

TARIFFS

	Most Favoured Nation
CANADA	
Ores of metal, n.o.p.	free
Silver anodes	free
Silver in ingots, blocks, bars, drops, sheets or plates, unmanufactured; silver sweepings	free
Scrap silver and metal alloy scrap containing silver	free[1]
Silver leaf	20%[2]
Articles consisting wholly or in part of sterling or other silverware, n.o.p.; manufactures of silver, n.o.p.	22½%[2]
UNITED STATES	
Precious metal ores, silver content	free
Silver or gold bullion, dore, and silver or gold precipitates	free
Silver (including platinum- or gold-plated silver, but not rolled silver), unwrought (except bullion, dore, and precipitates) or semi-manufactured:	
Platinum-plated	22.5%[3]
Gold-plated	35%[3]
Other	14.5%[3]
Rolled silver	14.5%[3]
Precious metal sweepings and other precious metal waste and scrap	
Silver content	free

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.

[1]Expires October 31, 1970; [2]Effective June 4, 1970; [3]Effective January 1, 1970.
n.o.p. Not otherwise provided for.

Sodium Sulphate

W.E. KOEPKE*

Canada's sodium sulphate industry has expanded sharply in the past decade to meet the requirements of the kraft pulp and paper industry, which is by far the largest single consumer of sodium sulphate in North America. Sodium sulphate (Na_2SO_4), commonly known as 'salt cake', 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. 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.

The industry in western Canada supplies over 90 per cent of this country's sodium sulphate needs; in addition, the level of production has generally been sufficient to allow for the export of one quarter to one third the total output. Production increased at an average annual rate of about 11 per cent in the decade 1960-69. Exports had increased at a similar rate throughout most of the last decade but levelled off in the last two years and in 1969 remained slightly below the peak established in 1967. Sodium sulphate imports, which have remained fairly constant over the past 15 years and now constitute less than 10 per cent of Canada's consumption, generally are of slightly higher grade than domestic output; they also serve markets not readily accessible to shipments from western Canada. Nearly all Canada's sodium sulphate trade is with the United States.

*Mineral Resources Branch.

PRODUCTION AND DEVELOPMENT IN CANADA

Production (shipments) of sodium sulphate in Canada increased for the seventh consecutive year in 1969 to reach 508,484 tons valued at $8.4 million, a tonnage increase of 11 per cent and a value increase of 19 per cent from 1968. The foregoing figures are preliminary and include only those producers in Saskatchewan. In mid-1969, a new sodium sulphate plant was placed on stream in Alberta but its shipments are not included in the preliminary statistical survey. A small quantity of byproduct salt cake (estimated at 15,000 tons in 1969) is recovered at a viscose-rayon plant in Ontario, but this is not included in Canada's sodium sulphate production statistics.

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 dissolved sulphate in 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

TABLE 1

Canada, Sodium Sulphate Production and Trade, 1968-69

	1968		1969P	
	Short Tons	$	Short Tons	$
Production (shipments)	459,669	7,082,575	508,484	8,388,717
Imports				
Total crude salt cake and Glauber's salt				
United States	23,105	565,000	20,016	490,000
Britain	3	...	5,604	102,000
Belgium and Luxembourg	1,821	35,000	3,967	76,000
Other countries	89	4,000	33	1,000
Total	25,018	604,000	29,620	669,000
Exports				
Crude sodium sulphate				
United States	104,153	2,290,000	107,233	2,556,000
Australia	4,831	114,000	3,284	78,000
Republic of South Africa	–	–	4,034	67,000
Other countries	–	–	5,858	106,000
Total	108,984	2,404,000	120,414	2,807,000

Source: Dominion Bureau of Statistics.
PPreliminary; – Nil; ... Less than one thousand dollars.

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 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.

TABLE 2

Canada, Sodium Sulphate Production, Trade and Consumption, 1960-69
(short tons)

	Production*	Imports**	Exports	Consumption
1960	214,208	25,857	63,831	183,062
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	401,523e
1969P	508,484	29,609	120,414	452,000e

Source: Dominion Bureau of Statistics.
* Producers' shipments of crude sodium sulphate.
**Includes Glauber's salt and crude salt cake.
PPreliminary; eEstimated.

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 and 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.

At Alsask, Saskatchewan, where plant operation began in mid-1967, difficulty was experienced in obtaining an adequate fresh water supply and production has been limited, in fact, the plant was shut down for most of 1968 and 1969. In the latter part of 1969 the property was taken over by Francana Minerals Ltd.

In mid-1969, Alberta Sulphate Limited, a subsidiary of Chemcell Limited and Western Minerals Ltd., placed a new $2.5 million sodium sulphate plant on stream at Metiskow, Alberta; Horseshoe Lake provides the source material for the 100,000 ton-a-year plant. This became Alberta's first producer of sodium sulphate and Canada's first producer to adopt a solution recovery system rather than the seasonal harvesting method described above. The raw Glauber's salt is recovered from the 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 1969 from the operation of a viscose-rayon plant at Cornwall, Ontario.

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 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 1969 – 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 430,000 tons in 1969, for an average annual growth rate of 12 per cent.

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, almost all to the United States, amounted to 120,414 tons valued at $2,807,000 in 1969. The quantity was slightly below the record export level in 1967 but above the average for the past five years.

TABLE 3

Canada, Sodium Sulphate Plants, 1969

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
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
Sodium Sulphate (Saskatchewan) Ltd.*	Alsask, Sask.	Alsask, Sask.	50,000
Sybouts Sodium Sulphate Co., Ltd.	Gladmar, Sask.	East Coteau, Sask.	50,000
		Total	890,000

*Inoperative for most of 1969.

TABLE 4

Canada, Available Data on Sodium Sulphate Consumption, 1967-69
(short tons)

	1967	1968	1969e
Pulp and paper	329,409	380,000e	430,000
Glass and glasswool	5,994	6,173	6,000
Soaps	6,649	8,655	9,000
Other products*	5,118	6,695	7,000
Total	347,140	401,523e	452,000

Source: Dominion Bureau of Statistics; breakdown by Mineral Resources Branch.

*Colour, pigments, gypsum products, textiles, medicinals and miscellaneous other uses.

eEstimated.

Imports of sodium sulphate, mainly from the United States, have remained fairly steady around 30,000 tons annually during the past 15 years. In 1969 imports totalled 29,609 tons valued at $669,000. Most of Canada's sodium sulphate imports are of the byproduct type which normally have a high purity, suitable for use in the manufacture of glass and detergents; however it is anticipated that improved product purity of some shipments from Saskatchewan will replace some imports during the next few years. A portion of the imports serves markets in eastern Canada that are not readily accessible to shipments from Saskatchewan.

Although the producers in western Canada are centrally located with respect to major market areas – British Columbia and Ontario and Quebec – freight charges may represent more than one half the cost of sodium sulphate to the consumer.

OUTLOOK

The outlook for Canada's sodium sulphate industry is favourable. The kraft pulp and paper industry is expanding and will require larger quantities of sodium sulphate in the years ahead. In late 1969 and early 1970 there were indications of weaker prices for sodium sulphate in western Canada; however, prices have subsequently increased in the United States, a reflection of a strong demand that will help to keep Canadian prices steady.

PRICES

Canadian prices for sodium sulphate, as quoted by *Canadian Chemical Processing* in December, 1969 were:

Sodium sulphate (salt cake)	(Can. $ per short ton)
Bulk, carlots, f.o.b. works	18.00 – 20.00
Detergent grade, bulk, f.o.b. works	23.50

According to *Oil, Paint and Drug Reporter*, December 29, 1969, 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 points	18.50
Sodium sulphate, detergent, rayon-grade, carlots, f.o.b. works, bulk	
East	34.00
West	24.50

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, 1969 to Dec. 31, 1969	40¢
Jan. 1, 1970 to Dec. 31, 1970	35¢
Crystallized (Glauber's salt), per long ton	
Jan. 1, 1969 to Dec. 31, 1969	80¢
Jan. 1, 1970 to Dec. 31, 1970	70¢

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.

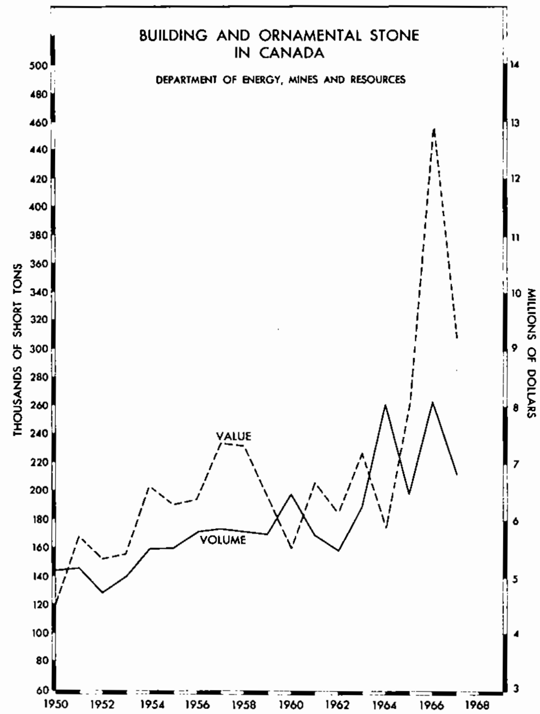
Source: Tariff Schedules of United States, Annotated (1969) T.C. Publication 272.

Stone, Building and Ornamental

D. H. STONEHOUSE*

Construction uses account for over 85 per cent of the consumption of building and ornamental stone produced and sold in Canada the remainder being 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.

Statistics relating to production and consumption of building and ornamental stone in Canada during 1968 and 1969 are not yet available. Production from 1965 to 1967 was influenced by requirements of Expo '67; in Quebec, which normally accounts for about 60 per cent of Canada's building and ornamental stone output, shipments rose from 92,898 tons in 1965 to a high of 167,479 tons in 1966 as Expo construction peaked, and dropped to 119,472 tons in 1967. Production of stone in other regions was not influenced to the same degree. Ontario production of building stone decreased as the demand for dimension stone fell off during 1966 and 1967. Output from the western provinces has remained reasonably steady while Atlantic production increased, mainly because of shipments of Wallace sandstone for reconstruction of the fortress at Louisbourg.



Import and export figures for 1967 through 1969 indicate a nearly-balanced trade structure. Imports do, however, include materials of higher unit value than do exports. Dressed, ornamental granite continued to command the highest unit value of all building and ornamental stone used in Canada.

*Mineral Resources Branch.

TABLE 1

Canada, Production* of Building and Ornamental Stone, 1966-67

	Granite		Limestone		Marble		Sandstone		Total	
	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$
1966										
By type										
Building										
Rough	38,972	794,708	30,234	308,069	2,785	116,685	26,719	518,005	98,710	1,737,467
Dressed	56,675	4,910,290	38,338	2,904,837	130	7,500	1,000	37,400	96,143	7,860,027
Total	95,647	5,704,998	68,572	3,212,906	2,915	124,185	27,719	555,405	194,853	9,597,494
Monumental										
Rough	29,892	1,092,093	2,095	48,532	–	–	–	–	31,987	1,140,625
Dressed	6,522	1,742,966	100	4,000	–	–	3,293	131,746	9,915	1,878,712
Total	36,414	2,835,059	2,195	52,532	–	–	3,293	131,746	41,902	3,019,337
Flagstone	3,950	26,645	6,303	59,264	–	–	340	9,000	10,593	94,909
Curbstone	9,225	176,329	–	–	–	–	–	–	9,225	176,329
Paving	5,000	10,000	–	–	–	–	–	–	5,000	10,000
Total	18,175	212,974	6,303	59,264	–	–	340	9,000	24,818	281,238
Grand Total	150,236	8,753,031	77,070	3,324,702	2,915	124,185	31,352	696,151	261,573	12,898,069
By areas										
Atlantic provinces	1,192	148,303	605	2,965	–	–	2,350	79,125	4,147	230,393
Quebec	142,891	8,446,913	20,578	1,585,716	–	–	4,010	42,000	167,479	10,074,629
Ontario	2,647	52,815	39,135	572,079	2,915	124,185	22,782	502,295	67,479	1,251,374
Western provinces	3,506	105,000	16,752	1,163,942	–	–	2,210	72,731	22,468	1,341,673
Total, Canada	150,236	8,753,031	77,070	3,324,702	2,915	124,185	31,352	696,151	261,573	12,898,069
1967										
By type										
Building										
Rough	50,109	1,022,665	12,395	139,832	3,896	99,065	27,999	574,371	94,399	1,835,933
Dressed	18,572	1,654,066	34,789	2,564,238	540	16,716	766	103,580	54,667	4,338,600
Total	68,681	2,676,731	47,184	2,704,070	4,436	115,781	28,765	677,951	149,066	6,174,533

TABLE 1 (Cont'd)

	Granite		Limestone		Marble		Sandstone		Total	
	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$
Monumental										
Rough	22,247	864,781	657	11,841	–	–	–	–	22,904	876,622
Dressed	7,767	1,731,056	–	–	–	–	–	–	7,767	1,731,056
Total	30,014	2,595,837	657	11,841	–	–	–	–	30,671	2,607,678
Flagstone	5,236	73,019	9,040	56,505	–	–	5,623	81,230	19,899	210,754
Curbstone	5,566	153,583	50	1,000	–	–	370	1,869	5,986	156,452
Paving blocks	7,000	14,500	1,070	18,686	–	–	–	–	8,070	33,186
Total	17,802	241,102	10,160	76,191	–	–	5,993	83,099	33,955	400,392
Grand Total	116,497	5,513,670	58,001	2,792,102	4,436	115,781	34,758	761,050	213,692	9,182,603
By areas										
Atlantic provinces	15,012	230,449	801	4,015	–	–	2,086	223,380	17,899	457,844
Quebec	90,296	4,947,295	13,342	1,349,573	2,183	21,829	13,651	161,572	119,472	6,480,269
Ontario	6,035	47,543	31,796	536,077	2,253	78,912	17,015	297,528	57,099	975,100
Western provinces	5,154	288,383	12,062	902,437	–	–	2,006	78,570	19,222	1,269,390
Total, Canada	116,497	5,513,670	58,001	2,792,102	4,436	115,781	34,758	761,050	213,692	9,182,603

Source: Dominion Bureau of Statistics.
*Producers' shipments; – Nil.

TABLE 2

Value of Construction in Canada, 1967-1970
(millions of dollars)

Type	1967	1968	1969	1970*
Residential	3,065	3,572	4,214	4,065
Industrial	870	731	831	932
Commercial	1,221	1,156	1,100	1,270
Institutional	1,258	1,397	1,341	1,456
Other building	412	426	420	457
Total building	6,826	7,283	7,906	8,180
Total engineering	4,768	4,959	5,116	5,731
Total construction	11,594	12,242	13,022	13,911

Source: Dominion Bureau of Statistics.
*Intentions.

CANADIAN INDUSTRY AND DEVELOPMENTS

GRANITE

Atlantic Provinces

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 to manufacture facing stone. In 1969 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.

Quebec

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 St. Jean area, and the region south of the St. Lawrence River in the Eastern Townships. North of the St. Lawrence, Precambrian rocks contain granites of various colours, compositions and textures. Red, brown, pink and black granites were quarried in the Lac St. Jean area; a fine-grained, pink granite and a black anorthositic rock were quarried near Alma and in the St.-Luger-de-Milot area. From the Rivière-à-Pierre region coarse-grained, blue-grey and dark-green granites are available. Black and grey gneissic rocks were quarried at Rivière-à-Pierre and at Notre-Dame-des-Anges. A red-pink granite came from St-Alban and a banded, pink-red gneiss from St-Raymond. Fine-grained, pink-coloured granite from the Laurier-Guenette area and a grey-pink gneiss at L'Annonciation were quarried. An augen-type granite was produced near Mont-Tremblant and a coarse-grained, brown granite was quarried in the St-Alexis-des-Monts area. Grey-speckled, black gabbroic rock was quarried in the Montpellier area and a dark-coloured anorthositic rock was quarried in the Rouyn area. Brown-red to green-brown syenites were quarried in the Grenville district while a mauve-red granite was produced in the Ville-Marie area on Lake Timiskaming. Many areas underlain by granite are too remote from transportation and markets to be attractive economically.

In the region south of the St. Lawrence River, granites are of much younger geological age and are essentially greyish in colour.

Ontario

Granites occur in northern, northwestern and southeastern Ontario. Few deposits have been exploited for the production of building stone because the consuming centres have developed 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.

Western Provinces

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 adesite has been quarried at Haddington Island, off the northeast coast of Vancouver Island, for use as a building stone.

TABLE 3

Canada, Stone Imports and Exports, 1967-1969

	1967		1968		1969p	
	Short Tons	$	Short Tons	$	Short Tons	$
Exports						
Building stone, rough	22,344	784,000	18,522	777,000	21,308	901,000
Natural stone basic products	..	1,067,000	..	1,628,000	..	2,175,000
Total		1,851,000		2,405,000		3,076,000
Imports						
Stone crude, n.e.s.	2,908	90,000	19,276	92,000	1,121	53,000
Building stone rough, n.e.s.	11,659	409,000	12,919	442,000	15,307	571,000
Granite, rough	12,312	568,000	13,166	582,000	14,271	665,000
Marble, rough	7,643	671,000	5,745	495,000	6,445	569,000
Shaped or dressed granite	..	290,000	..	227,000	..	548,000
Shaped or dressed marble	..	870,000	..	483,000	..	542,000
Natural stone basic products	..	336,000	..	247,000	..	281,000
Total		3,234,000		2,568,000		3,229,000

Source: Dominion Bureau of Statistics.
pPreliminary; ..Not available; n.e.s. Not elsewhere specified.

LIMESTONE AND MARBLE

Limestone quarries are operated at many locations in Quebec, Ontario and Manitoba producing dimension stone for building construction purposes. In the building stone trade the term "marble" is reserved for any calcareous, crystalline rock or serpentine, which will take a high polish. A number of deposits in Quebec and Ontario are potential sources of marble dimension stone.

Quebec

A fine-grained, brownish-grey, fossiliferous limestone is available in the St-Marc-des-Carrieres 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 from the Stukely and Philipsburg areas.

Ontario

Although limestone building stone has been produced from many locations in Ontario, commercial production is presently limited to Thorold, Queenston, Wiarton and Nogies Creek. The Black River and Trenton limestones and the Guelph and Lockport dolomites are the principal formations from which building stones are quarried.

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 underlays as much as one hundred square miles according to Ontario Department of Mine Reports.

Western Provinces

A mottled, dolomitic limestone, quarried at Garson, Manitoba, for use in the construction industry, has found wide acceptance. The stone, known as Tyndall Stone, is brown to grey-brown in colour and is used in both the rough and polished state as a decorative dimension stone.

SANDSTONE

Atlantic Provinces

A medium-grained, buff-coloured, sandstone was quarried at Wallace, Nova Scotia in 1969 for use as heavy rip rap and for dimension stone applications. Recently considerable tonnages have been used in the reconstruction of the fortress at Louisbourg. Small deposits in many parts of the province are quarried for local use.

In New Brunswick a red, fine-to-medium-grained sandstone is quarried periodically 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

During 1969 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

Sandstone quarried near Toronto, Ottawa and Kingston has been used widely in Ontario as building stones. 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

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

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.

Sulphur

P. R. COTE*

For the second consecutive year, sulphur production in the western world exceeded demand and producer stockpiles continued to mount. Western world production of sulphur in all forms in 1969 increased 5.3 per cent from 1968 to reach 28.9 million long tons while consumption increased about 4 per cent to reach 27.8 million long tons. The rate of increase in consumption is in line with the long term historical trend of between 4 and 5 per cent but is considerably less than the average annual growth rate of 8 per cent experienced from 1963 to 1967. Decreasing consumption rates can be attributed to slackening demands in the major sulphur consuming industries–in particular the fertilizer industry which consumes about 50 per cent of sulphur utilized. Coupled with a slower growth in demand has been a rapid increase in output particularly in Canada and Poland. The oversupply situation placed severe downward pressure on prices, which began to drop in 1968 and continued to decline sharply throughout 1969, and major export markets remained extremely competitive.

Since 1960, Canada has changed from a net importer of sulphur to become, in 1968 and 1969, 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 1969, the productive capacity of sulphur from sour natural gas stood at 13,492 long tons daily, an 8.6 per cent increase from 1968.

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.

PRODUCTION AND DEVELOPMENTS IN CANADA

Canadian sulphur shipments in all forms in 1969 amounted to 3,695,601 tons valued at $73,319,308. This represents a tonnage increase of 8.6 per cent and a value decrease of 20 per cent from 1968. The decrease in value clearly reflects the downward pressure on sulphur prices due to world oversupply. A price per long ton decrease of 62 per cent from January 1, 1969, to December 31, 1969, was experienced by producers of elemental sulphur in western 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 1969, 81 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 at various metallurgical plants or in byproduct pyrites shipped for subsequent conversion to sulphur dioxide or sulphuric acid.

In 1969, development activity was again directed towards sulphur extraction from sour natural gas. Interest in native sulphur deposits in northern Alberta waned somewhat in light of current world oversupply and depressed prices.

*Mineral Resources Branch

TABLE 1

Canada, Sulphur Production and Trade, 1968-69

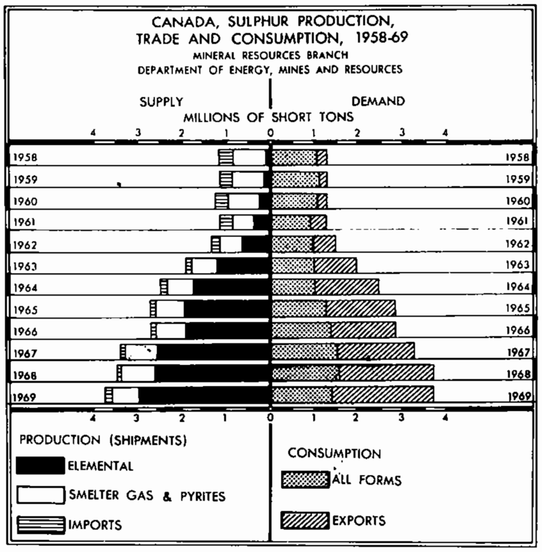
	1968		1969p	
	Short Tons	$	Short Tons	$
Production (shipments)				
Pyrite and pyrrhotite[1]				
Gross weight	(314,197)		(323,432)	
Sulphur content	155,797	2,286,442	159,860	2,111,198
Sulphur in smelter gases[2]	666,370	8,915,202	550,809	8,221,795
Elemental sulphur[3]	2,580,746	79,963,600	2,984,937	62,986,315
Total sulphur content	3,402,913	91,165,244	3,695,601	73,319,308
Imports				
Sulphur, crude or refined				
United States	75,815	3,057,000	45,483	1,694,000
France	–	–	25	3,000
Total	75,815	3,057,000	45,508	1,697,000
Exports				
Sulphur in ores (pyrite)				
United States	. .	930,000	. .	1,018,000
Japan	. .	–	. .	87,000
Taiwan	. .	126,000	. .	–
Total		1,056,000		1,105,000
Sulphur, crude or refined, n.e.s.				
United States	919,654	27,789,000	1,033,855	26,266,000
Australia	323,724	12,453,000	256,974	7,396,000
India	245,414	10,537,000	241,703	6,514,000
New Zealand	114,622	4,056,000	155,601	5,347,000
South Korea	114,577	5,301,000	147,950	4,623,000
Taiwan	83,962	3,682,000	119,931	3,904,000
Netherlands	–	–	107,238	2,670,000
Republic of South Africa	131,228	4,971,000	89,217	2,757,000
Britain	11,647	493,000	22,000	714,000
Other countries	151,980	7,144,000	89,812	2,551,000
Total	2,111,135	76,426,000	2,264,281	62,742,000

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.
pPreliminary; – Nil; . . Not available; n.e.s. Not elsewhere specified.

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 over tenfold from 274,359 tons to 2,984,937 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.

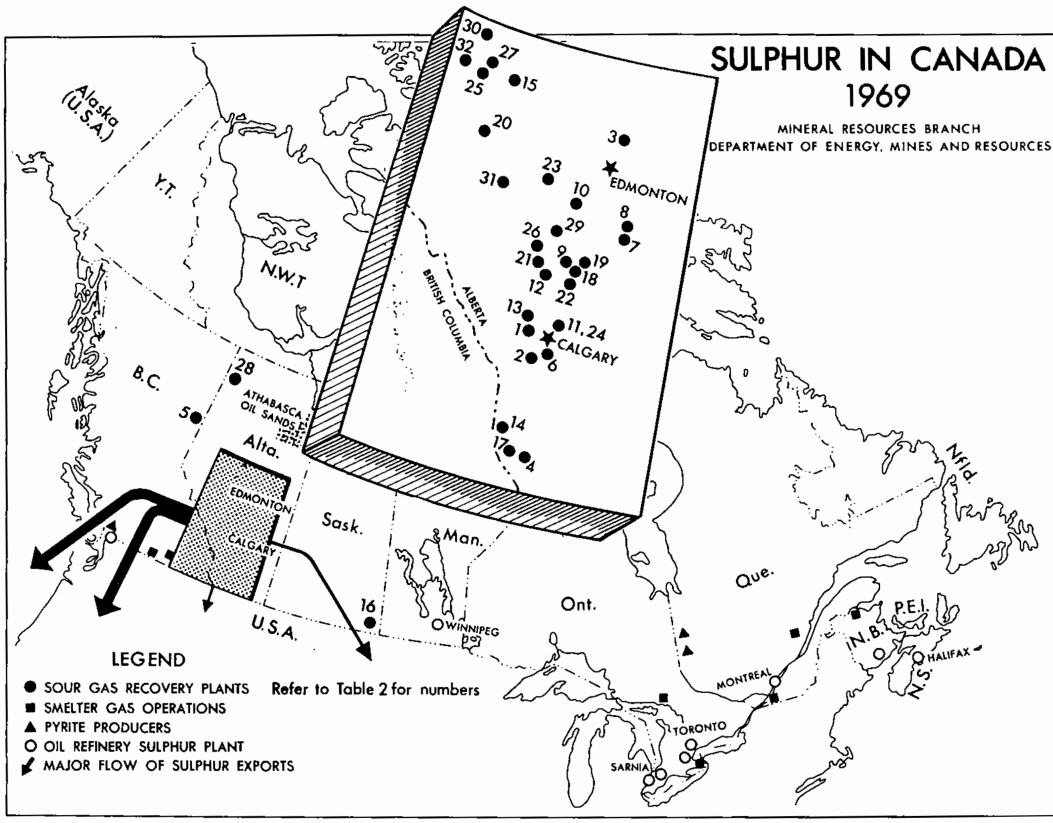
Briefly, H_2S contained in sour natural gas is absorbed chemically at sulphur recovery plants located at or near the gas producing fields. The acid gas fraction containing H_2S is burned under controlled conditions in a combustion chamber and elemental sulphur droplets are released in a vapour of steam. The vapour is passed over a sequence of condensers where liquid elemental sulphur is recovered and pumped to storage vats. The elemental sulphur so produced is generally considered as a byproduct of natural gas production.

Canada's first sour gas sulphur plant came on stream in Alberta in 1951. By the end of 1969, 32 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 amount to an estimated 139.7 million long tons, in 1969. Combined daily capacity of the sour gas plants in the three provinces was 13,492 long tons at the end of 1969. 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.

In 1969, production of sulphur from sour natural gas in Alberta, as reported by the Alberta Oil and Gas Conservation Board, was 3,653,957 long tons, an increase of 22 per cent from 1968. Sales amounted to 2,568,281 long tons, an increase of 16 per cent over the previous year, but value of sales decreased 23 per cent to $58,925,942 reflecting the sharp decline in prices which took place in 1969. Gross value for Alberta sulphur stood at $33.73 a long ton f.o.b. plant in January 1969 but by December had declined to $12.91 a long ton.

Three sour gas plants with a combined daily rated capacity of 190 long tons came on stream in 1969. They were: Hudson's Bay Oil and Gas Company Limited, Sturgeon Lake South (50); and Brazeau River (50); and Shell Canada Limited, Simonette (90). In addition, capacity was expanded at six existing plants which, together with the new plants mentioned above, resulted in an increase in daily rated capacity of 1,072 long tons over that existing at the end of 1968.

To meet ever-growing demands for Canadian natural gas, particularly in the United States market, new plants and expansions scheduled for completion in 1970 and 1971 will result in a further increase in daily rated capacity of 9,279 long tons by the end of 1971, representing an increase of 69 per cent over installed daily capacity at the end of 1969. This additional capacity could boost elemental sulphur production in Canada by 2.5 million long tons by the end of 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. The gas from one well drilled in the area by Shell Oil and Canadian Superior Oil Ltd. in the first half of 1969, tested 87 per cent H_2S. Further



development of the gas play will undoubtedly add considerably to sulphur reserves in Alberta and should, in the near term, result in substantial increases in sulphur production.

In order to move sulphur to export markets, Canadian producers will continue to explore methods of transporting their product at the lowest possible cost from Alberta to bulk loading facilities at Vancouver. In this regard, considerable efforts have been made in determining the feasibility of transporting sulphur (suspended in crude oil) by pipeline either as a slurry or in capsule form. In early 1970, movement of sulphur to the west coast by unit-train was inaugurated. A few examples of ocean freight rates from Vancouver to various export market areas are listed in Table 4.

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.

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 1969 some 48,000 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

TABLE 2

Canada, Sour Gas Sulphur Extraction Plants, 1969

Operating Company	Source Field or Plant Location	% H_2S in raw gas	Daily Capacity (long tons)	Production 1969†† (long tons)
			(Rated)†	
1. Shell Canada	Jumping Pound, Alta.	3-5	240	64,576
2. Gulf Oil Canada	Turner Valley, Alta.	4	35	5,642
3. Imperial Oil	Redwater, Alta.	3	13	3,165
4. Gulf Oil Canada	Pincher Creek, Alta.	10	675	82,255
5. Jefferson Lake Petro.	Taylor Flats, B.C.	3	325	57,032
6. Texas Gulf Sulphur	Okotoks, Alta.	33	430	131,953
7. Gulf Oil Canada*	Nevis, Alta.	3-7	198	39,663
8. Chevron Standard*	Nevis, Alta.	7	204	43,704
9. Shell Canada	Innisfail, Alta.	14	115	19,349
10. Gulf Oil Canada*	Rimbey, Alta.	1-3	328	101,153
11. Petrogas Processing	Crossfield, Alta.	31	1,970	573,356
12. Home Oil	Carstairs, Alta.	1	42	12,342
13. Canadian Fina Oil	Wildcat Hills, Alta.	4	137	46,563
14. Jefferson Lake Petro.	Savannah Creek, Alta.	13	375	24,201
15. Texas Gulf Sulphur*	Windfall, Alta.	16	1,875	531,531
16. Steelman Gas	Steelman, Sask.	1	12	3,000
17. Shell Canada	Waterton, Alta.	18-25	1,650	529,658
18. Amerada Hess Corp.	Olds, Alta.	11	180	59,460
19. Mobil Oil Canada	Wimborne, Alta.	14	244	90,291
20. Hudson's Bay Oil and Gas*	Edson, Alta.	3	304	57,819
21. Canadian Superior Oil	Harmattan-Elkton, Alta.	53	805	227,079
22. Hudson's Bay Oil and Gas*	Lone Pine Creek, Alta.	8-17	176	43,909
23. Canadian Delhi Oil	Minnehik-Buck Lake, Alta.		18	4,175
24. Amoco Canada Petroleum	East Crossfield, Alta.	34	1,480	504,488
25. Amoco Canada Petroleum	Bigstone, Alta.	19	320	116,077
26. Hudson's Bay Oil and Gas	Caroline, Alta.		26	3,254
27. Hudson's Bay Oil and Gas	Kaybob South, Alta.	2-17	1,044	256,817
28. Banff Oil	Rainbow Lake, Alta.		70	16,540
29. Hudson's Bay Oil and Gas	Hespero, Alta.		11	1,108
30. Hudson's Bay Oil and Gas**	Sturgeon Lake South, Alta.		50	2,462
31. Hudson's Bay Oil and Gas**	Brazeau River, Alta.		50	6,193
32. Shell Canada**	Simonette, Alta.		90	7,035
Totals December 31, 1969			13,492	3,665,850

*Plants increased capacity in 1969; **New plants 1969.
†Daily rated capacity in long tons of 2,240 pounds as reported by operators.
††Source: Alberta Oil and Gas Conservation Board; British Columbia, Oil and Gas Production Report; Saskatchewan estimated.

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

TABLE 3

Canada, Prospective Sour Gas Producers, and Expansions, 1970-71

Operating Company	Source Field or Plant Location	Daily Capacity (long tons)
Amerada Hess Corp.	Olds, Alta. (1970) Capacity increase of	420
Atlantic Richfield Canada	Gold Creek, Alta. (May 1970)	100
Chevron Standard	Kaybob South, Alta. (Dec. 1970)	2,666
Gulf Oil	Kaybob South, Alta. (Jan. 1970)	1,044
Gulf Oil	Strachan, Alta. (Nov. 1970)	830
Imperial Oil	Quirk Creek, Alta. (Nov. 1970)	225
Imperial Oil	Redwater, Alta. (1970) Capacity increase of	8
Shell Canada	Burnt Timber-Wildhorse Creek, Alta. (May 1970)	200
Shell Canada	Jumping Pound, Alta. (1970) Capacity increase of	180
Tenneco Oil & Minerals	Brazeau River (1970)	26
Total planned increase in daily rated capacity during 1970		5,679 long tons
Banff Oil	Ricinus, Alta. (1971)	1,900
Gulf Oil	Berland River, Alta. (1971)	125
Shell Canada	Waterton, Alta. (1971) Capacity increase of	1,325
Westcoast Transmission	Fort Nelson, B.C. (Aug. 1971)	250
Total planned increase in daily rated capacity during 1971		3,600 long tons
Total planned additional capacity 1970-71		9,279 long tons

TABLE 4

Selected Charter Ocean Freight Rates for Canadian Sulphur from Vancouver, 1969 (U.S. $ per long ton)

To:	
East Coast India	11.15
South Korea	4.30
Taiwan	8.00
North Island New Zealand	6.78
Italian Adriatic	9.25
West Coast India	14.50
Rotterdam (early 1969)	6.50

Source: The British Sulphur Corp. Ltd.

sulphur. Dominion Foundries and Steel, Limited, at Hamilton, Ontario, produces elemental sulphur from coke oven gas using the British-developed Stretford Process. Capacity of the plant allows for the recovery of 8 tons of sulphur daily.

METALLIC SULPHIDE SOURCES

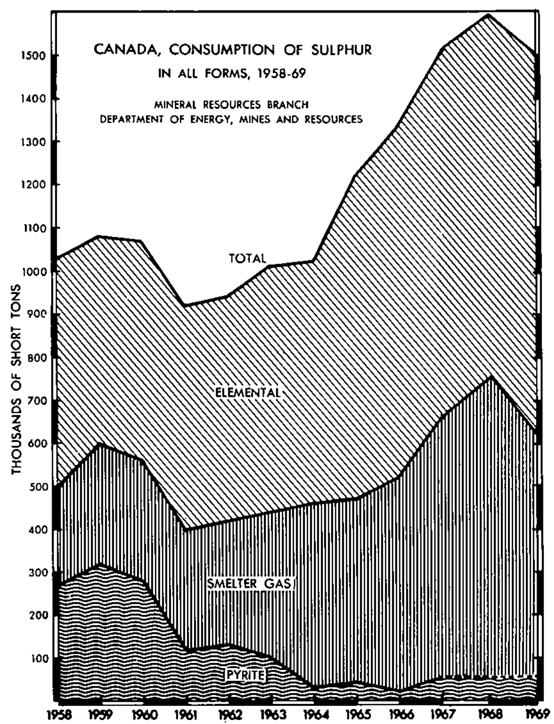
In Canada, the use of metallic sulphides for their sulphur content dates back to 1866. Early operations consisted essentially of roasting pyrite for the direct manufacture of sulphuric acid. In the 1920's, the use of base-metal smelter gases for the manufacture of byproduct H_2SO_4 began near Sudbury, 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 plant was built. In 1968, metallic sulphides provided almost 725,000 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 1969 was 550,809 tons of contained sulphur representing 17 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. Production of sulphuric acid at this operation was severely curtailed in 1969 due to a labour dispute at International Nickel's Sudbury works which lasted from July to November. 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 Aluminium 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.

PYRITE AND PYRRHOTITE

Pyrite and pyrrhotite concentrates produced as a byproduct from 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 from time to time in shipping pyrite and pyrrhotite concentrates to pyrite roasters, principally in the northeastern United States and in the case of Anaconda to Japan. Other companies are stockpiling pyrite concentrates pending development of future markets for this material. In 1969, Canada's pyrite and pyrrhotite shipments amounted to 323,432 tons of concentrates (159,860 tons contained sulphur) valued at $2,111,795.

In 1969, Superior Acid & Iron Limited carried out extensive feasibility studies on the company's pyrite deposit located near Goudreau, Ontario, approximately 180 miles north of Sault Ste. Marie. Plans called for the shipment of a pyrite concentrate to Ashtabula, Ohio, for treatment to yield iron ore pellets and sulphuric acid.

CANADIAN CONSUMPTION AND TRADE

Canadian consumption of sulphur in all forms in 1969 amounted to an estimated 1,477,000 tons of which elemental sulphur accounted for approximately 57 per cent with the remainder being supplied from metallic sulphides.

Production of sulphuric acid in Canada totalled 2,396,535 tons, down 16 per cent from 1968. In 1969, sulphuric acid was produced at 19 plants across Canada in all provinces except Saskatchewan, Newfoundland and Prince Edward Island.

TABLE 5

Canada, Principal Sulphur Operations Based on Metallic Sulphides, 1969

Operating Company	Plant Location	Raw Material	Annual Capacity in Short Tons: 100% H_2SO_4	Annual Capacity in Short Tons: Approx. S equivalent
Smelter Gases				
Belledune Acid	Belledune, N.B.	SO_2 lead-zinc	110,000	40,000
Alcan	Arvida, Que.	SO_2 zinc conc.	75,000	25,000
Allied Chemical	Valleyfield, Que.	SO_2 zinc conc.	130,000	43,000
Can. Electrolytic Zinc	Valleyfield, Que.	SO_2 zinc conc.	150,000	50,000
Sherbrooke Metallurgical	Port Maitland, Que.	SO_2 zinc conc.	90,000	30,000
Canadian Industries	Copper Cliff, Ont.	SO_2 pyrrhotite	900,000	335,000*
Cominco	Kimberley, B.C.	SO_2 pyrrhotite	360,000	120,000
Cominco	Trail, B.C.	SO_2 lead-zinc	525,000	193,000*
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	

*Includes sulphur content in liquid SO_2 production.

TABLE 6

Canada, Sulphur Production and Trade, 1960-69
(short tons)

	Production[1]				Imports	Exports	
	In Pyrites[3]	In Smelter Gases	Elemental Sulphur	Total	Elemental Sulphur	Pyrite[2] $	Elemental Sulphur
1960	437,790	289,620	274,359	1,001,769	328,765	1,259,151	143,040
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[p]	160,422	550,804	2,984,937	3,696,163	45,508	1,105,000	2,264,281

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.

TABLE 7

Canada, Sulphur Consumption, 1960-69
(short tons)

	From Pyrites and Smelter Gases[e]	Elemental Sulphur*	Total[e]
1960	552,190	507,810	1,060,000
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	627,015	850,000[e]	1,477,000

Source: Dominion Bureau of Statistics.
*As reported by consumers.
[e]Estimated by Mineral Resources Branch; [r]Revised.

TABLE 8

Canada, Consumption of Elemental Sulphur by Industry, 1967-68
(short tons)

	1967	1968
Chemicals	187,180	190,385
Pulp and paper	432,482	419,559
Rubber products	3,306	3,203
Fertilizers	185,389	179,266
Foundry	12,962	14,198
Other industries*	22,054	23,536
Total	843,373	830,147

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.

Difficulties in handling coupled with transportation costs result in limited international trade in sulphuric acid. The fertilizer industry, much of which is statistically classified with industrial chemicals, is by far the largest consumer of sulphuric acid.

In 1969, Canada's exports of elemental sulphur reached a record 2,264,218 tons valued at $62,742,000, a tonnage increase of 7 per cent over 1968. However, reflecting lower prices on international markets, the value of export shipments decreased 18 per cent. About 46 per cent of Canada's elemental sulphur exports went to the United States. The average value of Canada's elemental sulphur exports in 1969 was $27.71 a ton compared to $36.20 a ton in 1968, $33.09 in 1967 and $24.00 in 1966. Exports of pyrites for the manufacture of sulphuric acid were valued at $1,018,000 in 1969.

As shown in Table 6, Canada's imports of elemental sulphur have declined sharply over the past 10 years. In 1969, imports amounted to 45,508 tons of elemental sulphur, a decrease of 60 per cent from 1968. Sulphuric acid imports were negligible.

TABLE 9

Canada, Sulphuric Acid Production, Trade and Apparent Consumption, 1960-69
(short tons—100% acid)

	Production	Imports	Exports	Apparent Consumption
1960	1,673,000	9,526	43,430	1,639,096
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[p]	2,396,535	60,746	103,386	2,353,895

Source: Dominion Bureau of Statistics.
[p]Preliminary; [r]Revised.

WORLD REVIEW

Highlighting the world sulphur industry in 1969 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 27.8 million long tons, an increase of 4 per cent over 1968. Western world sulphur production was 28.9 million long tons an increase of 5.3 per cent over 1968. Production exceeded consumption for the second consecutive year.

A major increase in world sulphur production in 1969 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 1.8 million metric tons—approximately double that country's output in 1967.

Of this, nearly 1.1 million metric tons were delivered to western world markets. In 1970, Polish output is expected to reach 2.5 million metric tons. In late 1969 the Machow mine, which will eventually become the world's largest open-pit sulphur operation, came on stream. In addition, Poland is providing technical assistance and is financially involved in the development of large sulphur deposits in Iraq. It is anticipated that two mines in Iraq, with a combined annual output of 1.3 million tons, will be in operation within three years. Polish investment in these projects is in the order of £12.5 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 in 1969.

TABLE 10

Canada, Available Data on Consumption of Sulphuric Acid by Industry, 1967
(short tons—100% acid)

Iron and steel mills	52,918
Other iron and steel	14,360
Electrical products	6,565
Vegetable-oil mills[5]	
Sugar refineries[5]	
Leather tanneries	2,060
Textile dyeing and finishing plants[5]	
Pulp and paper mills	80,343
Processing of uranium ore	98,229
Manufacture of mixed fertilizers[1]	354,003
Manufacture of plastics and synthetic resins	24,103
Manufacture of soaps and cleaning compounds	19,171
Other chemical industries	16,584
Manufacture of industrial chemicals[2]	1,307,625
Petroleum refining	32,079
Mining[3]	47,549
Miscellaneous[4]	64,274
Total accounted for	2,119,863

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. [5]Included under miscellaneous.

In mid-year 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 continued to experience difficulty in the start-up of the company's Rock House facility, designed to recover some 1,000 long tons of sulphur a day from gypsum deposits in west Texas.

In Mexico, production of Frasch sulphur remained at a level of 1.6 million tons. In August 1969, Gulf Resources and Chemical Corporation negotiated an agreement with Inversiones Azufreras S.A. for the sale of the 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 1.66 million long tons, an increase of approximately 80,000 tons over 1968. In Iran, two new sources of production, the Kharg Island sulphur recovery plant and the Shahpur Chemical Company project came on stream late in the year.

OUTLOOK

Canada is firmly established as a major supplier of elemental sulphur to world markets. Planned increases in production at sour natural gas plants resulting from rising demand for Canadian natural gas in the United States, will strengthen Canada's position as a major source of world sulphur supply. In 1970, substantial production increases in Canada and Poland will add further sulphur to producers' stocks, which were already at a high level at the beginning of the year. Consumption is not expected to keep pace with production and the current oversupply situation is expected to continue at least into the mid-1970's. In the face of strong competition and large inventories overhanging world markets, further price decreases within the next year are a distinct possibility.

Competition on international markets will be severe and continued downward pressure on prices could force marginally economic producers, particularly the smaller Frasch producers, to suspend operations. The availability of low-cost elemental sulphur will adversely affect export markets for producers of pyrites, particularly in Europe where, in the past few months, Canadian and Polish sulphur has been selling in the $20 to $25 per long ton range at Rotterdam. For pyrites to continue as a viable alternative to elemental sulphur in sulphuric acid manufacture, the delivered price per ton of pyrite should not exeed 30 per cent of the cost of elemental sulphur. The export market for pyrites in western Europe in 1968 amounted to 2,855,900 metric tons; some of this may fall victim to low-cost elemental sulphur.

An important factor in future world sulphur supply will be sulphur removed from metallurgical and other industrial waste gases as anti-pollution legislation becomes progressively more stringent. Although in many instances the processes to remove sulphur from effluent gases may prove economically unattractive to the operator, nonetheless, significant quantities of sulphur, either in the form of elemental sulphur or sulphuric acid will be generated.

TABLE 11

World Production of Sulphur in All Forms, 1968-69
('000 metric tons)

	1968					1969e
	Frasch	Other Elemental	In Pyrites	In Other Forms*	Total	All Forms
U.S.A.	7,533	1,473	369	538	9,913	9,696
USSR	–	2,000	1,950	1,050	5,000	5,500
Canada (shipments)	–	2,323	140	599	3,062	3,326
Japan	–	320	1,531	840	2,691	2,700
France	–	1,630	33	140	1,803	1,850
Mexico	1,616	52	–	24	1,692	1,690
Poland	–	1,419**	91	95	1,605	1,800
Spain	–	40	1,150	–	1,190	1,200
China (Mainland)	–	130	750	120	1,000	1,100
Italy	–	82	633	196	911	1,000
West Germany	–	127	252	276	655	660
Britain	–	50	–	520	570	570
Cyprus	–	–	530	–	530	550
East Germany	–	125	58	202	385	390
Finland	–	125	110	176	411	430
Norway	–	1	320	30	351	360
Others	–	350	2,000	1,050	3,400	3,700
Total	9,149	10,247	9,917	5,856	35,169	36,522

Sources: U.S. Bureau of Mines, The Journal of World Sulphur, Dominion Bureau of Statistics, and Canadian Minerals Yearbook 1967. For 1968, production of sulphur by origin is in many instances estimated for individual countries.
*Sulphur from smelter gases, gypsum-anhydrite, spent oxide, and others.
**Some Polish sulphur included under other elemental is Frasch origin.
eEstimates except Canada and U.S.A.; – Nil.

PRICES

Reflecting the world oversupply situation and the extremely competitive nature of export markets, prices declined sharply throughout 1969. The following table shows delivered prices of sulphur in major marketing areas at various times during the year and clearly illustrates the downward price trend.

In January 1969, the unit value of elemental sulphur at sour gas plants in Alberta averaged Can. $33.73 a long ton. By the end of December this had decreased to Can. $12.91 a long ton. The posted price for U.S. Frasch sulphur at the end of the year was U.S. $39 a long ton, f.o.b. Gulf Ports, but most sales were transacted at prices of about $26 to $28 a long ton.

TABLE 12

Delivered Sulphur Prices in Major Market Areas, 1969
(U.S. $ per long ton)

	Early 1969	Mid-1969	Late 1969
Northwest Europe	42-45.50	32-36	20-29
Mediterranean	42-48	32-37	25-32
Latin America	43-46	31-36	26-32
Southeast Asia	47-50	34-38	30-38

Source: British Sulphur Corporation.

PRICES (cont'd)

Canadian sulphur prices in 1969, as quoted in *Canadian Chemical Processing*, were as follows:

Sulphur, elemental, f.o.b. works, contract, car load, per long ton

January 1969	–	\$30 – \$35
October 1969	–	25 – 30
November 1969	–	15 – 18

Sulphuric acid, f.o.b. plants, East 66° Be, tanks, per short ton

December 1969 – \$31

United States prices, quoted in *Engineering and Mining Journal*, December 1969, 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	\$29.50

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Sulphur of all kinds, other than sublimed sulphur, precipitated sulphur and colloidal sulphur	free	free	free
Sulphur, sublimed or precipitated; colloidal sulphur	free	free	free
Sulphur dioxide	free	free	free
Sulphuric acid; oleum	10%	15%	25%
Sulphur trioxide	free	free	free
UNITED STATES			
Pyrites	free		
Sulphur, elemental	free		
Sulphuric acid	free		
Sulphur dioxide			
On and after Jan. 1, 1969	10%		
" " Jan. 1, 1970	8.5%		

NOTE: Further United States tariff reductions on the above sulphur items will take place on Jan. 1, 1971 and Jan. 1, 1972.

Talc, Soapstone and Pyrophyllite

P.R. COTE*

In 1969, total value of talc, soapstone and pyrophyllite produced in Canada increased 10.2 per cent over 1968 to reach $1,191,213. Talc is produced in Ontario and Quebec while all Canadian pyrophyllite output originates from one producer in Newfoundland.

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

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 to the company's mill facilities located at Highwater, 10 miles to the south. In the past, Baker Talc has produced a relatively low-grade, low-cost product suitable for use primarily 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 and cosmetic industries. In 1969 a Jones Separator was added to the beneficiation plant and it is anticipated that 10 tons a day of high-quality, high-value product can be produced on a one-shift-a-day basis. In addition to expansions of and changes to the milling complex, the Van Reet mine inclined shaft was sunk to a second level, 125 feet below the first level. The company estimates ore reserves to be adequate for 15-20 years. Along with talc output, the company markets soapstone blocks to schools and art shops for carving.

Broughton Soapstone & Quarry Company, Limited quarries talc and soapstone from two separate 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-workers' crayons and blocks for sculpturing.

Canada Talc Industries Limited produces talc from underground workings at Madoc, Ontario. The deposits at Madoc are extensive and were formed by the alteration of dolomitic marble. Impurities in the deposit consist of tremolite and dolomite which limit the use of some ground products. A high-quality product suitable as a filler material in the paint industry is produced.

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.

*Mineral Resources Branch.

TABLE 1

Talc and Soapstone, Pyrophyllite Production,
Trade and Consumption

	1968		1969p	
	Short Tons	$	Short Tons	$
Production (shipments)				
Talc and soapstone				
Quebec[1]	..	245,923	..	289,213
Ontario[2]	..	298,991	..	352,000
Total	..	544,914	..	641,213
Pyrophyllite				
Newfoundland	..	535,740	..	550,000
Total production value		1,080,654		1,191,213
Imports (talc)				
United States	27,665	1,334,000	34,453	1,662,000
Italy	579	41,000	400	28,000
France	–	–	57	7,000
Total	28,244	1,375,000	34,910	1,697,000

	1967	1968
	Short Tons	
Consumption (ground talc, available data)		
Ceramic products	6,754	4,748
Paints and wall-joint sealers	6,500	6,990
Roofing	6,557	6,823
Paper and paper products	2,968	3,833
Rubber	1,264	1,954
Insecticides	620	636
Toilet preparations	761	709
Cleaning compounds	644	680
Pharmaceutical preparations	423	365
Linoleum and tile	363	129
Other products[3]	5,689	6,134
Total	32,543	33,001

Source: Dominion Bureau of Statistics.
[1]Ground talc, soapstone blocks and crayons; [2]Ground talc; [3]Chemicals, foundries, gypsum products and other uses.
pPreliminary; .. Not available; – Nil.

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.

TABLE 2

Production and Trade, 1960-69
(short tons)

	Production[1]				
	Talc and Soapstone		Pyrophyllite (all exported)	Imports Talc	Exports Talc
1960	21,411		20,225	19,153	1,660
1961	23,691		24,425	20,205	2,000^{e}
1962	23,367		22,794	24,148	2,300^{e}
1963	22,467		31,783	27,539	2,200^{e}
1964	25,316		32,816	31,598	2,600^{e}
1965	22,703		30,134	27,858	3,500^{e}
1966	29,596		40,548	24,918	..
1967		60,665[2]		26,482	..
1968		80,589[2]		28,244	..
1969^{p}		81,427[2]		34,910	..

Source: Dominion Bureau of Statistics.
[1]Producers' shipments. [2]Total talc, soapstone and pyrophyllite. Breakdown of tonnages not available for publication commencing 1967.
^{e}Estimated, not available as a separate trade class after 1960; ^{p}Preliminary; .. Not available.

TRADE AND MARKETS

Most talc and soapstone produced in Canada is consumed domestically while all pyrophyllite produced is exported. Although less talc is imported than produced, the value of imports greatly exceeds the value of domestic production. 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 this higher quality material in the near future. Imports in 1969 amounted to 34,910 tons valued at $1,697,000. Of this, 34,453 tons were imported from the United States with minor quantities received from France and Italy. Average value of imports in 1969 was $49 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 chemical limits, 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 coatings, 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.

TABLE 3

World Production of Talc, Soapstone and Pyrophyllite, 1967-1969
(short tons)

	1967	1968	1969e
Japan	1,521,597r	1,862,710	2,000,000
United States	902,512	958,262	981,000
USSR	408,000	408,000	. .
France	227,074r	232,000	235,000
India	148,953	193,577	. .
China (Mainland)	165,000	165,000	. .
South Korea	135,443	164,692	. .
Rumania	143,299	143,000	. .
Italy	130,586r	125,000	130,000
Norway	88,000	88,000	90,000
Austria	85,685r	86,000	90,000
Canada	60,665	80,589	81,427
Other countries	334,876	233,100	1,358,573
Total	4,351,690	4,739,930	4,966,000

Source: U.S. Bureau of Mines, Minerals Yearbook Preprint 1968; 1969 figures U.S. Bureau of Mines Commodity Data Summaries, January, 1970.
eEstimated; . . Not available; rRevised.

WORLD REVIEW

Deposits of talc are widely distributed throughout the world but they have been commercially developed in only the more industrialized countries. Because of the particular qualities of each of the many grades of talc, shipments of both raw talc and of finished products are made over extensive distances to supply the required product for a specific use.

Japan is the world's largest producer of talc followed closely by the United States. Canada ranks twelfth among world producers.

PRICES

United States talc prices according to *Oil, Paint and Drug Reporter*, December 29, 1969, were as follows:

Canadian – ground, bags, carlot, f.o.b. mines bags,
– per ton – $20.00-$35.00
bags, less carlot, works
– per ton – $37.00

Vermont – domestic, ordinary, off-colour, ground, bags, carlot, f.o.b. works
– per ton – $21.40

California – domestic, ordinary, off-colour, bags, carlot, f.o.b. works
– per ton – $34.00-$39.50

New York – domestic, fibrous, ground, bags, carlot, works
– per ton – $31.00
– bags, less carlot, works
– per ton – $36.00

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Talc or soapstone	10%	15%	25%
Micronized talc	free	5%	25%
Pyrophyllite	free	free	25%
Talc for use in manufacture of ceramic tile	free	free	25%
UNITED STATES			
Talc, steatite and soapstone			
Crude and not ground Jan. 1, 1969		0.02¢	
Ground, washed, powdered, or pulverized Jan. 1, 1969		9.5%	

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.

Reductions under the Kennedy Round of the General Agreement on Tariffs and Trade (GATT), that was convened in 1964 and concluded in 1967, were scheduled to lower United States tariffs to 02¢ and 6% respectively on and after Jan. 1, 1972.

UNDERGROUND ORE LOADING at Canadian Talc Industries Limited, Madoc, Ontario. (Photo by EMR Staff).

Tin

D. B. FRASER*

DOMESTIC INDUSTRY

A small amount of tin concentrate is produced in Canada and exported to foreign smelters for treatment. Industrial requirements of tin are purchased abroad. Imports in 1969 were 4,945 long tons** valued at $17,945,000. The main consumers use high quality tin, and Straits brand from Malaysia continues to be the main source.

Cominco Ltd., the only Canadian producer of tin concentrate, recovers cassiterite 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 production in 1969 of tin in tin concentrates and lead-tin alloys was 120 tons valued at $493,120.

Diamond drilling continued in New Brunswick at the Mount Pleasant property of Brunswick Tin Mines Limited, a subsidiary of Sullivan Mining Group Ltd. The drilling established the presence of two types of mineralization: copper-zinc-tin, and tungsten-molybdenum-bismuth. Laboratory metallurgical tests were begun, and an underground exploration program was started.

Cassiterite is known to occur in certain lead-zinc ores in Canada, and its further recovery depends on advances in ore treatment techniques and the economics of processing. Fine-grained cassiterite, which cannot be recovered at present, is a mineralogical component of some sections of the copper-zinc-lead-silver orebody near Timmins, Ontario, of Ecstall Mining Limited, and is also present in minor quantities in the zinc-lead orebodies of Brunswick Mining and Smelting Corporation Limited in New Brunswick.

The principal use of tin in Canada, accounting for 55 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 396,000 tons in 1969, a year of strikes in the Canadian steel industry, is now electrolytic. Estimated consumption of tin in the manufacture of tinplate is 2,200 tons.

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. Solder is used mainly in the automotive industry.

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* Mineral Resources Branch.

** Long tons of 2,240 pounds are used throughout this review.

TABLE 1

Canada, Tin Production, Imports and Consumption, 1968-69

	1968		1969P	
	Long tons	$	Long tons	$
Production				
Tin content of tin concentrates and lead-tin alloy	160	497,885	120	493,120
Imports				
Blocks, pigs, bars				
Malaysia	3,030	10,367,000	3,640	13,194,000
Nigeria	25	85,000	597	2,018,000
United States	924	3,338,000	573	2,223,000
Netherlands	–	–	75	284,000
Britain	6	21,000	60	226,000
Thailand	315	1,081,000	–	–
Total	4,300	14,892,000	4,945	17,945,000
Tinplate				
United States	4,531	820,000	6,027	1,219,000
Britain	260	95,000	465	114,000
Total	4,791	915,000	6,492	1,333,000
Tin, fabricated materials, n.e.s.				
United States	16	64,000	63	171,000
Exports				
Tin in ores and concentrates and scrap				
Mexico	104	359,000	188	502,000
United States	13	15,000	86	35,000
Britain	–	–	29	5,000
Total	117	374,000	303	542,000
Tinplate scrap				
United States	14,664	500,000	20,015	567,000
Republic of South Africa	19	. . .	–	–
Total	14,683	500,000	20,015	567,000
Consumption				
Tinplate and tinning	2,423		. .	
Solder	1,264		. .	
Babbitt	180		. .	
Bronze	205		. .	
Galvanizing	17		. .	
Other uses (including collapsible containers, foil, etc.)	162		. .	
Total	4,251		. .	

Source: Dominion Bureau of Statistics.
PPreliminary; . . . Less than one thousand dollars; n.e.s. Not elsewhere specified; – Nil; . . Not available.

WORLD DEVELOPMENTS

The largest 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 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 55 out of the total of 1,000 votes allocated to consumer members. The 19 consumer members in 1969 accounted for 53 per cent of total consumption. The total does not include most communist countries' consumption as the data is not available. The United States (57,400 tons) and West Germany (13,700 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 1969 in relation to price ranges considered desirable by Council at various periods. Prices 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 are:

	£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.

Production of tin in concentrates from 1960 to 1968 rose significantly and during 1968 exceeded consumption. To correct the imbalance, the Tin Council in September 1968 declared an export control period for the last quarter of 1968 and the first quarter of 1969. In March 1969 the Council declared the second quarter to be a further control period and authorized the Buffer Stock Manager, beginning April 1, to buy or sell tin in the middle price range. Later, at quarterly meetings, the Council successively extended the control periods to the third and fourth quarters, lightening the restriction on exports on each occasion as mine production and consumption came more nearly into balance. At the December meeting, following a sharp price rise, the Council decided that export control should not apply during the first quarter of 1970. It also re-adjusted export quota regulations for the fourth quarter of 1969 so as to allow producers to exceed their permissible export amount without penalty. The operations of the buffer stock were restricted on December 4, meaning that the Manager was released from the requirement that he must sell tin at the ceiling of £1,630 a long ton. He was authorized to operate within the middle price range for a further three months beginning January 1, 1970.

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
1969p	120	303	4,945	. .

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.
pPreliminary; . . . Not available.

TABLE 3

Estimated World* Production of Tin-in-Concentrates, 1960, 1968-69
(long tons)

	1960	1968	1969
Malaysia	51,979	75,069	72,167
Bolivia	20,219	29,101	30,332
Thailand	12,081	23,601	23,640
Indonesia	22,596	16,632	16,243
Federation of Nigeria	7,675	9,649	8,603
Congo (Dem. Rep.)	9,202	7,377	7,380
Australia	2,176	6,777	7,770
Total, including countries not listed	136,500	182,600	179,600

Source: International Tin Council, Statistical Bulletin.
*Excludes communist countries, except Czechoslovakia, Poland and Hungary; it should be noted that China (Mainland) and USSR are large tin producers.

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. Sales were made in the second and third quarters of 1969, and at December 31 the buffer stock had 4,590 tons. 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 during 1969 totalled 2,048 tons, all under the program of the United States Agency of International Development (AID). Releases from 1962 to the end of 1969 totalled 92,871 tons.

The net exports of tin to the communist countries have been increasing since 1966 and continue to cause uncertainty in predicting the supply-demand balance. China (Mainland) is a major producer whose output is in the order of 25,000 tons annually. The USSR produces 33,000 tons annually and East Germany 1,200 tons.

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 tons were used in 1969 in the production of 11.3 million tons of tinplate. The tin coating on the steel varies with the product mix of tinplate plants from 0.25 pound per 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.

TABLE 4

Estimated World* Production of Primary Tin Metal, 1960, 1968-69
(long tons)

	1960	1968	1969
Malaysia	76,366	88,185	86,878
Britain	26,374	24,933	25,982
Thailand	218	24,434	23,640
Netherlands	6,393	7,983	5;298
Federation of Nigeria	–	9,843	8,839
Belgium	8,255	4,799	4,444
Indonesia	1,977	4,560	4,560
United States	13,500	3,453	345
Australia	2,255	3,692	4,170
Spain	464	2,166	1,981
Brazil	1,312	2,100	2,100
Japan	1,189	1,863	1,387
Congo (Dem. Rep.)	2,507	1,800	1,800
Total, including countries not listed	145,900	184,400	175,900

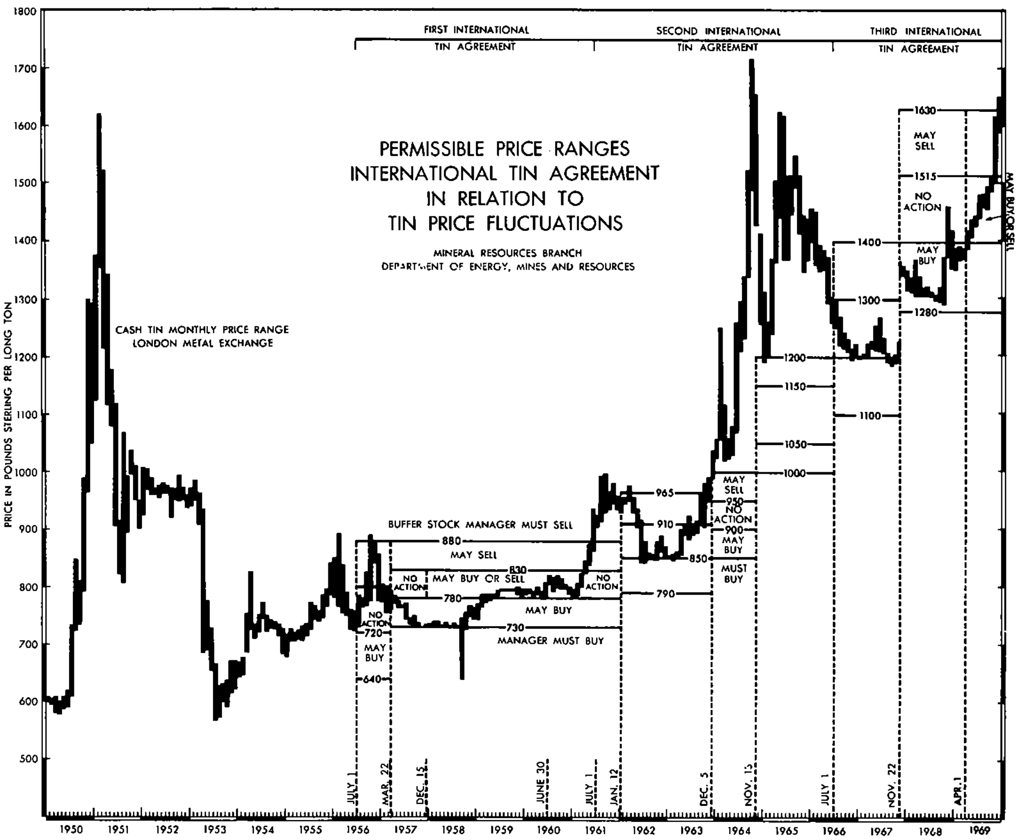
Source: International Tin Council, Statistical Bulletin.
*Excludes communist countries, except Czechoslovakia, Poland and Hungary.
– Nil.

TABLE 5

Estimated World* Tin Position, 1967-69
(long tons)

	1967	1968	1969
Ore Supply			
Production of tin-in-concentrates	171,900	182,600	179,600
Stocks at year's end	23,200	24,700	23,200
Primary Metal Supply			
Smelter production of tin metal	174,400	184,400	175,900
Net sales to centrally-planned countries	3,067	4,649	6,156
Government stockpile sales	6,146	3,495	2,048
Buffer stock, sales+, purchases –	4,720–	6,535–	6,700+
Commercial stocks at year's end	53,100	62,300	48,500
Primary metal consumption	169,000	174,400	181,300

Source: International Tin Council, Statistical Bulletin.
*Excludes communist countries, except Czechoslovakia, Poland and Hungary.



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 gunmetals contain copper, tin, zinc, and sometimes lead to improve 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 1969 on major markets was as follows: 1) Straits brand, delivered ex-works, Penang, Malaysia, 153.39 equivalent to £1431.7 per long ton; 2) Prompt tin, New York 164.43 (£1534.71); and 3) Cash tin, 155.49 (£1451.3) and Forward tin, 155.82 (£1454.2), 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 (22.4 lb), less a smelting charge of £15 to £12 a long 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

Most Favoured Nation Tariff

CANADA		
Item No.		
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 of iron or steel, corrugated or not, coated with tin	12½%
33507–1	Tin oxides	15%
UNITED STATES		
Item No.		
601.48	Tin in ore and black oxide of tin, unwrought tin	free
622.02	Tin, other than alloys of tin	free
622.04	Alloys of tin	free
622.10	Tin waste and scrap	free
608.91	Tinplate	
	Valued not over 9.4¢ per lb – after Jan. 1, 1969	8.5%
	– after Jan. 1, 1970	8.5%
	Valued over 9.4¢ per lb – after Jan. 1, 1969	0.8%
	– after Jan. 1, 1970	0.8%
644.15	Tin foil – after Jan. 1, 1969	28%
	– after Jan. 1, 1970	24%

In both Canada and United States there are varying tariffs on tin chemicals and compounds and on manufactured articles of tin.

Titanium and Titanium Dioxide

G. P. WIGLE*

Quebec Iron and Titanium Corporation (QIT) increased production by over 10 per cent in 1969 following similar increases in each of the prior two years. The company mined 1.75 million long tons of ilmenite to produce 668,959 long tons of titania slag containing 70 to 72 per cent titanium dioxide, and 469,109 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 in making sulphate-process titanium-dioxide pigments for the paint, paper and plastics industries.

Producers of titanium-dioxide pigments are the major consumers of the growing output of the titanium mineral industry but titanium metal and alloy production is expanding with the requirements of industrial applications, particularly the aircraft industry.

World production of concentrates of the two minerals of titanium, ilmenite ($FeOTiO_2$) and rutile (TiO_2), has increased steadily during the past decade. While the annual production of ilmenite has increased from 2.2 million tons in 1960 to 3.4 million tons in 1969, a growth rate of about five per cent, the production of rutile, preferred by the makers of welding rod, metal, and chloride-process pigments, has increased at a rate of nearly 15 per cent from 114,200 tons in 1960 to about 400,000 tons in 1969. Serious 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 pigment capacity alone would consume some 450,000 tons of rutile annually by 1972.

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 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

*Mineral Resources Branch.

TABLE 1

Canada – Titanium Production and Trade

	1968		1969p	
	Short Tons	$	Short Tons	$
Production[1] shipments				
Titanium dioxide	. .	28,016,183	. .	29,066,600
Imports				
Titanium dioxide, pure				
United States	951	502,000	1,025	552,000
West Germany	337	142,000	808	327,000
Britain	858	367,000	664	257,000
Other countries	241	78,000	7	3,000
Total	2,387	1,089,000	2,504	1,139,000
Titanium dioxide, extended				
United States	9,697	1,836,000	8,651	1,628,000
Titanium metal				
United States	183	1,643,000	305	1,788,000
Japan	20	56,000	73	205,000
Sweden	–	–	1	6,000
Britain	30	113,000	1	8,000
Total	233	1,812,000	380	2,007,000
Exports[2] to the United States				
Titanium metal, unwrought, incl. waste and scrap	237	674,900	214	138,421
Titanium metal, wrought	72	455,883	66	447,439
Titanium dioxide	2,624	1,064,957	3,993	1,674,566

Source: Dominion Bureau of Statistics.

[1]Producers' shipments of slag. [2]As reported by the U.S. Department of Commerce, U.S. Imports for Consumption, Report FT 135. No identifiable classes are available from Canadian export statistics.

pPreliminary; – Nil; . . Not available.

TABLE 2

Titania Slag and Iron Production,
Quebec Iron and Titanium Corporation, 1968-69
(long tons)

	1968	1969
Ore mined	1,501,634	1,754,747
Ore beneficiated	1,424,552	1,646,656
Ore smelted	1,232,354	1,381,342
Titania slag produced	600,773	668,959
Iron produced	410,085	469,109

Source: QIT.

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 1969. The company operated its 30,000 ton-a-year sulphate-process unit at or above rated capacity in 1969 and

TABLE 3

Canadian Titanium Production, Trade and Consumption, 1960-69
(short tons)

	Production		Imports			Consumption	
	Ilmenite[1]	Titanium Dioxide Slag[2]	Titanium Dioxide Pure	Titanium Dioxide Extended[4]	Total Titanium Dioxide Pigments[3]	Titanium Dioxide Pigments[5]	Ferro-titanium[6]
1960	967,373	386,639	. .	. .	26,896	36,394	257
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	43,431	49
1967	1,442,238	602,455	1,616	9,763	11,379	. .	54
1968	1,595,498	672,866	2,387	9,697	12,084	. .	22
1969[p]	1,844,255	749,234	. .	. .	. .	. .	. .

Sources: Dominion Bureau of Statistics, and company reports.
[1]Producers' shipments of ilmenite from Allard Lake and St. Urbain area, from company reports. [2]Gross weight of 70-72 per cent TiO_2 slag produced, from company reports. [3]1960 to 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. [4]Approximately 35 per cent TiO_2. [5]Includes pure and extended TiO_2 pigments. [6] Ti content.
[p]Preliminary; . . Not available.

brought into operation 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 is sold in the domestic market, a substantial part of the output was exported, particularly to Britain.

Tioxide of Canada Limited, a subsidiary of British Titan Products Company Limited, operated its 27,000 ton-a-year sulphate-process pigment plant at capacity during 1969. A small increase in capacity is foreseen in 1970 and late in the year plant capacity should be 33,000 tons a year. Most of the 1969 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 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 specializes in a refining process in which hard metal carbides are precipitated from a metal melt and recovered by leaching the acid soluble matrix.

Dominion Magnesium Limited, near Haley, Ontario, produces magnesium, calcium, and other mineral products. The company's production of co-products included a small amount of titanium metal in 1969.

A report by the Geological Survey of Canada, Economic Geology Report No. 25 by E.R. Rose, Geology of Titanium and Titaniferous Deposits of Canada, was published in 1969. The report describes the geology of titaniferous deposits in Canada, outlines their distribution, and indicates areas and geological conditions favourable for additional occurrences.

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 100 firms of which five titanium pigment producers in the eastern United States use 99 per cent of the total. Rutile was not produced in 1969. 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 4

Salient Titanium Statistics, United States, 1968-69
(short tons)

	Ilmenite		Rutile		Titanium[1]	
	1968	1969[e]	1968	1969[e]	1968	1969[e]
Production	979,000	950,000	. .	–	. .	. .
Imports	208,000[2]	360,000[2]	174,366	200,000	3,443	6,500
Consumption	1,042,000[2]	1,300,000[2]	160,273	170,000	14,237	19,500
Price per pound	na	na	6.2¢[4]	8.0¢[4]	$1.32	$1.32
Price per long ton	$20-21[3]	$20-21[3]	na	na	na	na

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; na Not applicable; – Nil.

TABLE 5

Consumption of Titanium Concentrates in United States
by Products, 1968
(short tons)

	Ilmenite[1]		Titania Slag		Rutile	
Products	Gross Weight	Estimated TiO_2 Content	Gross Weight	Estimated TiO_2 Content	Gross Weight	Estimated TiO_2 Content
Pigments	957,114	509,013	142,168	100,591	112,856	108,544
Titanium metal	–	–	–	–	(2)	(2)
Welding-rod coatings	(2)	(2)	–	–	21,414	20,409
Alloys and carbide	2,097	1,113	(3)	(3)	728	659
Ceramics	(2)	(2)	–	–	(4)	(4)
Glass fibres	–	–	–	–	(2)	(2)
Miscellaneous	347	207	–	–	25,275	33,527
Total	959,558	510,353	142,168	100,591	160,273	153,600

Data Source: U.S. Bureau of Mines, Minerals Yearbook 1968.
[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.

TABLE 6

Australian Production of Ilmenite and Rutile, 1967-68
(long tons)

	1967		1968	
	Concentrate	TiO_2 Content	Concentrate	TiO_2 Content
Ilmenite				
Production	544,216	297,385	550,167	299,018
Exports*	384,300	. .	395,911	. .
Leucoxene				
Production	696	617	5,797	5,226
Rutile				
Production	265,514	254,892	288,987	277,482
Exports	258,791	. .	284,995	. .

Data Source: Australian Mineral Industry, Quarterly Review, Vol. 22, No. 1, September 1969.

* Includes leucoxene; . . Not available.

AUSTRALIA

Estimates based on preliminary figures of production achieved in the January-June 1969 period indicate that Australia's output of titanium minerals in 1969 would establish new records. It was estimated that the production of rutile concentrates could amount to 330,000 long tons and ilmenite concentrates to 660,000 long tons compared with 288,987 and 550,167 long tons respectively in 1968. 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 has attained a growth rate of over 15 per cent a year for that period, in the aggregate value of its exports of the two mineral products.

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 is reported to contain over 90 per cent titanium dioxide.

SIERRA LEONE

Sherbro Minerals Limited was reported to have shipped 35,000 tons of rutile in 1969 from its operations on the large alluvial sand deposits in Sierra Leone. A considerable increase in production is expected in 1970. Sherbro Minerals is jointly owned by PPG INDUSTRIES, Inc. and British Titan Products Company Limited.

CEYLON

Increased production of ilmenite and rutile is expected from Ceylon where the Ceylon Mineral Sands Corporation has built a new dry separation plant to bring its annual production capacity of ilmenite up to 100,000 tons. The corporation planned to increase its rutile production to 6,000 tons a year in 1970.

INDIA

Indian Rare Earths Limited has completed some new installations and is adding to its facilities for production of ilmenite and rutile. Reported production and export figures were:

	Ilmenite		Rutile
	Exports	Production	Production
	(metric tons)		
1967	20,938	41,838	2,534
1968	48,526	58,725	2,686

BRITAIN

Facilities for the conversion of ilmenite to synthetic rutile are to be built by Woodall-Duckham at Grimsby for British Titan Products Company Limited. The plant at Grimsby will use a new process developed by the two companies and is expected to cost about £200,000. Woodall-Duckham are sole licensees for design and construction of plants using the process for making synthetic rutile which can be chlorinated for the manufacture of titanium-dioxide pigment. The process uses the more plentiful and cheaper ilmenite and is expected to produce synthetic rutile at a lower unit cost than present prices for concentrates of natural rutile.

TABLE 7

Production of Ilmenite Concentrates
by Countries, 1968-69
(thousand short tons)

	1968	1969[e]
United States	978.5	950
Canada*	673	749
Australia	616	739
Norway	441	450
Finland	154	
Malaysia	139	
Ceylon	82	
India	65	
Spain	43	
Brazil	20	(500[e])
Japan	5	
Malagasy Republic	..	
Portugal	0.5	
Senegal	..	
United Arab Republic	..	
Total	3,217	3,388

Data Sources: U.S. Bureau of Mines, Minerals Yearbook, Commodity Data Summaries; company reports.

*Titania slag containing 72% TiO_2.

[e]Estimated; .. Not available.

TABLE 8

Production of Rutile Concentrates
by Countries, 1968-69
(short tons)

	1968	1969[e]
Australia	323,665	370,000
Sierra Leone	28,660	30,000
India	2,961	
Ceylon	1,270	
Brazil	126	
Senegal	..	(5,000[e])
United Arab Republic	..	
United States	..	
Total	356,682	405,000

Data Source: U.S. Bureau of Mines, Minerals Yearbook, Commodity Data Summaries.

[e]Estimated; .. Not available.

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.

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. 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° Centigrade. 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

TABLE 9

Estimated Annual TiO_2 Pigment Production Capacity by 1973 (short tons)

	Sulphate Process	Chloride Process		Sulphate Process	Chloride Process
Argentina	4,400		Italy	135,000	
Australia	41,400		Japan	150,000	36,000
Brazil	4,400		Mexico	7,700	
Britain	110,000	70,000	Netherlands	12,000	
Belgium	16,500		Norway	16,500	
Canada	57,000	10,000	Portugal	6,600	
Finland	17,600		South Africa	21,000	
France	114,000	20,000	Spain	10,500	
West Germany	215,000	38,000	United States	501,000	270,000
India	16,500				
			Total	1,457,100	440,000

Data Sources: Industrial Minerals, published by Metal Bulletin Ltd., London; Australian Mineral Industry, Quarterly Review, Canberra, Australia.

TABLE 10

Canada, Consumption of Titanium Dioxide and Titanium Dioxide Pigments (short tons)

	1965	1966	1967
Refined Titanium Dioxide			
Paint and varnish	22,884	24,235	25,629
Paper	3,804	4,073	4,206
Linoleum	1,570	2,104	1,174
Rubber	1,691	2,078	2,090
Miscellaneous nonmetallic products	806	835	741
Synthetic textiles	68	–	–
Toilet preparations	27	33	32
Industrial chemicals	39	121	105
Other chemicals	601	821	673
Extended Titanium Dioxide Pigments			
Paint and varnish	8,193	9,131	8,658

Source: Dominion Bureau of Statistics, Ottawa.

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, 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.

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 28,517 tons in 1969 compared with 19,231 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.

OUTLOOK

Continuing growth of the titanium minerals industry is assured by the rapid increase in the requirements for titanium oxide in the pigments industry and the expanding use of titanium metal products in industrial applications. Supplies to the consuming industries will, almost certainly, be supplemented by the development of processes for the production of high-grade titanium dioxide (synthetic rutile) from the cheaper and more abundant ilmenite. This development is an evolving step in mineral processing – not a source of prime supply. Such a technological development will provide a regulatory effect on the price of natural rutile concentrates, a levelling of an extravagant rate of depletion of existing rutile reserves, and an expansion of the utilization of ilmenite concentrates.

Successful economic production of high-grade titanium dioxide from ilmenite if accomplished on an adequate scale in the near future would assist currently expanding production sources to meet the growing demand. Nevertheless, rutile will continue in short supply and growth of ilmenite production will remain restrained to about 5 per cent annually for three to five years due to the time required to bring new process facilities into production.

PRICES

Prices in the United States published in *Metals Week* of December 29, 1969 were:

	US Currency
Titanium ore	
f.o.b. cars Atlantic ports, Great Lakes ports,	
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	
Billet, Ti – 6AL-4V (8" diameter, random lengths)	2.63
Bar, Ti – 6AL-4V (2" diameter)	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

	US Currency
Titanium dioxide (cont.)	
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%

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, 1969	19%
	" " " Jan. 1, 1970	18.5%
629.20	Titanium metal wrought	18%
607.60	Ferrotitanium and ferrosilicon titanium	
	On and after Jan. 1, 1969	8%
	" " " Jan. 1, 1970	7%
473.70	Titanium dioxide	
	On and after Jan. 1, 1969	12%
	" " " Jan. 1, 1970	10%
422.30	Titanium compounds	
	On and after Jan. 1, 1969	12%
	" " " Jan. 1, 1970	10%

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.

Tungsten

G.P. WIGLE*

Tungsten production in Canada in 1969 was 3,222,746 pounds of contained tungsten (W) or 203,174 short-ton-units** of WO_3 in scheelite ($CaWO_4$) concentrates compared with 2,855,160 pounds of contained tungsten or 180,000 short-ton-units** of WO_3 in 1968. Canada's only tungsten producer, Canada Tungsten Mining Corporation Limited, completed a second full year of operation since rebuilding, in 1967, its milling and concentrating plant that had been destroyed by fire in December 1966. The company also produced 466,113 pounds of byproduct copper in chalcopyrite concentrates. There were 167,389 tons of ore milled averaging 1.54 per cent WO_3 (tungstic oxide) and 0.21 per cent copper compared with 116,558 tons averaging 1.98 per cent WO_3 and 0.32 per cent copper in 1968. Recovery of scheelite was 78.81 per cent and 77.74 per cent in the respective years. Canada Tungsten estimated its ore reserves at the end of 1969 at 733,823 tons averaging 1.68 per cent WO_3 and 84,058 tons averaging 1.56 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 company's leaching and roasting plant in North Vancouver, for the final treatment and packaging of its tungsten-bearing concentrates, upgraded scheelite flotation concentrates from 31 to 68 per cent WO_3 content. The hydrochloric acid leach followed by filtering removes calcite and apatite. Roasting of the leached concentrate, at 800°F, removes process reagents and some sulphur. The mine, mill and concentrating plant, employing 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, announced that it intends to bring to production, in late 1970 or early 1971, its tungsten property near Salmo, east of Trail, in south central British Columbia. The scheelite orebody (North Invincible) is estimated to contain 278,000 tons averaging 0.78 per cent tungstic oxide (WO_3). Production is proposed at a milling rate of about 10,000 tons a month. The company will make use of mill equipment previously used in treating its Emerald and Dodger tungsten orebodies, 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 extended, to a total length of 5,300 feet, the adit driven to explore a tungsten (wolframite $FeMnWO_4$) deposit at Grey River on the south coast of Newfoundland. This work was interrupted pending the results of metallurgical testing to determine grade and recovery for feasibility studies.

Burnt Hill Tungsten & Metallurgical Limited carried on shaft sinking and underground development on its tungsten property in York County, New Brunswick.

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*Mineral Resources Branch.

**A short-ton-unit is 20 pounds of WO_3 and contains 15.862 pounds of tungsten (W).

TABLE 1

Canada, Tungsten Production, Imports and Consumption 1968-69

	1968		1969P	
	Pounds	$	Pounds	$
Production (WO_3)	..	..	4,060,940	..
Imports				
Tungsten in ores and concentrates				
United States	63,300	145,000	279,700	653,000
South Korea	34,600	69,000	130,200	285,000
New Zealand	–	–	16,600	37,000
Britain	33,800	66,000	–	–
Total	131,700	280,000	426,500	975,000
Ferrotungsten[1]				
Britain	46,000	117,000	210,000	561,000
Portugal	72,000	186,000	–	–
Total	118,000	303,000	210,000	561,000
Consumption W content				
Tungsten metal and metal powder	764,689	..	..	..
Tungsten wire	14,148	..	..	..
Other[2]	402,704	..	..	..
Total	1,181,541	..	..	..

Sources: Dominion Bureau of Statistics; and company reports.
[1] Gross weight; [2] Includes tungsten ore, tungsten carbide powder, ferrotungsten and tungsten chemicals.
PPreliminary; – Nil; .. Not available.

TABLE 2

Canada, Tungsten Production, Trade and Consumption, 1960-69
(pounds)

	Production[1]	Imports		Consumption
	WO_3 Content	Tungsten Ore[3]	Ferrotungsten[4]	W Content
1960	–	1,156,900	980,700	947,222
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
1969P	4,060,940[2]	426,500	210,000	..

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, reported in W content; [4] Gross weight.
PPreliminary; .. Not available; – Nil.

TABLE 3

World Tungsten Production in
Ores and Concentrates, 1960-69
(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	69,670	33,750	38,200	

Sources: United Nations Conference on Trade and Development, Tungsten Statistics; U.S. Bureau of Mines, Minerals Yearbook.

MARKETS AND SOURCES OF SUPPLY

Notwithstanding the unprecedented release for sale of some 38 million pounds of tungsten from United States stockpile surplus the price of tungsten in world markets rose sharply in December 1969. Although stockpile sales continued on the basis of U.S. $43 a short-ton-unit of WO_3 the price in Europe rose to 625 shillings a long-ton-unit, or approximately $67 a short-ton-unit of WO_3 in wolfram ore (65% WO_3) in the latter part of December. World production of tungsten in ores and concentrates at 69.7 million pounds includes an estimated 35.9 million pounds produced by China, USSR and North Korea. Stockpile releases of 38 million pounds exceeded the annual production of either the non-communist world or the communist countries in a period of: (1) sustained demand and relatively high prices for tungsten, (2) very limited export sales by the principal producer, China, and (3) a reversal of the position of the United States from that of principal importer to that of substantial net exporter. The United States stockpile at the end of 1969 contained some 150 million pounds of tungsten in ores and concentrates, ferro-tungsten, tungsten powder, and tungsten carbide powder. The stockpile objective remained at 44 million pounds of contained tungsten, and additional releases for sale to domestic consumers were approved. The United States exported an estimated 5.6 million pounds of tungsten in ores and concentrates; some 9 times the amount exported in 1968 while imports were an estimated 1.8 million pounds compared with 1.7 million pounds imported in 1968.

TABLE 4

Tungsten Production in Ores and
Concentrates by Countries, 1967-69

(thousands of pounds of contained tungsten)

	1967	1968	1969[e]
China[e]	17,600	17,600	17,600
USSR[e]	13,600	13,600	13,600
United States	8,644	10,188	9,500
North Korea[e]	4,720	4,720	4,720
South Korea	4,464	4,615	4,700
Bolivia	3,494	4,000	4,200
Canada	–	2,855	3,220
Portugal	2,416	2,855	3,000
Australia	2,118	2,561	2,700
Japan	862	1,165	
Peru	871	1,120	
Thailand	956	988	
Brazil	638	958	(6,430)
Rwanda	611	708	
Mexico	328	586	
Burma	338	307	
Other countries[e]	1,106	1,318	
Total	62,766	70,144	69,670

Sources: U.S. Bureau of Mines, Minerals Yearbook, and Commodity Data Summaries; Australian Mineral Industry Quarterly Review; company reports.

[e]Estimated; – Nil.

CONSUMPTION AND USE

The growing demand for tungsten, so prominently displayed in 1969, was similar to trends in consumption of several other alloying metals (e.g. columbium, molybdenum, titanium, vanadium). Increased demand for tungsten is indicative of more widespread and diversified applications as well as strong economic conditions in the world's major industrial economies, particularly those of Japan and some countries in western Europe.

United States consumption of tungsten in 1969 was an estimated 12 million pounds, approximately 1 million pounds more than 1968 but below the average annual consumption of the years 1964 to 1968 which include the 1968 low of 11 million pounds and the high of 18 million pounds consumed in 1966. Tungsten was used in the form of: tungsten carbide – 40 per cent, metal powder – 28 per cent, ferrotungsten – 12 per cent, scheelite and scrap – 18 per cent, and tungsten chemicals about 2 per cent. Additional consumption data also published in the Bureau of Mines Minerals Yearbook, 1968, 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. Flame-plating 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 per cent to 18 per cent tungsten and other carbide-forming elements such as chromium, molybdenum and vanadium.

TABLE 5

Consumption of Tungsten by End Uses in the United States, 1968
(thousand pounds of contained tungsten)

	1968	
	Total	Per Cent
Steel (ingots and castings):		
High speed and tool	1,970	15.0
Stainless	201	1.5
Alloy (excluding stainless)	322	2.5
Other steel	97	0.7
Cast irons	63	0.5
Cutting and wear resistant materials:		
Cemented or sintered carbides	5,060	38.6
Other	104	0.8
Welding and hard facing rods and materials	1,155	8.8
Nonferrous alloys	678	5.2
Electrical materials	131	1.0
Chemical and ceramic uses:		
Pigments	141	1.1
Other	221	1.7
Miscellaneous and unspecified	2,963	22.6
Total	13,108	100.0

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 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 6
Consumption of Tungsten in Canada, by Use, 1968
(pounds of contained tungsten)

Carbides	887,034
Alloy steels	239,101
Electrical and electronic	26,298
Other[1]	29,108
Total	1,181,541

Source: 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*, Crucible Steel of Canada Ltd., Sorel; Shawinigan Chemicals Division of Gulf Oil Canada Limited, Montreal; *in Ontario*, Atlas 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.

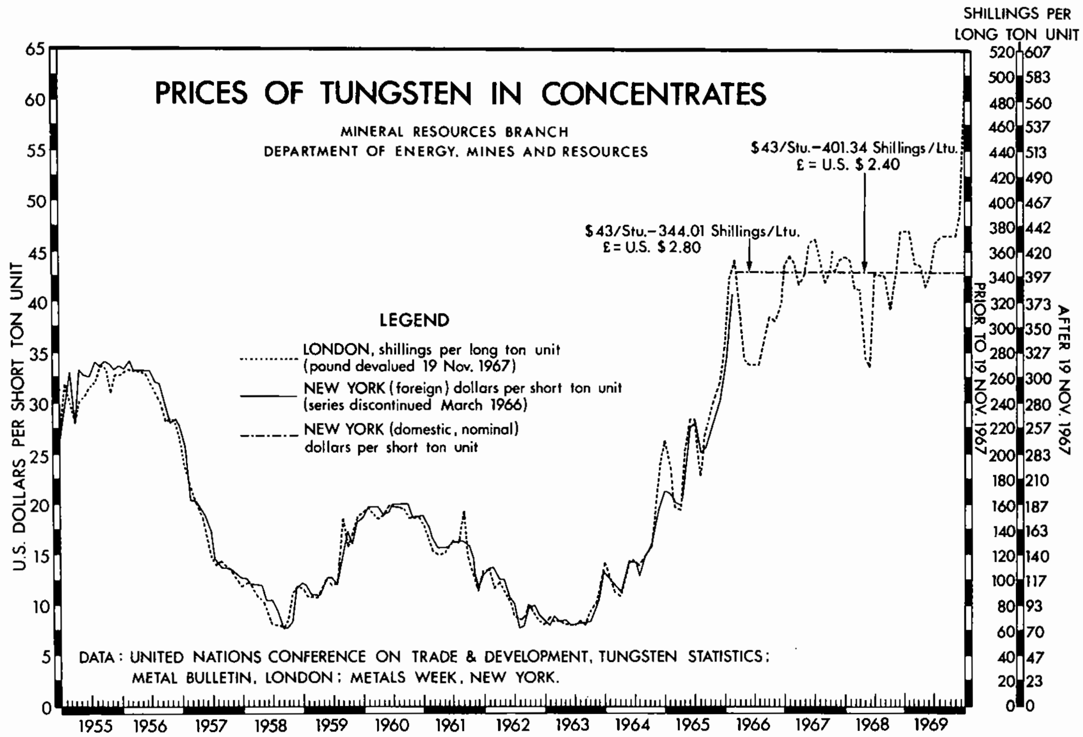
Tungsten mineral occurrences are found mostly in quartz veins and in contact-metamorphic deposits but pegmatite and placer deposits have also been productive. Disseminations of tungsten minerals in igneous rocks occur in many parts of the world but are rarely sufficiently concentrated to be of economic 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 the 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.

OUTLOOK

The recent period of 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 established commercial applications, and in advanced industrial products.

The resumption of tungsten exports in significant 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 any prolonged period is unlikely. Substantial stocks of tungsten-bearing materials are available to, or in the hands of, users and distributors. 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 continuing period of sustained attractive returns to producers and stimulation of new production developments appears reasonably assured.



PRICES

Metals Week, December 29, 1969,
published tungsten prices as follows:

	$US
Tungsten ore:	
per short-ton unit of WO_3, clean	
65% minimum WO_3, c.i.f. US ports,	
Wolfram	43.00
Scheelite	43.00
($6.34 duty per short-ton unit of WO_3, or 40¢ per lb of W, included)	

Tungsten metal	
per lb, c.i.f. US ports,	
Carbon red, 98.8% 1,000 lb lots	3.06
Hydrogen red, 99.99%, depending on	
Fisher No., range	4.91 - 5.75
Typical Fisher No. 4.00	4.91
Ferrotungsten - per lb contained W, f.o.b. shipping point,	
Low-molybdenum	3.65
High-molybdenum	3.65
"UCAR" high-purity	3.86
Dealers	3.25 - 3.45

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General
CANADA				
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, strips, plates, bars, rods, tubing, wire scrap (Expires October 31, 1971)	free	free	25%
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, 1969	40¢ per lb on tungsten content
	" " " Jan. 1, 1970	35¢ " " " " "
	Tungsten metal – unwrought, other than alloys	
629.28	Lumps, grains, powders	
	On and after Jan. 1, 1969	33¢ per lb on W content + 20%
	" " " Jan. 1, 1970	29¢ " " " " " + 17.5%
629.29	Ingots and shot	
	On and after Jan. 1, 1969	16.5%
	" " " Jan. 1, 1970	14.5%
629.30	Other tungsten unwrought metal	
	On and after Jan. 1, 1969	20%
	" " " Jan. 1, 1970	17.5%
	Tungsten metal, waste and scrap	
629.25	Not over 50% of tungsten	
	On and after Jan. 1, 1969	33¢ per lb on W content + 10%
	" " " Jan. 1, 1970	29¢ " " " " " + 8.5%
629.26	Over 50% of tungsten	
	On and after Jan. 1, 1969	16.5%
	" " " Jan. 1, 1970	14.5%
629.35	Tungsten metal, wrought	
	On and after Jan. 1, 1969	20%
	" " " Jan. 1, 1970	17.5%
	Tungsten, unwrought alloys	
629.32	Not over 50% tungsten	
	On and after Jan. 1, 1969	33.5¢ per lb on W content + 10%
	" " " Jan. 1, 1970	29.4¢ " " " " " + 8.5%
629.33	Over 50% tungsten	
	On and after Jan. 1, 1969	20%
	" " " Jan. 1, 1970	17.5%
422.40	Tungsten carbide	
	On and after Jan. 1, 1969	33¢ per lb on W content + 20%
	" " " Jan. 1, 1970	29.4¢ " " " " " + 17%
422.42	Other tungsten compounds	
	On and after Jan. 1, 1969	33¢ per lb on W content + 16%
	" " " Jan. 1, 1970	29¢ " " " " " + 14%

607.65	Ferrotungsten	
	On and after Jan. 1, 1969	33.5¢ per lb on W content + 10%
	" " " Jan. 1, 1970	29.4¢ " " " " " + 8.5%

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

Uranium and Thorium

R.M. WILLIAMS*

Uranium

Optimism waned temporarily in the uranium industry during 1969, as continued efforts on the part of uranium producers to negotiate additional long-term sales met with only limited success. Although the long-term future of the industry continues to look bright, prospects for a rapid growth in market possibilities for deliveries during the next two or three years are not encouraging. The slippage in the near-term demand is due to several factors. Foremost among these are delays in nuclear plant construction, and the consequent build-up of uranium inventories by reactor manufacturers and utilities. Such delays, as well as escalations in capital costs for nuclear plants, have forced some utilities to switch to conventional thermal plants. In addition, improvements in design have contributed to some reduction in fuel requirements. Despite this softening in the near-term uranium market, plans for additional uranium production facilities are under consideration in several quarters, and some positive results are beginning to show as a consequence of the surge in exploratory effort during the past two or three years.

The limited success in negotiating uranium sales has been felt nowhere more severely than in Canada. Canadian producers continue to be cut off from the United States market and are being faced by increased competition overseas, primarily from United States, South African and French companies. Only one of four Canadian producers is operating at capacity, two are operating at considerably less than full capacity and the fourth is recovering uranium solely from its mine water. All four producers as well as some past-producers and one new operation have made plans to expand, reactivate and begin production respectively, when markets permit. Such developments could triple Canada's uranium production capability within three to five years. Unfortunately, this increase in capacity is not yet warranted on the basis of present commitments. The current low demand is expected to be of a temporary nature however, and producers and potential producers alike continue to look forward with optimism to a bright future.

PRODUCTION

Canadian uranium production continued to come from four operations in two producing areas near Elliot Lake, Ontario and Uranium City, Saskatchewan. Three operations in the Elliot Lake area accounted for over 80 per cent of this production which is from quartz-pebble conglomerates: Denison Mines Limited continued to operate its mine and mill at about two-thirds capacity; Rio Algom Mines Limited's Quirke mill, which was being supplied by ore from two mines, was operated at full capacity; and Stanrock Uranium Mines Limited continued to produce uranium by treating its mine water. The fourth Canadian operation, Eldorado Nuclear Limited, which produces from pitchblende vein-type deposits in the Uranium City area, was operating its Beaverlodge mine and mill at about 50 per cent of

*Mineral Resources Branch.

TABLE 1

Uranium Production in Canada, by Province, 1968-69

	1968		1969P	
	Pounds	$	Pounds	$
Production (U_3O_8 shipments)				
Ontario	5,361,460	39,163,777	6,150,215	38,750,506
Saskatchewan	2,040,736	13,120,803	1,559,332	10,915,000
Total	7,402,196	52,284,580	7,709,547	49,665,506

Source: Dominion Bureau of Statistics.
PPreliminary.

daily capacity at year-end. Production from these four producers in 1969 totalled about 4,450 tons of uranium oxide (U_3O_8)* in concentrates, of which only 3,855 tons valued at $49,665,506 were shipped.

Denison continued to make changes in equipment aimed at increasing efficiencies of its underground operation. By year-end, 80 per cent of the production tonnage was being handled by new loading and haulage equipment. In addition to the eastward Can-Met development drive, completed in January 1969, a second such drive was completed to Denison's southern boundary in the fall of 1969. A third development drive was also under way to open up reserves to the southwest. Meanwhile, production was confined to the northeast quadrant of the mine, now being serviced with a new conveyor system installed in 1968. Mining in the northwest quadrant has been completed and the mine is now being serviced entirely through the centrally located No. 2 production shaft. Denison's 6,000-ton-a-day mill operated at about 4,000 tons a day throughout most of 1969 except for a short period when output was decreased to about 50 per cent capacity due to difficulties in obtaining sulphuric acid. Denison treated 1,237,000 tons of ore in 1969, with an average grade of 3.43 pounds of U_3O_8 a ton, the highest in the history of the mine. A total of 4,002,949 pounds of U_3O_8 were produced, of which 210,000 pounds were attributable to underground leaching. Production of rare-earth concentrates** as a byproduct resumed in 1969, under a contract with Molybdenum Corporation of America.

Rio Algom operated its Quirke mill at a daily average of 3,940 tons during 1969, some 6.5 per cent above the mill's 3,700-ton-a-day rated capacity; average recovery was 94.1 per cent. Ore to the mill came in increasing amounts from the New Quirke mine, which was opened in 1968. By year-end about two thirds of the mill-feed was coming from New Quirke and the remainder came from the old Quirke mine, where reserves are expected to be exhausted by 1971. Rio Algom's $1.25 million, electric, surface railroad was put into service in early 1969 to transport ore from New Quirke just over a mile to the Quirke mill. Of particular importance during the year were tests at the Quirke mill which demonstrated that a rate of 4,500 tons a day could be maintained by adjusting the grinding circuit to produce a coarser particle size without a significant loss in recovery. The additional capacity will be utilized as soon as the mines can support this rate of production. A total of 1,363,000 tons of ore were milled with an average recovered grade of 2.41 pounds of U_3O_8 a ton; 3,290,000 pounds of U_3O_8 were produced of which 157,000 were attributable to underground leaching at the inactive Nordic mine.

Production from Stanrock's underground leaching program declined slightly during 1969 and at year-end was averaging about 4,500 to 5,000 pounds of U_3O_8 a month. Now in the second phase of the program, the company expects to be able to produce at this rate for some time. By late 1969, over 750,000 tons of water, consisting mostly of acidic, barren, mill-effluent, had been fed underground and impounded primarily in the western portion of the mine behind seven bulkheads. It was expected that a total of one million tons of water would eventually be impounded following completion of the last bulkhead, which was still under construction late in 1969. Recovery of the water was at the rate of about 2,200 tons of water a day. Total 1969 production of U_3O_8 had a sales value of $427,885.

In May 1969, due to the uncertain short term market outlook, Eldorado announced its intention to reduce the milling rate of its Beaverlodge mill to about 900 tons of ore a day, just less than 50 per cent of its capacity. The reduction was completed by year-end and production is expected to remain at this level for the five-year period 1969 to 1973. Associated with the reduction in production was the shut-down of the Verna part of the mining opera-

* 1 short ton U_3O_8 = 770 kilograms of uranium metal.

**See 1969 Mineral Review No. 40, Rare Earths, by Robert J. Shank.

tion. Production will be confined to the Fay orebody and increasing tonnage will be taken from the Bolger open pit, located just east of the Verna shaft. In addition, production from the company's new Hab mine, located some 7 miles northeast of the Beaverlodge complex will be delayed until late 1971. Consequent to the curtailment of production was a reduction in manpower from 737 in 1968 to 491 at the end of 1969, largely through normal attrition.

Despite the decision to reduce the level of production at its Beaverlodge operation, Eldorado proceeded with preparations to sink an internal production shaft to develop downward extensions of the Fay orebody. Initially, the shaft will be sunk 2,000 feet beginning at the 24th level (3,475 feet), and may eventually be sunk a further 2,000 feet to a total depth from surface of nearly 7,500 feet. During 1969, Eldorado treated 456,156 tons of ore to recover 1,562,357 pounds of U_3O_8 with an average recovery of 3.43 pounds of U_3O_8 a ton. Costs per ton milled increased by 16.5 per cent while the cost per pound increased by 8.5 per cent, reflecting both the lower throughput and escalating costs.

DEVELOPMENT

Development plans at Rio Algom's New Quirke mine were adjusted somewhat in 1969 to offset difficulties experienced when unexpected faulting of the ore horizon was encountered. The scheduling of the mine's full productive capacity (5,200 tons a day) in 1971 is not expected to be unduly affected. In addition, due to changes in the near-term marketing situation, work on the development drive between Rio Algom's Nordic and Lacnor orebodies was temporarily suspended. In view of the planned increase in the productive capacity of the Quirke mill, it is unlikely that this work will be resumed in the near future. Consequently, it is now planned to place the Nordic mine and 3,700-ton-a-day mill on a care-and-maintenance basis, pending developments in the uranium market. Rio Algom's Elliot Lake production capability also includes the Panel mine and 3,000-ton-a-day mill which has been idle since July 1961. Plans were announced in 1968 to rehabilitate this operation, at an estimated cost of $14 million, when markets warrant.

TABLE 2

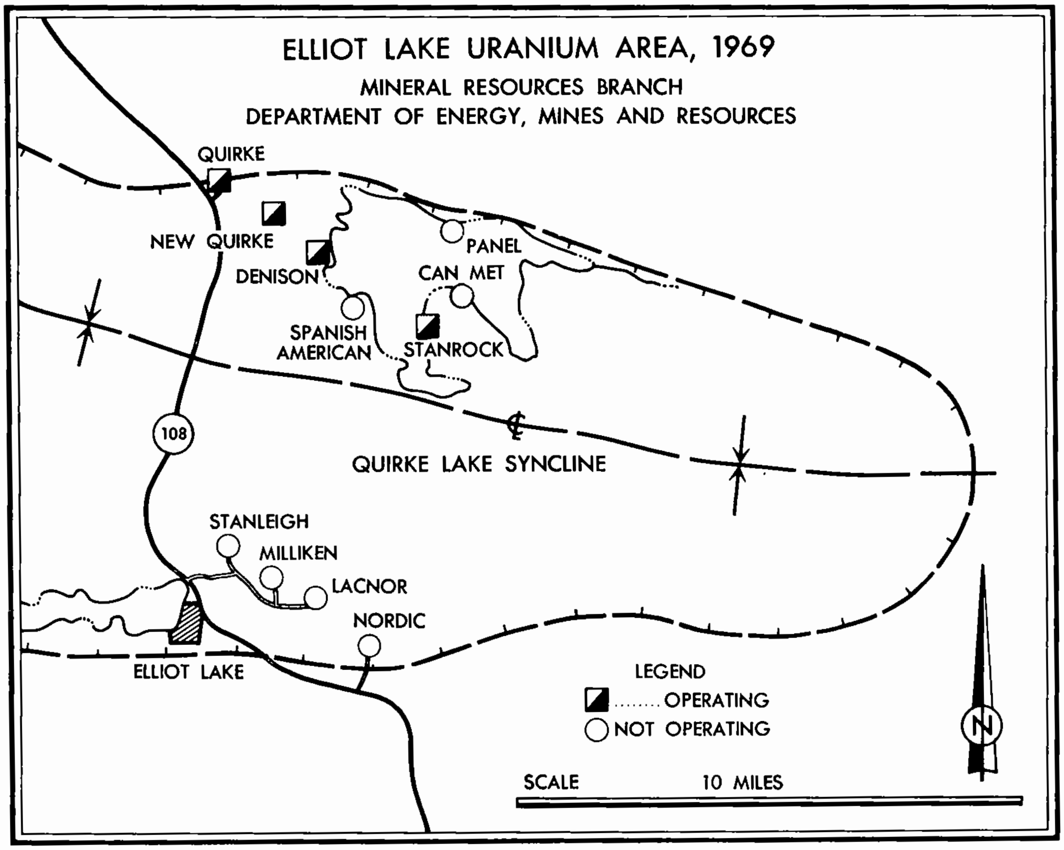
Uranium Production by Major Producing Countries, 1959-69
(short tons U_3O_8)

Year	Canada	United States	South Africa	Congo	Australia	France*	Non-communist World
1959	15,892 $331,143,043	16,420	6,445	2,300	1,100	1,065	43,350
1960	12,748 $269,938,192	17,760	6,409	1,200	1,300	1,379	41,130
1961	9,641 $195,691,624	17,399	5,468	–	1,400	2,141	36,300
1962	8,430 $158,183,669	17,010	5,024	–	1,300	2,603	34,500
1963	8,352 $136,909,119	14,218	4,532	–	1,200	2,692	31,025
1964	7,285 $ 83,509,429	11,847	4,445	–	370	2,113r	26,204r
1965	4,443 $ 62,361,377	10,442	2,942	–	370	2,210r	20,586r
1966	3,932 $ 54,334,787	9,587	3,286	–	330	2,223r	19,520r
1967	3,738 $ 53,021,936	9,125	3,360	–	330	2,206r	18,978r
1968	3,701 $ 52,284,580	12,338	3,865	–	330	1,973	22,344
1969p	3,855 $ 49,665,506	13,500	3,900	–	330	2,050	24,000

Source: U.S. Bureau of Mines Minerals Yearbook Preprint, 1968 and U.S. Bureau of Mines Commodity Data Summaries, January 1970; for Canada, Dominion Bureau of Statistics, producers' shipments.

*Includes Gabon and Malagasy Republic.

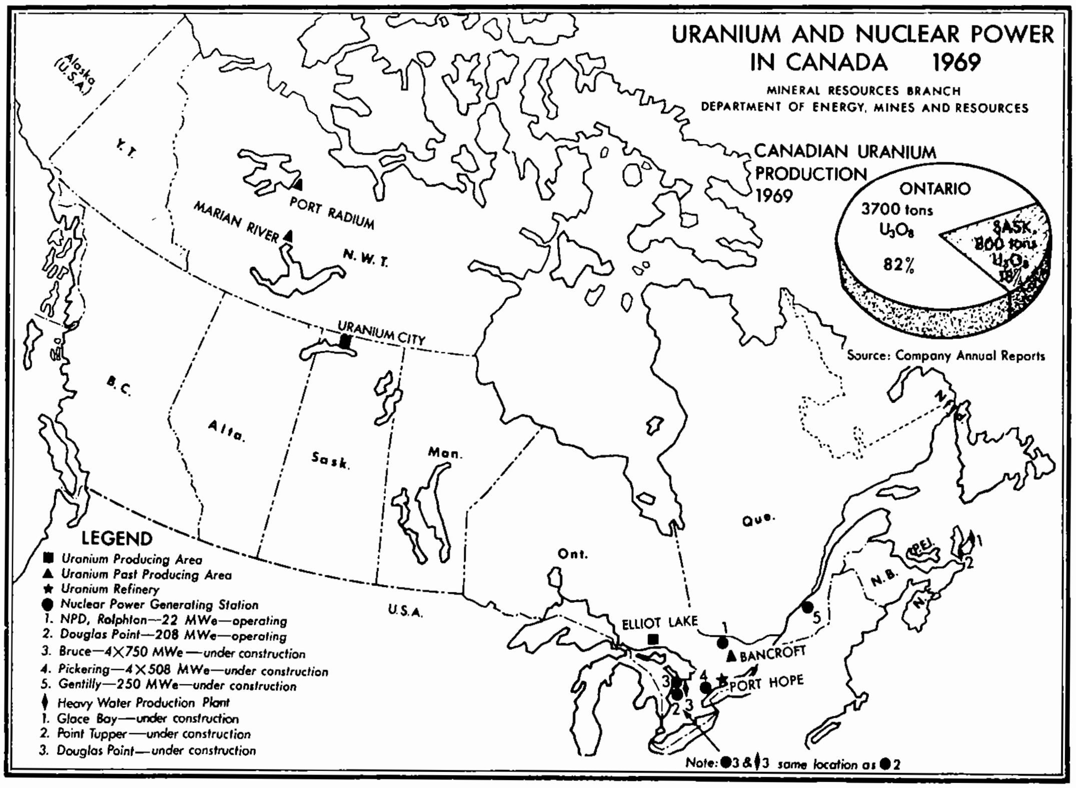
pPreliminary; rRevised; –Nil.



Of significance to Rio Algom's operations was the commencement of development work on its United States Humeca uranium property near Moab, Utah, where production is scheduled to begin in 1972 at a rate of about 600 tons of U_3O_8 a year. Sinking of the ventilation shaft began in March and of the production shaft in November 1969, both to be sunk to a depth of 2,650 feet. Preliminary mill design was also completed following process and flowsheet development by Rio Algom's metallurgists in Elliot Lake. The total cost to bring the mine into production is estimated at about $20 million (US).

Underground development work at Consolidated Canadian Faraday Limited's mine near Bancroft, Ontario was suspended in the spring of 1969. Reserves containing some 3 million pounds of U_3O_8 had reportedly been outlined at average grades in the order of 3 pounds of U_3O_8 a ton. The development program was carried out under an option agreement with Federal Resources Corporation of Salt Lake City, Utah, which formed a subsidiary, Can-Fed Resources Corporation, to manage the project. Under the agreement, which expires on July 1, 1970, Federal can gain 51 per cent interest in the property by financing its return to production. It has been estimated that the property could be returned to production, at a minimum rate of 1,000 tons of ore a day at a cost of $3,240,000. The development program, having been successful, reactivation now depends on obtaining a suitable sales contract. Meanwhile, the mine is being kept dewatered pending the decision to resume underground operations.

Development work at Agnew Lake Mines Limited's property, 30 miles west of Sudbury, Ontario, continued on schedule. The production shaft was bottomed in November 1969 at a depth of 3,411 feet. Lateral development of the Elliot Lake-type orebody was proceeding on four levels (700, 900, 1,300 and 1,500 foot) and a ventilation raise was being driven from the 900 foot level to surface. Trackless haulage is being utilized during this development stage and development ore is being hoisted and stockpiled on surface. Underground work confirmed the re-



sults of the surface diamond drilling program, which indicated 7,750,000 tons of ore grading 1.8 pounds of U_3O_8 a ton to a vertical depth of 3,500 feet; an additional 1,400,000 tons of similar grade has been outlined on an intervening claim of Kerr Addison Mines Limited, which has an 80 per cent interest in the Agnew Lake operation. On surface, clearing of the mill site and ore stockpile areas was well under way by year-end and construction of a retaining dam in the tailings area was begun. Although the design of a 3,000-ton-a-day mill had almost been completed, construction will not be started until after a sales contract has been obtained. Finally, an additional four houses and sixteen townhouse units were constructed for staff in Espanola, Ontario.

As indicated earlier, development of Eldorado's new Hab mine was delayed in 1969 in line with the company's plan to curtail production. Production is now planned for late 1971. Indicated reserves at the Hab mine were increased somewhat during the year to 446,000 tons grading 4.4 pounds U_3O_8 a ton.

EXPLORATION

The tempo of uranium exploration activity in Canada remained high during 1969 and several new areas of interest were identified. By the end of December 1969, 82 new exploration permits had been issued by the Atomic Energy Control Board, to companies engaged in examination of uranium prospects across Canada, making a total of over 200 issued since January 1967; comparatively, from 1956 to 1966, only a handful of permits were issued by the Board. It is expected that exploration activity will level off during 1970 and that it may even decline slightly as a result of the temporary lull in the uranium market. Higher costs of exploration and competition for the exploration dollar may also contribute to the levelling off in uranium exploration activity.

Uranium exploration activity was reported from coast to coast during 1969 but uranium areas in Ontario, Quebec and Saskatchewan remained the scenes of most interest. In Ontario, the Elliot Lake and Agnew Lake areas continued to be the focal point of attention, and these areas probably accounted for the major portion of the uranium drilling activity in Canada during 1969. Several companies were drilling to depths of 4,000 and 5,000 feet within the Quirke Lake syncline and others were actively investigating areas immediately west of this area. Of the former, the program of Preston Mines Limited on its Stanleigh property was perhaps the most significant. The program was begun in 1967 and by the end of 1969 twelve deep holes had been completed at a cost of almost $600,000. All but one of these holes encountered mineralization; 16 million tons of ore grading 1.7 pounds recoverable U_3O_8 a ton were indicated. The results of the program are being studied in relation to the possible future reactivation of the company's Stanleigh mine. Few positive results were available at year-end to illustrate the success of other drilling programs in the area, but at least one company, Cominco Ltd., had found significant mineralized intersections of quartz-pebble conglomerate. Lesser activity was still evident in other parts of the belt, from Sault Ste. Marie to Sudbury, which contains the favourable Huronian sediments.

In Quebec, the area of most prominence continued to be the Lac Forestier-Ste Anne du Lac area, a north-south trending belt some 5 to 10 miles wide, and 40 miles long, northeast of Mont Laurier. Numerous pegmatitic uranium occurrences were being examined and an appreciable amount of drilling was reported. By year-end, however, nothing of economic significance had been outlined. In addition, some activity was reported, also connected with pegmatitic uranium occurrences, about 20 miles west of Mont Laurier in the Grand-Remous area, in the Huddersfield Township area north of Shawville, and in the Portland Township area northeast of Wakefield.

The Grindstone Lake area, about 25 miles northeast of Temiscaming, Quebec, received a great deal of attention during 1969. A number of uranium discoveries were made, several miles apart, in quartzite and arkose formations. Gold and silver values were reported in some cases, similar to the Multi-Minerals Limited occurrence in the same area which was discovered in 1957. Sturdy Mines Limited, Talisman Mines Limited and Imperial Oil Limited were conducting a joint program in the area and had begun drilling at year-end. Atlantic Richfield Company was also a prominent claim-holder in the area.

In northern Saskatchewan, a uranium discovery by Gulf Minerals Company in the Wollaston Lake area late in 1968 was of particular significance. It precipitated a land acquisition rush early in 1969 involving literally millions of acres of mineral rights and dozens of companies. By the end of 1969, Gulf had completed 60,000 feet of drilling on its prospect. Selected diamond drill holes had mineralized intersections ranging from 20 to 236 feet with average grades ranging from 3.6 to 13.0 pounds U_3O_8 a ton; these holes were situated along a strike length of 1,400 feet. The deposit, termed the Rabbit Lake deposit, has been described as hydrothermal in origin, occurring in highly altered metasediments, with pitchblende being the principal uranium mineral; it is an open-pit proposition. Drilling on the property was temporarily suspended over freeze-up, but continued in January 1970 with three drills. Reserve calculations for feasibility and marketing studies had also been initiated. Indications were that development of the deposit would likely proceed, as Gulf has an internal demand for uranium relative to the nuclear activities of Gulf General Atomic Inc.

Gulf's Rabbit Lake success makes the uranium potential of the northeasterly-trending Wollaston Lake structural belt appear most promising. The belt, some 250 miles long, extending through the northwest corner of Manitoba and into the Northwest Territories, was essentially all tied up and numerous investigations in the area were under way. Several exploration programs were also under way in the Athabasca sandstone basin, bounded on the southeast by the Wollaston Lake structural trend and on the north by Lake Athabasca. The basin contains sandstones, with minor shales and conglomerates thought to be Middle Proterozoic in age, which are thought to be favourable for uranium.

The Beaverlodge area, in northern Saskatchewan, continued to receive a great deal of attention and a significant amount of drilling was completed. Several pitchblende vein-type prospects were being investigated, a small number of which may have some economic potential should custom mill service be reinstituted by Eldorado.

In the Northwest Territories, although activity continued to be evident in the District of Mackenzie along the edge of the Precambrian Shield, the area of most prominence was the Dubawnt Lake, Baker Lake, Henik Lake and Ennadai Lake areas of the District of Keewatin. In October 1969, following a shallow test drilling program, New Continental Oil Company of Canada Limited announced two uranium discoveries of hydrothermal origin in the Baker Lake area. The company was planning a major program in the area for 1970. Uranium investigations were also reported under way in southern Baffin Island.

In the Makkovik-Kaipokok area of Labrador, British Newfoundland Exploration Limited (Brinex) continued its exploration program under joint venture with Urangesellschaft M.B.H. of West Germany, in which Metallgesellschaft A.G. is one of the principal shareholders. Activity in the area was focussed along two geological belts which are particularly promising. The Kaipokok Bay zone, a belt of volcanic rocks, extends some 14 miles southwestward from Brinex's Kitts uranium deposit first discovered in the late 1950's. Two new pitchblende-vein type prospects were discovered along this belt in 1969, at Inda Lake and Witch Lake, in addition to the previously reported Nash and Gear occurrences. Approximately 5 miles of the 14 mile zone had been tested by drilling. The second belt of activity, the Michelin-McLean Lake zone, is a belt of sedimentary rocks located some 20 miles south of the Kaipokok Bay zone. Drilling at the

Michelin prospect, where a uranium-bearing zone 3,600 feet long had been outlined, was also encouraging. Three other promising prospects are located in the Michelin-McLean Lake zone, one of which was discovered in 1969. Finally, a number of uranium occurrences were under investigation in a third geological belt, termed the Shoal Lake zone, which lies east of the Kaipokok Bay zone.

Foreign participation in Canadian uranium exploratory activity increased during 1969. Most of the major United States uranium producers were present as well as many of the major oil companies. In addition, Japanese and West German interests were participating in programs in various areas of Canada. The Governments of France, and Italy were indirectly involved in projects in Saskatchewan and Quebec, respectively, and the Government of Japan was directly involved in a project in southern British Columbia. Meanwhile, Denison, Rio Algom and Kerr Addison were active in the western United States. Of particular significance in this regard were Rio Algom's preparations for production at its Humeca uranium property near Moab, Utah, mentioned earlier, and Kerr Addison's success in developing a sandstone-type uranium deposit in the Grant's area of New Mexico. The Fernandez Joint Venture, in which Kerr Addison has a 26 per cent interest and management (Noranda Mines Limited has 25 per cent interest), had drilled a total of 462,000 feet by year-end. In the 'Main Ranch Area', some 2,319,000 tons of ore grading 6.4 pounds of U_3O_8 a ton had been indicated, with an average thickness of 7.8 feet at an average depth of 2,700 feet.

REFINING

Eldorado Nuclear Limited continued to be Canada's only producer of refined uranium products, with its refinery at Port Hope, Ontario. Until early 1967, the bulk of Eldorado's refinery operation was connected with the conversion of mine concentrates to orange oxide (UO_3). More recently, the principal product has been natural ceramic UO_2 powder which is used to manufacture nuclear fuel for heavy water moderated reactors of Canadian design. Production of this material reached a record 246 tons of equivalent U_3O_8 in 1969, and with the increasing market for this specialized product, plans were under way to expand the circuit, including conversion of some parts of the operation from a batch to a continuous process.

Smaller quantities of other refined uranium products have also been produced for both domestic and export markets. These include natural uranium metal and various alloys, a variety of depleted and enriched uranium products, and some high density oxide and alloy fuels such as uranium carbide (UC) and uranium silicide (U_3Si). Of particular interest was a marketing study, in consort with a design and a fabricating company in Canada, which surveyed the market possibilities for the extensive use of depleted uranium metal in the manufacture of casks for the transportation of spent nuclear fuels to reprocessing plants. Beginning in 1970 Eldorado will also be in a position to produce zirconium* metal and alloys at its Port Hope refinery.

Construction of Eldorado's uranium hexafluoride (UF_6) plant at its Port Hope refinery, which had begun late in 1968, continued throughout 1969. By March 1969, the shell of the 155-foot high building had been completed, and by July it was fully enclosed. Installation of services and equipment proceeded throughout the fall and winter with a target date for completion of March 31, 1970. The plant will have a capacity to convert 2,500 tons of U_3O_8 to UF_6 per year, and production is scheduled for mid-1970. Upon completion it is expected that the project will have cost over $11 million. The process will utilize Eldorado's existing solvent extraction circuit for conversion of U_3O_8 to UO_3. In addition, existing equipment for the conversion of UO_3 to uranium tetrafluoride (UF_4), or green salt, has been replaced and a new fluorinating plant for conversion of UF_4 to UF_6 has been added. Provision has been made for expansion of the new plant to 5,000 tons a year and, in view of the growth in requirements, these plans may be implemented before the end of 1971.

SALES

Little evidence of success was apparent at year-end as a result of intensive effort on the part of Canadian producers to negotiate additional long-term uranium sales contracts. Two small contracts were reported, one each for Eldorado and Rio Algom, for deliveries to Japanese utilities (Table 4). A third small sale was made by Rio Algom to Mitsubishi Atomic Power Industries Inc., for 55,500 pounds of U_3O_8 to fuel the first Japanese nuclear ship. Finally, late in 1969, Denison confirmed that it had reached agreement with The Tokyo Electric Power Co., Inc. to extend its portion of the long-term contract announced in 1967. In January 1970, the company announced that the contract covered 16,750 tons of U_3O_8 for delivery over a 10-year period, beginning in 1974.

The era of commercial uranium sales began for Canadian producers in 1966, and by January 31, 1970 some 54,000 tons of U_3O_8 had been committed. About 86 per cent of this total was destined for export markets, primarily in Japan, Britain and West Germany; at the end of 1969 some 2,800 tons of U_3O_8 had been delivered under these contracts. In addition to these commitments, at year-end, Rio Algom had still to deliver about 2,300 tons of U_3O_8 to the United Kingdom Atomic Energy Authority (UKAEA) under old 'master contracts' made by

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***See 1969 Mineral Review No. 57, Zirconium, by G.P. Wigle.**

TABLE 3

Exports of Uranium Concentrates from Canada, 1959-69
(thousands of dollars)

Year	United States	Britain	West Germany	Japan	Switzerland	India	Others	Total
1959	278,913	32,603	129	107	122	20	10	311,904
1960	236,594	25,905	294	147	1	570	30*	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**	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
1969P	477	14,997	5,469	3,564	–	–	–	24,507

Source: Dominion Bureau of Statistics, exports of radioactive ores and concentrates that cleared customs.
*Includes Sweden ($27,720); **Brazil.
PPreliminary; –Nil.

Eldorado on behalf of Canadian producers; Rio Algom is the only producer still delivering under these contracts. Finally, deliveries to the Canadian government stockpile, which will end on June 30, 1970, are well below permissible quantities during the year, with only one producer delivering 755 tons of U_3O_8. It is expected that by June 30, 1970 there will be a total of about 9,500 tons of U_3O_8 in the stockpile.

On June 19, 1969 Canada's Acting Minister of Energy, Mines and Resources made a statement on Canadian uranium policy in the House of Commons. This policy continues to be based on the principle of the 'peaceful uses of atomic energy', as first announced in May 1958 and further amplified by the Prime Minister in June 1965. In view of the many significant changes in the world uranium market in recent years, the government is now setting out its uranium policy in greater detail to ensure that full account is taken of the Canadian public interest in these new circumstances. The statement further clarified the Prime Minister's announcement of 1965 that the government is prepared to authorize forward commitments to supply existing or committed reactors in the importing country for the average life of each reactor. In this regard, provision must be made in contracts of more than ten years' duration for renegotiation of price, and actual export in any one year will be limited to that sufficient to maintain the *moving-five-year-requirement* of the importing country. Additional stockpiling by the importing country in Canada is not precluded.

Of serious and continued concern to Canadian producers is the existing restriction on the enrichment, in United States Atomic Energy Commission's (USAEC) enrichment plants, of foreign uranium for domestic use. Eager to obtain a slice of the growing United States uranium market, several Canadian companies launched uranium exploration programs in the southwestern United States. Rio Algom has successfully developed a deposit near Moab, Utah from which production will begin in July 1972 to supply two contracts, with Duke Power Company of Charlotte, North Carolina, totalling 7.9 million pounds of U_3O_8; deliveries will be made from 1972 to 1980.

Also of serious concern to Canadian producers is speculation related to the possible disposal procedures of USAEC surplus uranium stocks, now stated to be equivalent to 50,000 tons of U_3O_8. Proposals for the removal of the restriction on enrichment and the disposal of this surplus inventory were in the drafting stage in 1969 and were expected to be announced by the USAEC in 1970. Lifting of the restriction will likely be on a gradual basis, beginning in 1973, under a quota system. Similarly, the proposal to dispose of the surplus uranium is expected to be on a quota system based on a proportion of projected domestic uranium requirements. Sales will likely be on a bid basis to producers and consumers alike, both domestic and foreign, with deliveries beginning around 1975. At year-end, however, the possible outcome of these two issues was clouded somewhat by indications that the United States and Canada might soon be involved in wider discussions relative to possible exchanges of other energy fuels.

Canadian producers met with appreciably more competition in the world uranium market during 1969. Late in 1969, the Commissariat a l'Energie Atomique (CEA) of France announced the formation of a new uranium sales company called URANEX. The company is owned in equal shares by the CEA, Société

Minière Pechiney Mokta and Compagnie Française des Minerais d'Uranium (Rothschild-Pennaroya). The CEA estimated that by 1973 URANEX will be in a position to offer between 2,000 and 3,000 short tons of uranium annually, mostly in the form of UF_6. Subsequently, it was announced that URANEX had completed negotiations for the sale of $28 million of uranium, probably in the form of UF_6, to Sweden. Other contracts were reported to be under negotiation, particularly a significant long-term contract with Japan.

Of concern to Canadian producers was a provision relative to uranium included in an agreement negotiated between the Governments of the United States and West Germany under which West Germany will purchase $125 million of United States goods and services to help offset the cost of maintaining its military establishment in West Germany. Of this total $50 million will be for enriched uranium (U_3O_8 plus enriching services) which will be kept in stockpile for from five to ten years prior to its use as nuclear fuel. Also affecting Canadian sales efforts abroad was the availability to European customers of relatively small quantities of uranium at bargain prices from various sources. These included the occasional United States producer, a United States reactor manufacturer with a surplus inventory of uranium, and governments of at least two European countries with surplus uranium available from their stockpiles.

Canada's uranium marketing position is currently being augmented with the construction of Eldorado's uranium hexafluoride plant discussed earlier. In this regard Eldorado had, at year-end, arranged UF_6 conversion for all five of its major uranium export sales (Table 4) and in addition had negotiated two contracts for conversion on a toll basis with a Japanese and a Swedish utility. A further substantial contract with a large United States utility was signed early in 1970. These contracts will more than fill half the rated capacity of the new plant for 1970 and 1971, and it is expected that the plant's full capacity will be committed before the end of 1970.

NUCLEAR DEVELOPMENTS

Valuable design, development and operating data continued to be accumulated during 1969 relative to nuclear power stations of Canadian design. The 22 net electrical megawatt (MWe) Nuclear Power Demonstration (NPD) station at Rolphton, Ontario operated successfully during the year with a boiling-heavy water (BHW) cooling system, following conversion from a pressurized-heavy water (PHW) system in 1968. The conversion was made to provide data for design of future Hydro-Electric Power Commission of Ontario (Ontario Hydro) plants; the plant will be returned to pressurized non-boiling operations in the latter part of 1970. Ontario Hydro's 208-MWe Douglas Point Gen-

TABLE 4

Major Canadian Uranium Sales, Announced Since 1966
(as of January 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
	Kernkraftwerk Lingen	West Germany	212	1969 to 1973
	Oskarshamnsverkets Kraftgrupp	Sweden	150	1971 to 1973
	Chugoku Electric	Japan	119	1971
Rio Algom	UKAEA	Britain	2,300[1]	1970 to 1971
	UKAEA	Britain	11,500[2]	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
Stanrock	Unnamed reactor manufacturer	United States	total prod.	1967 to 1970

[1] Remaining under old master contract at rate of 1,200 tpy; [2] Includes delivery options.

erating Station experienced mechanical difficulties in early 1969; however, by year-end the plant was again operating satisfactorily.

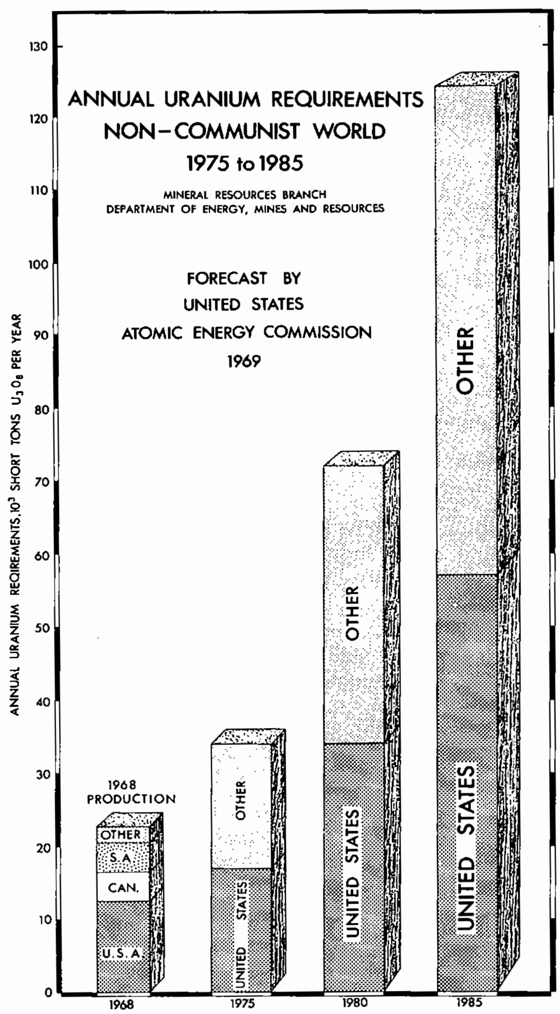
Construction progressed on Ontario Hydro's four unit, 2,032-MWe Pickering Generating Station, 20 miles east of Toronto, where the first unit is expected to be in service in September, 1971. The second and third units are to be completed in March and October of 1972, with the fourth unit scheduled for October, 1973. Site preparation began for the new, four unit, 3,000-MWe Bruce Generating Station near the existing Douglas Point Generating Station on the east shore of Lake Huron near Kincardine, Ontario. The plant was moved one mile north of its original proposed location, to avoid potential health hazards to construction workers resulting from the simultaneous construction of the nuclear plant and a new heavy water plant being built immediately adjacent to the Douglas Point station. The first unit of the Bruce station is scheduled to go critical in the summer of 1975, with full power in 1976; other units will follow at yearly intervals. Construction at Hydro-Quebec's 250-MWe nuclear plant at Gentilly, Quebec, proceeded on schedule toward an in-service date of 1971. At present, there are seven nuclear power stations (14 reactors) of the Canadian design (natural uranium-fuelled and heavy water-moderated) either in operation, or under construction, representing a total capacity of 6,043 MWe. All are designed to use a PHW cooling system, except the Gentilly station which utilizes a boiling-light-water cooling system. The years 1970 and 1971 are tremendously important to Canada's nuclear industry as four of the twelve nuclear units presently under construction are scheduled to be in service.

In September 1969, Atomic Energy of Canada Limited (AECL) announced the sale of a nuclear research reactor to the Chinese Atomic Energy Council in Taiwan. The reactor will be an up-to-date version of the Chalk River NRX research reactor, at a cost of $35 million, of which approximately $28 million will be Canadian content provided by Canadian companies. AECL was continuing negotiations with Romania at year-end for the sale of a 600-MWe CANDU-type nuclear steam plant, and a bid had been submitted to Mexico for a similar sized plant. Further, it was expected AECL would be requested to submit a bid for a 500-MWe Australian nuclear steam plant early in 1970.

Construction of AECL's heavy water (D_2O) production plant, adjacent to the Douglas Point Generating Station, was well under way in 1969. Capacity of the 'Bruce Heavy Water Plant' will be 800 tons annually, when it comes into production in 1972, rather than 400 tons as originally planned. Doubling of the plant's capacity was considered necessary to meet the needs of the Canadian nuclear power program and the foreign D_2O requirements that are in prospect. It is estimated that the expansion will cost an additional $50 million for a total of $115 million.

Construction also continued at the Canadian General Electric Company Limited (CGE) D_2O plant at Point Tupper, Nova Scotia, which is scheduled to begin production at 400 tons yearly in 1970. Efforts continued to complete the 400-ton-a-year D_2O plant of Deuterium of Canada Limited at Glace Bay, Nova Scotia.

In November 1969, first reading was given in the House of Commons to Bill C-158, which provides that nuclear power plants, fuel processing plants and other installations of a non-military nature handling nuclear materials maintain liability insurance to a maximum of $75 million. Following second reading the bill was referred to the Standing Committee on National Resources and Public Works for study.



OUTLOOK

The uranium industry can look forward to a growing market for its product beginning in the mid-1970's. Requirements in the near to medium-term, however, have been modified and the critical year of 1973 or 1974, where demand was to surpass available supply, has been delayed by at least two years. This change in outlook from one year ago has been due to a number of factors, foremost among these being a variety of construction, equipment and licencing delays involving nuclear power plants already committed. These delays have forced some utilities to switch to conventional thermal plants, their decision being made easier by a narrowing of the cost advantage of nuclear over conventional plants. In addition, fuel consumption factors have been modified due to improvements in nuclear reactor and fuel technology, and the delays in nuclear plant construction have resulted in a build-up of large inventories of uranium by reactor manufacturers and utilities.

On the basis of some of these factors, the United States Atomic Energy Commission (USAEC), in October 1969, revised its projections of nuclear capacity and uranium requirements in the non-communist world (Table 5). For comparison, the European Nuclear Energy Agency (ENEA) estimated, in January 1969, that requirements would be between 73,000 and 106,000 tons of U_3O_8 annually by 1980, and 508,000 to 684,000 tons of U_3O_8 cumulative from 1969 to 1980. Of particular interest to Canada was a forecast, released in November 1969 by Canada's National Energy Board, which projects that by 1990 Canada will have 31,000 MWe of installed nuclear capacity, all of the CANDU type. At that time Canada's total inplant U_3O_8 inventory, including that in various stages of the fuel fabrication cycle, will be 7,200 tons of U_3O_8 and the annual U_3O_8 burn-up will be 3,975 tons of U_3O_8. This equates to an annual domestic uranium requirement of about 5,200 tons of U_3O_8 a year, again verifying that Canada's uranium production will be primarily for the export market.

TABLE 5

Uranium Requirements, Non-Communist World (Tons U_3O_8)

	1975	1980	1985
United States			
annual (tons/year)	17,000	34,000	57,000
cumulative (tons)	..	212,000	450,000*
Other			
annual (tons/year)	17,000	38,000	67,000
cumulative (tons)	..	212,000	490,000*
Total			
annual (tons/year)	34,000	72,000	124,000
cumulative (tons)	..	424,000	930,000*

Source: R.L. Faulkner, "Uranium Supply and Demand", paper presented, American Mining Congress, San Francisco, October 19, 1969.
*Figures have been rounded; .. Not reported.

On the supply side, uranium exploratory effort over the past two or three years has begun to show some promising results, particularly in the United States. The USAEC estimated at year-end that reasonably assured reserves available at $8 a pound in the United States had increased by about 27 per cent during 1969 to 204,000 tons of U_3O_8. Maximum production capability available in the short-term in the United States was estimated at almost 20,000 tons of U_3O_8 a year, up considerably over 1968's estimate. The CEA has had marked success in its exploratory ventures, primarily in Niger and the Central African Republic, as illustrated by France's entrance into the world uranium market sooner than expected. Rio Tinto South Africa (Pty) Ltd. has been developing an extensive low-grade uranium deposit at Rossing in the Swakopmund district of South West Africa, which is reportedly a large open-pit proposition. In Australia, Queensland Mines Ltd. has made a significant uranium discovery in the Westmoreland conglomerates of northwestern Queensland. The company has announced plans to build a $A20 to $A30 million production facility. Even in Canada developments have been such that the 11,000 ton U_3O_8 a year capability figure published in 1968 can be revised upward. In short, it is now estimated that the non-communist world could expand its productive capacity to about 50,000 tons of U_3O_8 a year by 1975, assuming that contemplated plans for plant expansion, reactivation and construction are carried out. It is important to note, however, that there are no firm plans for some 25 per cent of this capacity, and that its availability is entirely contingent on markets being developed.

The USAEC estimates that reported uranium sales commitments in the non-communist world are sufficient to cover nuclear fuel requirements through 1973. However, some utilities have overbought, while others have some unfilled needs so that additional sales will likely be made. Further, since nearly all nuclear power plants requiring fuel in 1970 and 1971 have now been covered for those years, producers are now seeking sales with deliveries beginning not earlier than 1972.

As noted above, potential production capability in the non-communist world is substantially in excess of estimated short-term requirements so that, if contemplated expansion plans are carried out with appropriate timing, the industry is *now* in a position to meet demand at least until 1975. The timing of decisions to expand or prepare new production capacity in advance of requirements is critical. In this regard it should be emphasized that such decisions are not speculative in nature but are made on the basis of a producer or potential producer obtaining reasonable forward 'base-load' contracts. Between 1975 and 1980 projected requirements will more than double and substantial new capacity will be required. This will necessitate that current levels of uranium exploration activity be maintained for an indefinite period in order to identify and develop reserves sufficient to support the new capacity.

Canada's uranium industry is in a good position to meet a substantial share in this growing world uranium market. Only about 25 per cent of its maximum production capability, available in the short-term, and 20 per cent of its low-cost, reasonably assured uranium reserves have been committed. Moreover, there are many areas of potential in Canada for new uranium discoveries which will be required to support future production facilities. Given reasonable economic incentives and sufficient lead-time, the Canadian industry will be able to expand in line with increasing requirements.

Thorium

There was no production of thorium concentrates in Canada during 1969. 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 and the reactivation of the Quirke 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.

TABLE 6

Thorium Production in Canada, 1968-69

	1968		1969[p]	
	Pounds	$	Pounds	$
Production (shipments of ThO_2 in concentrates)	139,191	261,836	29,014	55,127

Source: Dominion Bureau of Statistics.
[p] Preliminary.

*1 short ton ThO_2 = 795 kilograms of thorium metal.

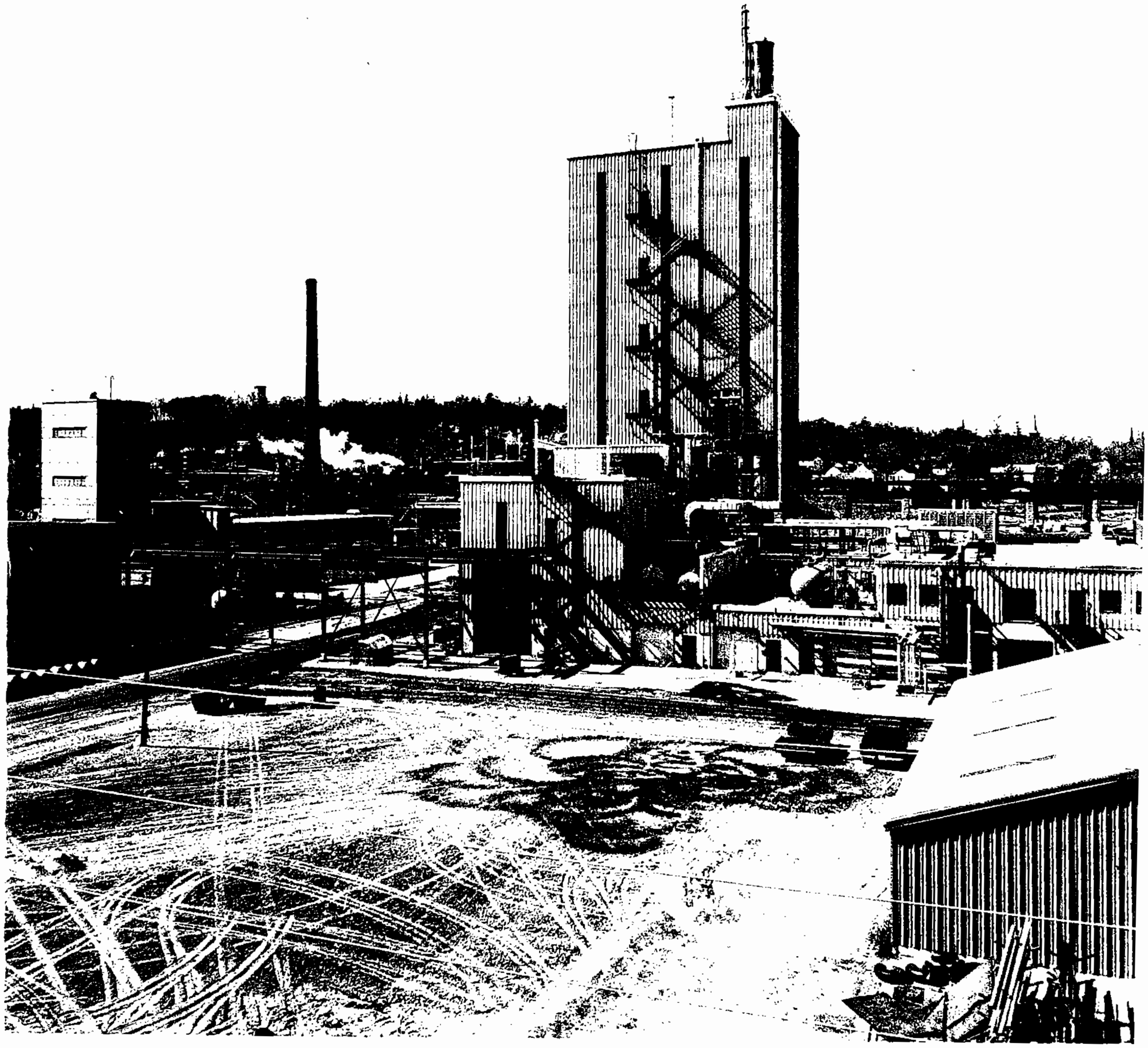
Since thorium production began at Elliot Lake in March 1959, Rio Algom's principal customer has been Thorium Ltd., in Britain. The final shipment to Thorium Ltd. was made in March 1969. In addition, small quantities of thorium cake were transferred as required to the Nuclear Products Department's Quirke refinery, where it has been refined to metallurgical-grade thorium oxide (99.8 per cent + ThO_2) and shipped to Dominion Magnesium Limited, Haley, Ontario. At Haley, Dominion Magnesium produces sintered pellets of pure (98 per cent) thorium and thorium powder (99.5 per cent). Although the plant has a capacity of 200,000 pounds of thorium metal a year production in 1969 was only 919 pounds compared with 1,048 pounds in 1968.

Prices* for thorium products in the United States were fairly steady during 1969. Thorium pellets and powder were priced at $15 a pound, thorium nitrate at $2.75 a pound contained ThO_2 and thorium metal at $65 a pound. Thorium-magnesium hardener (30-40 per cent Th) was quoted at $11.50 to $12 a pound of contained thorium plus the market value of the contained magnesium (35.25 cents a pound); on this basis 40 per cent thorium hardener costs about $4.82 a pound.

USES

The use of thorium nitrate as an essential ingredient in the manufacture of gas lamp mantles began in

*Thorium, by Richard F. Stevens, Jr., Engineering and Mining Journal, March 1970.



ELDORADO NUCLEAR LIMITED'S URANIUM HEXAFLUORIDE PRODUCTION PLANT, Port Hope, Ontario. (Photo courtesy Eldorado Nuclear Limited) the period 1890 to 1911, and continues to account for about 50 per cent of the total consumption of thorium. Because of its great tensile strength at high temperatures (730°F) thorium is alloyed with magnesium for use in the skin and structural components of supersonic aircraft. Nickel-thorium alloys have proved to have great strength and resistance to corrosion at temperatures as high as 2400°F; similar properties have been demonstrated in tungsten-thorium alloys. Thorium is also used as a deoxidant in the production of molybdenum and its alloys, as a catalyst in the chemical and petroleum industries, in the manufacture of electronic tubes and electrodes for inert-arc welders, as a refractory material, and in the manufacture of special optical glass.

The greatest potential use for thorium, however, is as a nuclear fuel for advanced converter and breeder type reactors. Although thorium (Th_{232}) is not a fissile material like U_{235}, it is a fertile material and can be converted into fissionable uranium – 233 (U_{233}) under irradiation. The use of this 'Th_{232}–U_{233} fuel cycle' has many potential advantages in both advanced converters and breeder reactors, but the technology is presently at a very early stage of development compared with conventional reactor technology.

OUTLOOK

Although a minor increase in demand can reasonably be anticipated for thorium due to current and new industrial uses, a major increase in thorium consumption must wait the full development of breeder and near-breeder reactor technology. Development of a commercial breeder reactor is not expected much before 1985 although commercial advanced converter (near-breeder) reactors could be operating somewhat earlier. The economic incentive for the development of these reactors is great and the benefits to be accrued through the resulting efficient use of energy resources are many. Consequently, while the requirements for thorium for nuclear purposes may amount to no more than a few hundred tons a year during the next 15 years, the demand can be expected to rise significantly thereafter. Canadian reserves of thorium are substantial and, being intimately associated with uranium in the Elliot Lake and Agnew Lake uranium deposits, will be readily available to meet a major portion of this potential market.

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 1969 was an estimated 15,700 tons of vanadium in ores, concentrates and vanadium pentoxide (V_2O_5). The United States produced 11,456 tons of vanadium pentoxide containing 6,418 tons of vanadium. South Africa produced 2,570 tons of V_2O_5 in the first six months of 1969. New and increasing production was expected from the United States and South Africa in 1970.

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. It is the only plant in Canada that recovers vanadium commercially. Capacity is about 1,000 pounds of V_2O_5 a day.

World production and consumption of vanadium were higher in 1969 than in 1968 with prices increasing from U.S. 95 cents a pound of V_2O_5 in January to U.S. $1.75 in December. United States standard grade ferrovanadium increased from U.S. $2.90 to U.S. $3.00 a pound of contained vanadium in December 1969.

Sales of vanadium pentoxide for domestic use from surplus United States government stocks were resumed in August 1969 after an interruption of over two years. Total stockpile sales for 1969 were 1,217 tons of V_2O_5 containing 682 tons of vanadium at prices varying from U.S. $1.26 to $1.65 a pound of vanadium pentoxide.

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 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.

Great Canadian Oil Sands Limited started oil recovery from the Athabasca tar sands near Fort McMurray in northern Alberta in September 1967. The operation will produce and use some 3,000 tons of petroleum coke a day in producing 45,000 barrels of oil a day. The ash from the coke is reported to contain about 4 per cent vanadium, most of which might be recovered in due course.

Canada's imports of ferrovanadium in the six years, 1964 to 1969 inclusive, were 2,407 tons valued at $7.9 million. The only year that exceeded the average annual importation of 401 tons was 1966 when 478 tons valued at $2.2 million were imported.

*Mineral Resources Branch.

TABLE 1

Canada, Imports and Consumption of Vanadium, 1968-69

	1968		1969p	
	Short Tons	$	Short Tons	$
Imports				
Ferrovanadium				
United States	106	437,000	118	477,000
USSR	–	–	110	183,000
Austria	59	157,000	48	223,000
Netherlands	–	–	41	98,000
Belgium and Luxembourg	1	1,000	39	137,000
Other countries	99	389,000	35	96,000
Total	265	984,000	391	1,214,000
Consumption				
Ferrovanadium				
Gross weight	263		..	
Vanadium content	173		..	

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

TABLE 2

World Production of Vanadium in Ores and Concentrates, 1966-69
(short tons)

	1966	1967	1968	1969e
United States	5,166	4,963	6,483	6,400
Republic of South Africa	1,711	2,115r	2,498	5,500
South-West Africa	1,353	1,323	1,323	..
Finland	1,069	1,292	1,321	..
Norway	730	816r	937	..
Total	10,029	10,509	12,562	15,700*

Source: U.S. Bureau of Mines, Minerals Yearbook Preprint, 1968; 1969 figures U.S. Bureau of Mines Commodity Data Summaries, January 1970.
*Total includes estimates for last three countries.
eEstimated; rRevised; . . Not available.

UNITED STATES

Estimated world production of vanadium in 1969 was 15,700 tons of which the United States produced 6,418 tons in 11,456 tons of vanadium pentoxide. Consumption in the United States was 6,026 tons compared with 5,495 tons in 1968. The steel industry used about 80 per cent of the total consumed, nonferrous alloys used 10 per cent, and chemicals, ceramics and other uses the balance. The amounts consumed in the common forms of supply are shown in Table 3. Table 4 outlines vanadium consumption in the United States by end-use. 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 complex of Union Carbide Corporation at Wilson Springs, Arkansas. Union Carbide expects to increase its output of vanadium in 1970.

TABLE 3

Vanadium Consumed in the United States, 1968-69
(pounds of vanadium)

	1968	1969
Ferrovanadium	9,071,832	10,233,042
Oxide	266,858	221,019
Ammonium metavanadate	183,111	229,180
Other	981,661	1,368,775
Total	10,503,462	12,052,016

Source: U.S. Bureau of Mines, Mineral Industry Surveys.

TABLE 4

Vanadium Consumed in the United States
by End-Use, 1968-69
(short tons of vanadium)

	1968r	1969p
Steel		
High-speed and tool	610	647
Stainless	50	37
Alloy (excluding stainless and tool)	2,591	2,648
Carbon	1,092	1,317
Other steel	7	63
Cast irons	57	45
Cutting and wear resistant materials	16	8
Welding and hardfacing rods and materials	12	12
Magnetic alloys	6	3
Nonferrous alloys	459	619
Chemical and ceramic uses	168	160
Miscellaneous and unspecified	426	467
Total	5,495	6,026

Sources: U.S. Bureau of Mines Minerals Yearbook Preprint 1968 and U.S. Bureau of Mines, Mineral Industry Surveys.
rRevised; pPreliminary.

REPUBLIC OF SOUTH AFRICA

The Republic of South Africa produced 2,570 tons of vanadium pentoxide in the first half of 1969 compared with 1,720 tons in the same period of 1968. Production in the latter half of 1969 was at a much higher rate than previously. The Vantra Division of Highveld Steel and Vanadium Corporation Limited near Witbank in the 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 complex, also near Witbank, came into production 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.

PRODUCTS AND USES

Vanadium is a steel-grey metallic element with a melting point of 1,900° Centigrade (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, 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 1 to 3 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 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 in 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 known. 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. The data available is not yet sufficient to assess the economic significance of these discoveries which were made in November, 1968, by officers of the Geological Survey.

OUTLOOK

Increased production of vanadium and assurance of improving availability of supply has contributed to a higher growth rate in the use of this alloy metal. European and Japanese, as well as United States, demand improved in 1969 and producers prepared for further increases in output. Vanadium prices doubled in less than 12 months, sales from United States stockpile surplus were resumed and demand was sustained. Oversupply is unlikely because of the time required to increase production facilities and place new supply on the market. A period of near-balanced supply and demand should extend through 1972 with prices about $2 a pound of vanadium pentoxide. New large producers of byproduct vanadium will have established their advantages of scale production and distribution in the period mentioned and consequent price stability should extend a period of expanding use.

PRICES

United States vanadium prices published in *Metals Week* of December 29, 1969 were:

Vanadium pentoxide	
per lb, f.o.b. mine or mill	
98% fused	$1.51
Air dried (technical)	1.54
Dealers (mainly export)	1.75 – $1.80
Ferrovanadium	
per lb V, packed, f.o.b. shipping point, freight equalized to nearest main producer	
Standard grade	$3.00 – $3.12
Imported	4.00 (nominal)
Carvan	2.70
Solvan	2.70
Vanadium metal (from Metals Week June 9, 1969)	
per lb 90%, 100 lb lots	$3.45

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General
CANADA				
32900–1	Vanadium ores and concentrates	free	free	free
37520–1	Vanadium oxide (effective Jan. 1, 1969)	free	free	5%
35101–1	Vanadium metal, ex alloys (effective June 6, 1969)	free	5%	25%
37506–1	Ferrovanadium	free	5%	5%
UNITED STATES				
601.60	Vanadium ores and concentrates	free		
632.58	Vanadium metal unwrought, waste and scrap (duty and waste and scrap suspended to June 30, 1971)			
	On and after Jan. 1, 1969	8%		
	" " " " 1970	7%		

632.68	Vanadium alloys, unwrought	
	On and after Jan. 1, 1969	12%
	" " " " 1970	10%
633.00	Vanadium metal, wrought	
	On and after Jan. 1, 1969	14%
	" " " " 1970	12.5%
607.70	Ferrovanadium	
	On and after Jan. 1, 1969	10%
	" " " " 1970	8.5%
422.60	Vanadium pentoxide	
	On and after Jan. 1, 1969	25.5%
	" " " " 1970	22%
422.58	Vanadium carbide	
	On and after Jan. 1, 1969	10%
	" " " " 1970	8.5%
427.22	Vanadium salts	
	On and after Jan. 1, 1969	25.5%
	" " " " 1970	22%
422.62	Other vanadium compounds	
	On and after Jan. 1, 1969	25.5%
	" " " " 1970	22%

NOTE: Further reductions will take place on January 1, 1971 and on January 1, 1972.

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.

Zinc

ROBERT J. SHANK*

In 1969, the production of zinc from Canadian mines rose for the eighth consecutive year, totalling 1,323,520 short tons, an increase of 38,378 tons over 1968. Canada remained the leading producer in the non-communist world, although its share fell to 28 per cent from 29 per cent the previous year. Canadian output is expected to increase substantially in 1970 as major new sources of supply become fully operational, but little increase is expected for 1971.

The four domestic primary zinc plants operated at 89 per cent of their rated capacity to produce 466,351 tons of metal in 1969. This was a rise of 9 per cent over 1968 production when the plants operated at 81 per cent of capacity.

Canadian consumption of primary refined zinc in 1969 rose by 2 per cent to 118,681 tons from 115,978 tons in 1968.

The demand for zinc concentrates was strong through most of 1969 as world smelters manoeuvred to assure themselves of an adequate supply of feed for the next few years. About 39 per cent of mine output was smelted in Canada, compared to 37 per cent in 1968. Zinc concentrates in excess of requirements for domestic smelters, containing 804,664 tons of zinc, were exported for treatment to 10 countries, primarily to the United States, Europe and Japan. Exports of refined zinc totalling 307,394 tons, went to 40 countries, 48 per cent of the total going to the United States (36 per cent in 1968) and 27 per cent to Britain (31 per cent in 1968). This change reflects new smelter capacity in Britain.

On the international scene, the production and consumption of zinc in the non-communist world was in close balance during 1969, as it was in 1968. The International Lead and Zinc Study Group, a United Nations agency, at its meeting in November 1968 forecast a substantial increase in both mine and metal production of zinc in 1969, and a more modest rise in consumption. The Group cautioned, however, that forecasts made in previous years tended to overestimate production and underestimate consumption. Statistics presented to the Study Group at its meeting in Geneva in October 1969, indicated that consumption of zinc in 1969 had risen by 7.4 per cent to 4.4 million tons. Production of metal rose from 4.0 million tons in 1968 to 4.5 million tons in 1969, a gain of over 12 per cent. The surplus, which was less than 0.1 million tons, was partly absorbed by increased producer stocks. Mine production of zinc in concentrates increased by 6.9 per cent to 4.7 million tons. The strong demand for metal, coupled with low stock positions and a shortage of concentrates for near-term delivery, caused upward price adjustments during the year.

Two conflicting forces are obscuring the course zinc supply and demand will follow in 1970. On the one hand, measures being taken in North America to combat inflation could cause a slow-down in business activity, particularly in the automobile industry. On the other hand, Japanese and European markets appear to be continuing the strength shown in 1968 and 1969. The most probable result will be a modest increase in consumption of zinc in the non-communist world in 1970 and a build-up of producer's stocks.

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*Mineral Resources Branch.

TABLE 1

Canada, Zinc Production, Trade and Consumption, 1968-69

	1968		1969P	
	Short Tons	$	Short Tons	$
Production				
All forms[1]				
Ontario	346,757	97,786,640	349,408	106,429,692
Northwest Territories	203,916	57,504,129	220,000	67,012,000
Quebec	213,152	60,109,037	195,923	59,678,030
New Brunswick	135,430	38,191,075	158,201	48,188,025
British Columbia	146,099	41,199,754	148,128	45,119,758
Manitoba	45,532	12,839,826	48,909	14,897,699
Newfoundland	36,729	10,357,709	33,906	10,327,540
Saskatchewan	29,012	8,181,451	28,218	8,595,317
Yukon	2,653	748,206	17,075	5,201,045
Nova Scotia	112	31,769	121	37,020
Total	1,159,392	326,948,596	1,199,889	365,486,126
Mine output[2]	1,285,142		1,323,520	
Refined[3]	426,915		466,351	
Exports				
Zinc, blocks, pigs and slabs				
United States	115,872	29,292,000	147,685	38,586,000
Britain	98,940	23,306,000	82,894	19,358,000
West Germany	8,120	1,922,000	13,107	2,967,000
Brazil	7,772	1,607,000	11,177	2,237,000
India	14,972	3,181,000	6,214	1,253,000
Sweden	5,070	1,204,000	4,584	1,156,000
Netherlands	1,908	443,000	3,856	848,000
Italy	2,980	545,000	3,711	751,000
Philippines	5,324	1,180,000	3,457	752,000
Argentina	4,114	875,000	3,439	688,000
Thailand	2,787	635,000	3,216	745,000
Belgium and Luxembourg	3,673	747,000	3,085	617,000
Venezuela	3,173	651,000	2,783	576,000
Hong Kong	3,905	912,000	2,722	620,000
Other countries	40,097	8,911,000	15,464	3,411,000
Total	318,707	75,411,000	307,394	74,565,000
Zinc contained in ores and concentrates				
United States	365,475	42,284,000	383,177	46,157,000
Belgium and Luxembourg	208,397	22,916,000	156,397	19,387,000
West Germany	44,422	5,343,000	110,954	15,259,000
Japan	98,671	12,071,000	66,873	9,271,000
France	17,108	2,310,000	45,308	6,310,000
Britain	37,312	4,057,000	21,374	2,765,000
India	6,382	379,000	5,804	287,000
Italy	2	...	5,528	750,000
Netherlands	50,345	6,014,000	5,002	695,000
Norway	19,693	2,308,000	4,247	519,000
Poland	8,011	1,067,000	–	–
Total	855,818	98,749,000	804,664	101,400,000

TABLE 1 (Cont'd)

	1968		1969P	
	Short Tons	$	Short Tons	$
Zinc fabricated materials, n.e.s.				
United States	5,884	2,005,000	4,388	1,787,000
Britain	605	167,000	1,025	352,000
Sweden	58	19,000	117	39,000
Italy	–	–	110	37,000
Singapore	–	–	96	31,000
Other countries	72	37,000	36	38,000
Total	6,619	2,228,000	5,772	2,284,000
Zinc and alloy scrap, dross and ash (gross weight)				
United States	4,095	676,000	6,319	1,017,000
Belgium and Luxembourg	1,253	87,000	1,710	118,000
Britain	434	48,000	429	29,000
Netherlands	311	16,000	219	24,000
Spain	–	–	85	11,000
Italy	–	–	58	12,000
Other countries	165	17,000	–	–
Total	6,258	844,000	8,820	1,211,000
Imports				
In ores and concentrates	128	12,000	60	5,000
Dust and granules	1,061	411,000	1,312	540,000
Slabs, blocks, pigs and anodes	1,518	315,000	772	177,000
Bars, rods, plates, strip and sheet	567	378,000	564	381,000
Slugs, discs, shells	163	70,000	56	27,000
Zinc oxide	1,648	524,000	2,559	900,000
Zinc sulphate	2,381	281,000	2,594	319,000
Lithopone	404	53,000	–	–
Zinc fabricated material n.e.s.	578	684,000	740	887,000
Total	8,448	2,728,000	8,657	3,236,000

	1968			1969P		
	Primary	Secondary	Total	Primary	Secondary	Total
Consumption						
Zinc used for, or in, the manufacture of:						
Copper alloys (brass, bronze, etc.)	15,303	..	..	16,369	..	..
Galvanizing						
electro	1,154	..	..	911	..	..
hot-dip	49,336	..	..	46,099	..	..
Zinc die-cast alloy	29,880	..	..	32,268	..	..
Other products (including rolled and ribbon zinc, zinc oxide)	20,305	1,902	22,207	23,034	2,016	25,050
Total	115,978	2,603	118,581	118,681	2,736	121,417
Consumers stocks on hand at end of year	10,035	723	10,758	12,698	435	13,133

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.
PPreliminary; .. not available for publication; – nil; n.e.s. Not elsewhere specified; ... Less than $1,000.

TABLE 2

Principal Zinc Mines in Canada 1969 and (1968)

Company and Location	Mill or Mine Capacity (tons ore/day)	Grade of Ore				Ore Produced (tons)	Contained Zinc Produced (tons)	Remarks
		Zinc (%)	Lead (%)	Copper (%)	Silver (oz /ton)			
NEWFOUNDLAND								
American Smelting and Refining Company, Buchans	1,250 (1,250)	12.78 (12.83)	7.07 (7.14)	1.12 (1.11)	4.01 (3.93)	371,000 (378,000)	43,272 (45,322)	Normal operations.
NOVA SCOTIA								
Dresser Minerals, Division of Dresser Industries, Inc., Walton	125 (125)	0.58 (0.26)	5.50 (3.80)	0.28 (0.40)	5.50 (7.10)	49,870 (49,786)	153 . .	Normal operations. Planning to explore lower levels.
NEW BRUNSWICK								
Brunswick Mining and Smelting Corporation Limited, Bathurst No. 6 Mine	2,500 (2,500)	5.78 (5.66)	2.28 (2.47)	0.35 (0.35)	1.87 (1.53)	1,134,224 (984,280)	51,257 (41,185)	New jaw crusher being installed at open pit.
No. 12 Mine	5,000 (5,000)	8.05 (8.56)	3.04 (3.38)	0.33 (0.27)	2.13 (1.92)	1,696,408 (1,724,465)	100,085 (112,057)	Developing new stoping areas above 1,550 level.
Heath Steele Mines Limited, Newcastle	3,000 (1,600)	4.00 (4.89)	1.33 (1.55)	1.46 (1.19)	1.71 . .	321,403 (391,363)	7,809 (14,492)	Mill capacity expanded. Milling interrupted for 5 months for equipment installation.
Nigadoo River Mines Limited, Robertville	1,000 (1,000)	. . (2.44)	. . (2.46)	. . (0.32)	. . (3.33)	. . (284,867)	. . (5,158)	Normal operations.
QUEBEC								
Bell Allard Mines Limited, Matagami	370 (370) (Ore trucked to Orchan mill)	8.50 (10.16)	– –	0.88 (1.72)	0.95 (0.98)	97,354 (98,037)	7,353 (8,598)	Production temporarily suspended at the end of September.

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
Delbridge Mines Limited,	500	10.30	–	0.70	3.25	57,494	4,575	Started production in
Noranda	–	–	–	–	–	–	–	October. May start
	(ore trucked to Quemont mill)							exploring at depth.
Lake Dufault Mines, Limited,	1,300	2.21	–	1.71	0.77	405,790	6,125	Reserves declining at main
Noranda	(1,300)	(3.94)	–	(2.03)	(1.24)	(415,009)	(12,306)	mine. Development of new mine 3 miles south of mill progressing favourably.
Manitou-Barvue Mines	500	..	..	–	..	..	..	Exploration to east continuing.
Limited, Val d'Or	(500)	(2.21)	(0.07)	–	(0.81)	(181,250)	(3,561)	
	800			..	..	..	–	Copper circuit. Milling copper
	(800)	–	–	(0.82)	(0.14)	(285,160)	–	ore extended to fall of 1970. Will then handle custom ore from Louvem.
Mattagami Lake Mines Limited,	3,850	9.60	–	0.62	1.02	1,413,651	122,276	Exploration of low grade
Matagami	(3,850)	(10.00)	–	(0.58)	(0.80)	(1,363,705)	(124,739)	Cu-Ni deposit on north side of No. 1 orebody being conducted underground.
Mines de Poirier inc.,	2,500	..	–	1.98	..	521,886	991	Mining of zinc ores suspended
Joutel	(2,500)	(2.10)	–	(1.50)	..	(566,551)	(8,053)	during the year.
	(Mills ore for Joutel Copper Mines)							
New Hosco Mines Limited,	900	1.79	–	0.94	0.33	277,768	3,596	Production expected to cease
Matagami	(900)	(2.50)	–	(1.07)	(0.29)	(327,715)	(5,815)	in first half of 1970.
	(Ore trucked to Orchan mill)							
Normetal Mines Limited,	1,000	6.65	–	1.67	1.48	355,495	20,566	Reserves expected to be
Normetal	(1,000)	(7.33)	–	(1.48)	(1.79)	(358,557)	(23,406)	exhausted in 1972.
Orchan Mines Limited,	1,900	11.53	–	1.04	1.09	308,732	32,403	Will install onstream x-ray
Matagami	(1,900)	(10.62)	–	(1.19)	(0.98)	(269,084)	(25,712)	analyser in mill.
	(Mills ore for Bell Allard and New Hosco)							

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
Quemont Mines Limited, Noranda	2,300 (2,300) (Mills ore for Delbridge)	1.96 (2.09)	– –	0.78 (0.83)	0.74 (0.79)	334,432 (429,309)	5,112 (6,779)	Reserves expected to be exhausted in 1971.
Sullivan Mining Group Ltd., Stratford Centre	1,500 (1,500)							
Cupra Division (formerly Cupra Mines Ltd.)		3.38 (3.75)	0.47 (0.47)	2.52 (2.81)	1.07 (1.21)	246,009 (225,702)	7,749 (6,298)	Developing new parallel ore shoot.
Solbec Division (formerly Solbec Copper Mines, Ltd.)		4.21 (4.59)	0.96 (0.87)	1.07 (1.30)	2.09 (1.85)	185,288 (262,076)	7,014 (9,813)	Ore reserves expected to be exhausted by late 1970. Mine on salvage basis.
ONTARIO								
Big Nama Creek Mines Limited, Manitouwadge	350 .. (Ore trucked to Willroy mill)	3.90 (5.08)	0.09 (0.11)	0.88 (0.87)	1.08 (1.21)	57,472 (10,655)	1,917 (424) -	Development ore milled in 1968 and 1969. Regular production to start early in 1970.
Canadian Jamieson Mines Limited, Timmins	450 (450)	4.40 (4.49)	– –	2.50 (2.86)	.. ..	196,140 (165,526)	6,551 (5,364)	Reserves declining. Continuing underground diamond drilling.
Ecstall Mining Limited, Timmins	9,000 (9,000)	.. (9.55)	.. (0.50)	.. (1.57)	.. (5.19)	3,617,226 (3,614,860)	307,885 (305,747)	Started inclined ramp and vertical shaft for underground mining.
Jameland Mines Limited, Timmins	700 (Ore trucked to Kam-Kotia mill)	0.25 –	– –	1.38 –	.. –	26,931 –	.. –	Production of mainly copper ore commenced in November.
Kam-Kotia Mines Limited, Timmins	2,600 (2,500) (Mills Jameland ore)	3.22 (3.37)	– –	1.21 (1.37)	.. (0.20)	817,716 (669,400)	15,625 (15,650)	Extensive exploration program underway.

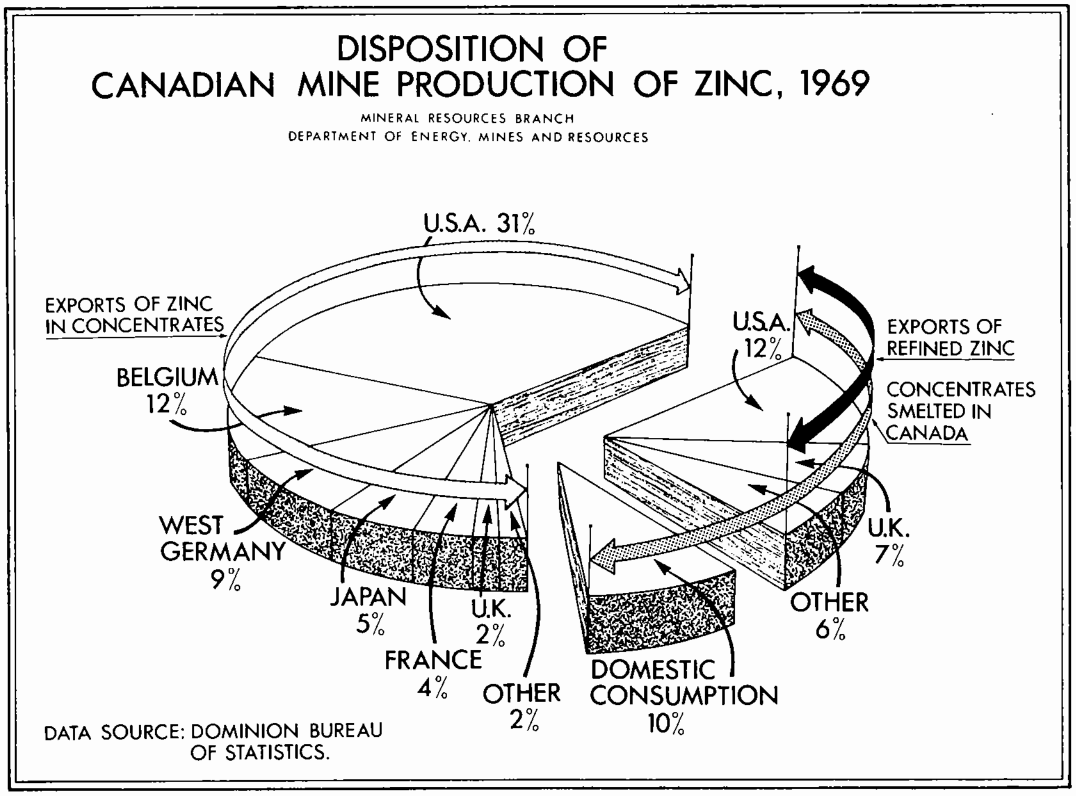
TABLE 2 (Cont'd)

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
Noranda Mines Limited,	4,000	4.90	..	2.48	2.34	1,320,000	51,440	Mill capacity to be expanded
Geco Division,	(4,000)	(4.67)	..	(2.18)	(2.20)	(1,495,369)	(54,753)	in 1970. Labour strike
Manitouwadge								started November 22.
Willecho Mines Limited,	(Ore trucked to	4.06	0.26	0.44	2.13	318,149	11,035	Incline driven to develop ore
Manitouwadge	Willroy mill)	(3.43)	(0.26)	(0.44)	(2.15)	(346,444)	(9,354)	below bottom level.
Willroy Mines Limited,	1,700	2.38	0.06	0.91	0.61	127,300	2,605	Normal operations.
Manitouwadge	(1,700)	..	..	..	..	..	(2,909)	
	(Mills ore from Big Nama Creek and Willecho)							
Zenmac Metal Mines Limited,	200	13.24	–	..	..	35,283	4,313	Mine on a salvage basis.
Schreiber	(200)	(17.30)	–	(0.30)	..	(47,329)	(7,488)	
MANITOBA AND SASKATCHEWAN								
Hudson Bay Mining and								
Smelting Co., Limited,	6,000	4.30	0.20	2.70	0.60	1,702,000	67,069	Normal operations.
Flin Flon and Snow Lake	(6,000)	(5.00)	(0.30)	(2.80)	(0.70)	(1,610,000)	(73,300)	
Flin Flon area								
Flin Flon Mine,		3.30	–	1.70	0.80	622,400		
Schist Lake Mine,		5.50	–	4.20	0.90	122,600		
Flexar Mine,		0.60	–	4.00	0.10	93,400		Started production April 1.
Snow Lake area								
Osborne Lake Mine		1.50	–	4.30	–	376,100		
Chisel Lake Mine		13.70	0.40	0.70	0.80	282,400		
Stall Lake Mine		0.60	–	4.10	0.60	204,100		
Western Nuclear Mines, Ltd.,	350	10.42	6.01	0.57	..	59,718	5,361	Ore reserves exhausted. Mine
Hanson Lake	(350)	(10.89)	(6.32)	(0.48)	(2.89)	(60,789)	(4,596)	closed down in July.
BRITISH COLUMBIA								
Anaconda Britannia Mines Ltd.,	3,000	0.17	–	1.18	..	605,273	267	Developing new orebody
Britannia Beach	(3,000)	(0.33)	–	(1.12)	..	(604,676)	(1,182)	called 040 zone.

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
Canadian Exploration, Limited, Salmo	1,900 (1,900)	2.76 (3.23)	1.01 (1.44)	– –	0.05 –	517,648 (506,220)	13,162 (14,638)	Reserves declining. Production expected to end late 1970 or early 1971.
Cominco Ltd., Sullivan Mine, Kimberley	10,000 (10,000)	. . . .	. . . .	– –	. . . .	2,157,522 (2,155,749)	87,141 (71,169)	Normal operations.
Bluebell Mine, Riondel	700 (700)	. . . .	. . . .	– –	. . . .	230,956 (251,497)	11,674 . .	Normal operations.
Mastodon-Highland Bell Mines Limited, Beaverdell	115 (115)	0.90 (0.72)	0.80 (0.80)	– –	13.74 (15.45)	37,120 (36,413)	346 (262)	Normal operations.
Reeves MacDonald Mines Limited, Remac	1,200 (1,200)	4.69 (3.68)	1.43 (1.11)	– –	. . . .	201,215 (309,311)	8,728 (10,530)	Shaft at Annex mine completed and development underway.
Western Mines Limited, Buttle Lake, V.I.	1,000 (1,000)	. . (9.26)	. . (0.89)	. . (1.89)	. . (2.15)	. . (330,223)	. . (25,659)	
YUKON TERRITORY								
Anvil Mining Corporation Limited, Faro	5,500 –	5.60 –	3.50 –	 –	 –	 –	15,153 –	Milling commenced in September. Construction underway to expand production to 6,600 tons a day.
United Keno Hill Mines Limited, Elsa	500 (500)	4.67 (5.55)	4.56 (6.53)	– –	27.98 (33.93)	87,483 (60,800)	3,923 (3,106)	Ore came from Hector-Calumet, Elsa and Sadie-Ladue. Development continuing at Husky. No Cash to be reopened.
NORTHWEST TERRITORIES								
Pine Point Mines Limited, Pine Point	8,000 (5,000)	. . (6.60)	. . (3.50)	– –	. . . .	3,604,980 (2,138,000)	246,001 . .	New 3,000-ton mill for Pyramid (Sphinx mine) ore started in January. Sales of direct shipping ore ended in 1969.

– Nil; . . Not available.



CANADIAN SUPPLY AND DEMAND

MINE PRODUCTION

Five new zinc-producing mines began operations during 1969 and one was terminated. In Quebec, Delbridge Mines Limited, in which Falconbridge Nickel Mines, Limited has the controlling interest, started shipping ore from the former D'Eldona property to the Quemont mill for concentrating. Copper concentrates will be smelted at the Noranda smelter and zinc concentrates will be sold through the Noranda Sales organization. Jameland Mines Limited, owned by Dickenson Mines Limited and Kam-Kotia Mines Limited, went into production at its Timmins, Ontario property. Ore is trucked to the Kam-Kotia mill; the copper concentrates are sent to the Noranda smelter and the zinc concentrates to Port Maitland, Ontario or the United States. Hudson Bay Mining and Smelting Co., Limited opened up the Flexar mine in Saskatchewan during 1969, although this is primarily a low tonnage, high grade copper mine. In the Yukon Territory, Anvil Mining Corporation Limited, owned by Cyprus Mines Corporation and Dynasty Explorations Limited, started its 5,500-ton-a-day mill on schedule in September. Zinc and lead concentrates are shipped to Japan for smelting. Work is already under way to expand the milling rate to 6,600 tons a day to produce 90,000 tons a year of bulk zinc-lead concentrate for sale in West Germany. Pine Point Mines Limited, in the Northwest Territories, started operating its 3,000-ton-a-day mill addition in January on ore from the new Sphinx mine (formerly known as the Pyramid orebody). Western Nuclear Mines, Ltd., closed down its Hanson Lake, Saskatchewan, operation in July when reserves were exhausted.

In New Brunswick, Heath Steele Mines Limited temporarily stopped milling for about five months while modifications were made that would permit milling at 3,000 tons a day. Operations resumed at this new rate late in the year. Manitou-Barvue Mines Limited, near Val-d'Or in Quebec, has announced it will expand the capacity of its zinc milling circuit from 500 to 800 tons a day by mid-1970. Milling of copper ore from its own mine will be phased out during 1970 and by the fall it is expected to be treating copper-zinc ore from the nearby property of Louvem Mining Company Inc. on a custom basis. In

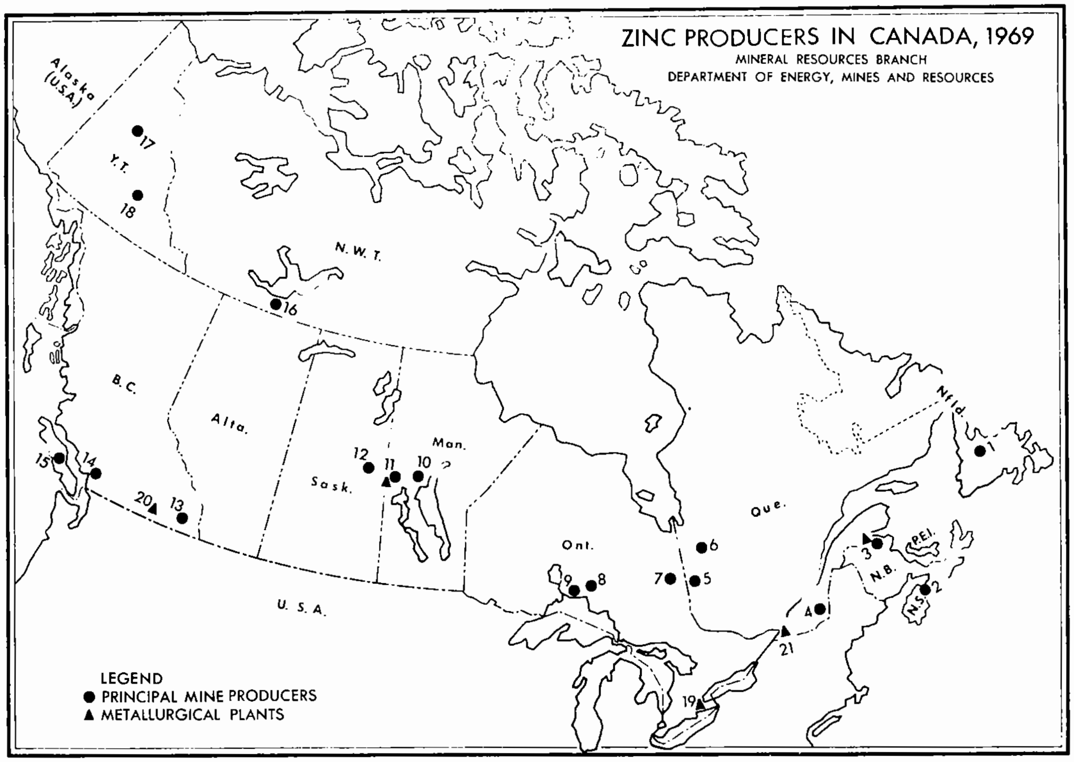
TABLE 3

Prospective* Zinc Producing Mines

Company and Location	Year Production Expected	Mill or Mine Capacity (tons ore/day)	Indicated Ore Reserves (Tons)	Grade of Ore: Zinc (%)	Grade of Ore: Lead (%)	Grade of Ore: Copper (%)	Grade of Ore: Silver (oz /ton)	Remarks
QUEBEC								
D'Estrie Mining Company Ltd., Stratford Centre	1970	. .	380,000	3.41	0.66	3.03	1.05	Mine being developed from Cupra workings. Ore will be treated in Cupra mill.
Louvem Mining Company Inc., Louvicourt Twp.	1970	800	530,000	. .	–	2.60	. .	Open-pit production expected by July. Ore to be trucked to Manitou-Barvue mill. Shaft to be sunk to 1,000 feet.
Weedon Mines Ltd., Stratford Centre	1970	500	345,000	0.50	. .	1.74	. .	Old incline shaft deepened to 2,132 feet. Ore to be trucked to Cupra mill.
ONTARIO								
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								
Anderson Lake mine	1971	1,000	1,781,000	. .	–	3.79	0.17	
Dickstone mine	1971	. .	575,200	3.20	–	2.53	–	
Sherritt Gordon Mines, Limited, Lynn Lake, Fox Lake mine	1970	3,000	12,269,000	2.35	. .	1.74	. .	
BRITISH COLUMBIA								
Copperline Mines Ltd., Golden	1970	500	900,000	3.75	3.06	–	4.30	Property owned by Columbia River Mines Ltd.
YUKON TERRITORY								
Venus Mines Ltd., Carcross	1970	300	75,470	1.67	2.58	–	11.55	Reserves being recalculated. Ore is reported to contain 0.39 oz. gold per ton and 0.09 per cent cadmium.

*Those with announced production plans.

– Nil; . . Not available.



ZINC PRODUCERS IN CANADA, 1969
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES

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
   Mines de Poirier inc.
   New Hosco Mines Limited
   Orchan Mines Limited
7. Canadian Jamieson Mines Limited
   Ecstall Mining Limited
   Jameland Mines 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
11. Hudson Bay Mining and Smelting Co., Limited
    Flexar, Flin Flon, Schist Lake
12. Western Nuclear Mines, Ltd.
13. Canadian Exploration, Limited
    Cominco Ltd. – 2 mines: Sullivan, Bluebell
    Mastodon-Highland Bell Mines Limited
    Reeves MacDonald Mines Limited
14. Anaconda Britannia Mines Ltd.
15. Western Mines Limited
16. Pine Point Mines Limited
17. United Keno Hill Mines Limited
18. Anvil Mining Corporation Limited

METALLURGICAL PLANTS

3. East Coast Smelting and Chemical Company Limited, Belledune
21. Canadian Electrolytic Zinc Limited, Valleyfield
19. Sherbrooke Metallurgical Company Limited, Port Maitland (Roasting plant only)
11. Hudson Bay Mining and Smelting Co., Limited, Flin Flon
20. Cominco Ltd., Trail

TABLE 4

Indicated Zinc Deposits Under Exploration

Company and Location	Indicated Ore Tonnage (tons)	Grade of Ore: Zinc (%)	Grade of Ore: Lead (%)	Grade of Ore: Copper (%)	Grade of Ore: Silver (oz/ton)	Remarks
NEWFOUNDLAND						
American Smelting and Refining Company, Tulk's Pond	..	..	..	..	..	Exploration continuing.
Newfoundland Zinc Mines Limited, Daniel's Harbour	5,400,000	7.70	..	..	..	Property optioned to Cominco Ltd.
NEW BRUNSWICK						
The Anaconda Company (Canada) Ltd. Bathurst, Caribou property	50,000,000	..	..	..	..	Production of copper ore to start late 1970. Pilot mill to test lead-zinc zone to be built.
Chester Mines Limited, Newcastle	4,300,000 3,800,000	0.89 ..	0.36 ..	0.75 1.58	.. ..	Ore available for open-pit mining. Ore available for underground mining.
Key Anacon Mines Limited, Bathurst	1,800,000	7.43	3.03	0.20	2.67	Mine partially developed. Awaiting financing.
Teck Corporation Limited, Portage Lakes area Restigouche property	3,270,000	5.90	4.60	..	2.50	Negotiations underway to bring property into production.
Texas Gulf Sulphur Company, Half Mile Lake property	..	..	..	..	..	
ONTARIO						
Mattagami Lake Mines Limited, Sturgeon Lake area	10-15,000,000	..	..	..	..	Discovered late in 1969. Exploration continuing.
MANITOBA						
Copper-Man Mines Limited, Wekusko Lake	250,000	4.40	..	2.50	..	Western Nuclear Mines carrying on exploration.
Hudson Bay Mining and Smelting Co., Limited,						
White Lake mine	352,500	6.20	0.50	2.22	1.12	Exploration continuing.
Ghost Lake mine	261,000	11.60	0.70	1.42	1.14	
Wim mine	1,000,000	..	..	3.00	..	

TABLE 4 (Cont'd)

Company and Location	Indicated Ore Tonnage (tons)	Grade of Ore Zinc (%)	Lead (%)	Copper (%)	Silver (oz/ton)	Remarks
Sherritt Gordon Mines, Limited, Ruttan Lake	12,900,000	2.61	–	1.44	..	Discovered in 1969. Production studies under way.
Stall Lake Mines Limited, Snow Lake	629,400	2.15	..	4.76	..	Falconbridge Nickel Mines is joint owner of this property.
SASKATCHEWAN						
Bison Petroleum & Minerals Limited, Brabant Lake	3,750,000	5.75	..	0.77	..	
Western Nuclear Mines, Ltd., Quandt group, Hanson Lake area	900,000	1.77	..	2.16	0.20	Exploration continuing.
YUKON TERRITORY						
Hudson Bay Mining and Smelting Co., Limited, Tom deposit MacMillan Pass	10,470,000	5.00	..	–	..	Adit being driven for detailed information.
Kerr Addison Mines Limited, Swim Lake deposit, Vangorda Creek	5,000,000	9.50 (Pb & Zn)		..	1.50	Exploration continuing.
Vangorda Mines Limited, Vangorda Creek	9,400,000	4.96	3.18	0.27	1.76	Feasibility study being updated.
NORTHWEST TERRITORIES						
Buffalo River Exploration Limited, Pine Point	1,350,000	9.60	3.40	–	..	Production plans being considered.
Coronet Mines Ltd., Pine Point	1,100,000	13.20 (Pb & Zn)		–	..	Exploration continuing.
Texas Gulf Sulphur Company, Strathcona Sound	..	..	..	..	..	Underground exploration carried out. Work will continue.

– Nil; . . Not available.

the Eastern Townships of Quebec, the Sullivan Mining Group Ltd. expects that ore at its Solbec mine will be exhausted late in 1970. Milling operations are expected to be maintained by starting production from the D'Estrie mine, which adjoins the producing Cupra mine and is being developed from the Cupra. A former mine in the same area, the Weedon mine, is being re-opened underground by the Sullivan Group and is also expected to supply mill feed in 1970.

In Ontario, operations at the Geco Division of Noranda Mines Limited, at Manitouwadge, were halted by a strike on November 21 that was still in effect at the end of the year. Ecstall Mining Limited started work on a shaft and inclined ramp to prepare their Timmins area mine for underground production.

South Bay Mines Limited, a subsidiary of Selection Trust Limited of London, England, announced plans to bring its Uchi Lake property into production in 1971.

Hudson Bay Mining and Smelting Co., Limited continued its long-range plan of maintaining its operation by developing satellite mines in the Flin Flon-Snow Lake areas. Operations at the Sullivan and Bluebell mines of Cominco Ltd. in British Columbia were normal. Production at Reeves MacDonald Mines Limited was down somewhat due to decreasing production and reserves from the older workings. Development of the new Annex mine proceeded during the year and it is expected that ore from this source will be increasingly available in 1970.

Some of the most promising zinc properties that are currently being explored are listed in Table 4. It is from these properties that new producers will come in 1972 and beyond.

METAL PRODUCTION

Production of refined zinc at the four Canadian zinc plants in 1969 was as follows:

	Refined Zinc (short tons)*	Annual Capacity (short tons)
Canadian Electrolytic Zinc Limited, Valleyfield, Quebec	129,300	140,000
Cominco Ltd. Trail, B.C.	225,054	263,000
East Coast Smelting and Chemical Company Limited	28,776	42,000
Belledune, N.B.	3,500**	
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Man.	79,711	79,000
	466,341	524,000

*From annual reports.

**Non-refined I.S.F. zinc shipped.

Production during 1969 was about 89 per cent of rated capacity compared with 81 per cent in 1968. Operations at the three electrolytic zinc plants were normal throughout the year. Canadian Electrolytic Zinc Limited (C.E.Z.) at Valleyfield, Quebec treated concentrates from mines in Quebec and Ontario, mainly Noranda's Geco mine, and Mattagami Lake, Orchan, Bell Allard, and New Hosco mines. The plant of Cominco Ltd. at Trail, B.C., largest in the world, treated concentrates from Cominco's own Sullivan and Bluebell mines, along with concentrates from Pine Point, Mastodon-Highland Bell and other mines in British Columbia. Concentrates for the Hudson Bay Mining and Smelting Co., Limited plant at Flin Flon, Manitoba came mainly from Hudson Bay's own mines, but were augmented by concentrates from Western Nuclear Mines, Ltd. and other sources. The Imperial Smelting Furnace (I.S.F.) of East Coast Smelting and Chemical Company Limited at Belledune, New Brunswick, a wholly-owned subsidiary of Brunswick Mining and Smelting Corporation Limited, continued to respond to improvements in design and operating techniques. In addition to the 28,776 tons of refined zinc turned out by East Coast, 3,500 tons of unrefined zinc, called I.S.F. Zinc, was sold. This material was blast furnace product and could not be classified as Prime Western Zinc. Only concentrates from Brunswick Mining and Smelting are treated by East Coast.

TABLE 5

Canadian Mine Output, 1968-69

	1968	1969p
	s.t.	s.t.
Newfoundland	44,667	42,945
Nova Scotia	146	244
New Brunswick	172,930	167,387
Quebec	238,294	221,986
Ontario	388,605	400,923
Manitoba-Saskatchewan	77,099	71,829
British Columbia	136,555	146,831
Yukon Territory	3,107	20,928
Northwest Territories	223,739	250,447
Total	1,285,142	1,323,520

Source: Dominion Bureau of Statistics.
pPreliminary.

CONSUMPTION

A comparison of consumption statistics between 1968 and 1969 shows that the amount of primary zinc used in copper alloys increased by 7 per cent, in diecastings by 8 per cent and in 'other products' by 13 per cent. Consumption in electro-galvanizing declined by 21 per cent, and in hot-dip galvanizing by 7 per cent. The use of secondary zinc rose by 5 per cent.

TABLE 6

Canada, Zinc, Production, Exports and Consumption, 1960-69
(short tons)

	Production		Exports			
	All Forms[1]	Refined[2]	In ores and concentrates	Refined	Total	Consumption[3]
1960	406,873	260,968	169,894	207,091	376,985	55,803
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
1969p	1,199,889	466,351	804,664	307,394	1,112,058	118,681

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.

pPreliminary; rRevised.

In general, the usage of zinc by Canadian industry has fluctuated to increasingly higher levels during the past few years. This trend should continue. Decreased automobile production in 1970 may result in less demand for Special High Grade zinc used in die-castings.

TABLE 7

Canada, Producers Domestic Shipments of Refined Zinc, 1968-69
(short tons)

	1968	1969
1st quarter	29,918	37,787
2nd quarter	39,158	33,765
3rd quarter	24,342	27,362
4th quarter	31,512	28,358
Total	124,930	127,272

Source: Dominion Bureau of Statistics.

WORLD SUPPLY AND DEMAND

MINE PRODUCTION

Zinc mines throughout the non-communist world enjoyed a sellers market in 1969 for their ores and concentrates. This condition should ease during 1970 as smelters adjust their production of metal to meet consumption.

TABLE 8

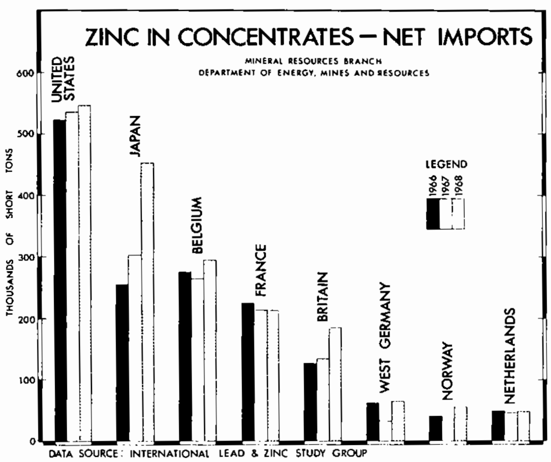
World Mine Production of Zinc, 1968-69
(excluding communist-bloc countries)
(short tons)

	1968	1969p
Canada	1,285,142	1,323,520
United States	581,800	596,500
Australia	422,800	511,000
Peru	334,300	400,000e
Japan	291,300	297,400
Mexico	262,900	269,300e
West Germany	147,900	151,700
Italy	154,400	146,800
Dem. Republic of the Congo (Kinshasa)	131,500	..
Sweden	83,400	94,100
Spain	83,400	91,500
Yugoslavia	121,700	..
Zambia	74,100	..
Argentina	28,900	29,900e
Other countries	402,000	..
Total	4,405,542	4,697,520

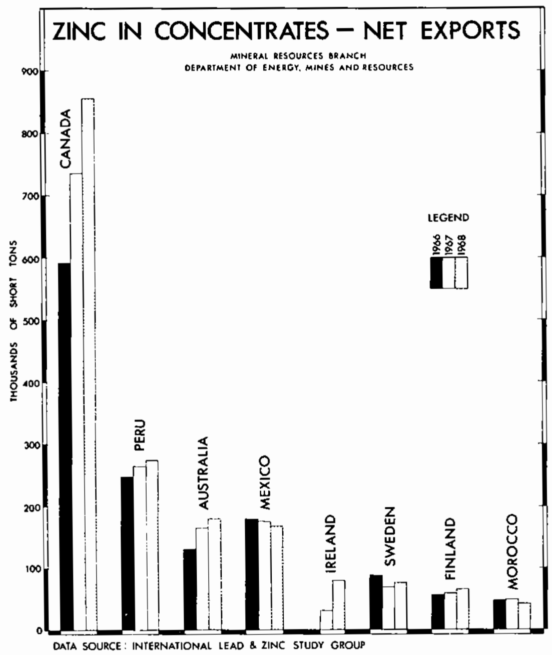
Source: International Lead and Zinc Study Group, March 1970. For Canada, compilation by Mineral Resources Branch from Dominion Bureau of Statistics source data.

pPreliminary; eEstimated; .. Not available.

A perusal of the graph on page 18 will clearly point up the odd relationship anticipated between smelter capacity and mine production. Normally, these two lines should be almost coincidental (assuming that scrap input balances zinc oxide produced directly from concentrates). Smelters operate at something less than true capacity, usually at 85 to 95 per cent, because of breakdowns, labour strikes and other causes. At the same time, only about 90 per cent of the zinc contained in concentrates is recovered as metal, due to metallurgical losses in the smelters. When smelter capacity is consistently above mine production it means that some smelters are not operating at an optimum level. The graph shows this condition has existed since 1966, due initially to voluntary cutbacks in production to match demand. It will spread to an unprecedented proportion by 1972 because of new smelter construction. Custom smelters throughout the world recognized this fact during 1969 and started a scramble for available mid-term (two to three years) supply of concentrates that caused the sellers market mentioned earlier.



Mine production has grown from 2.7 million tons of zinc in 1959 to 4.7 million tons in 1969, a rise of 75 per cent over the ten-year period, or 5¾ per cent compounded annually. The United States price for Prime Western Zinc has gone from an average of 11.4 cents a pound in 1959 to 14.6 cents in 1969, but in terms of constant 1959 dollars this becomes 11.6 cents in 1969. The price fluctuations in the intervening years have been small. As a result, the real price of zinc has been almost constant over this period. The graph indicates the rate of expansion of mine output will be lower for the years 1971 to 1974, with the total supply falling far short of the amount required for optimum smelter operation. It must therefore be inferred that the price for zinc from 1959 to 1969 was high enough to warrant bringing known or convenient deposits into production, but not high enough to encourage exploration activities at a rate needed to replenish those reserves committed to production.



No major new sources of world mine production of zinc are expected to be brought into production before about 1975, except for one or two Canadian deposits now being explored. There will be a new medium-sized mine (33,000 tons of zinc a year) starting in Peru in 1971, and expansion of the Balmat mine in upper New York State, will net an additional 65,000 tons of zinc in 1971. Minor expansion of some Australian mines is anticipated. By 1975, production might be forthcoming from a new source in Tennessee, owned by The New Jersey Zinc Company, and Mount Isa Mines Ltd. expects to have its Hilton Mine in Queensland, Australia, operating by 1976. Mount Isa reports reserves at the Hilton mine are 35 million tons averaging 9.6 per cent zinc, 7.7 per cent lead and 5.5 ozs of silver per ton; the production rate will be 7,000 tons of ore a day.

METAL PRODUCTION

World smelter capacity rose by 4.5 per cent during 1969 to approximately 4.95 million tons. With output of metal of 4.5 million tons, smelters were operating at 91 per cent of their capacity compared to 85 per cent in 1968 and 83 per cent in 1967. Major changes in smelter capacity from 1969 to 1973 are as follows:

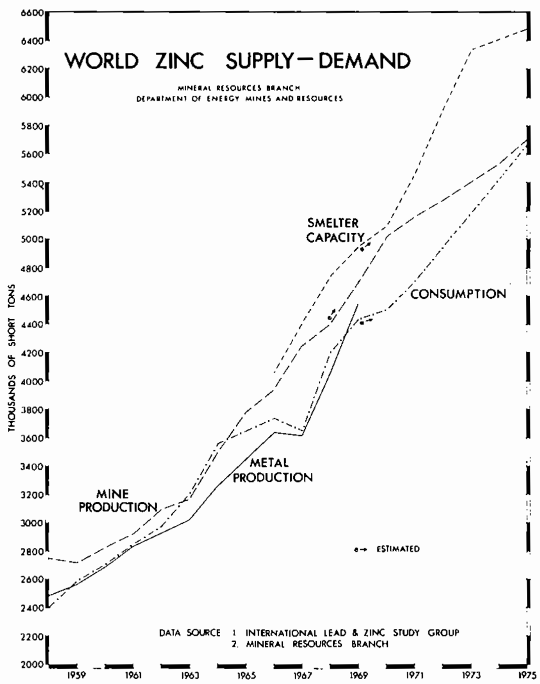
Country	Type	Capacity (tons)
	1969	
Japan	I.S.F. (new)	66,000
South Africa	Electrolytic (new)	33,000
United States	Horizontal Retort (expansion)	15,000
	Horizontal Retort (closed)	−35,000
	Electrolytic (closed)	−90,000
	1970	
Finland	Electrolytic (new)	110,000
Italy	I.S.F. (new)	60,000
Japan	Electrolytic (new)	66,000
	1971	
Argentina	Electrolytic (expansion)	12,000
Brazil	Electrolytic (expansion)	14,000
Japan	Electrolytic (new)	79,000
	Electrolytic (expansion)	50,000
	Horizontal Retort (expansion)	35,000
Norway	Electrolytic (expansion)	20,000
South Africa	Electrolytic (expansion)	20,000
	1972	
Australia	Electrolytic (expansion)	65,000
Algeria	Electrolytic (new)	44,000
Canada	Electrolytic (new)	110,000
Ireland	Electrolytic (new)	60,000
Japan	I.S.F. (expansion)	11,000
	Electrolytic (expansion)	35,000
	Horizontal Retort (closed)	−30,000
	Electrolytic (new)	66,000
Netherlands	Electrolytic (new)	110,000
	Horizontal Retort (closed)	−55,000
West Germany	Electrolytic (new)	100,000
	Horizontal Retort (closed)	−46,000
Yugoslavia	I.S.F. (new)	57,000
	1973	
Mexico	Electrolytic (new)	110,000
Peru	Electrolytic (new)	40,000

Much of this new capacity is being constructed in Japan and Europe, areas that are deficient in ores and concentrates. This trend of building new smelters near the markets, rather than near the source of raw materials or energy, is of concern to countries rich in resources but short on domestic markets, such as Canada, Australia, Peru, Mexico, and some African nations. A similar trend is showing up in other nonferrous sectors, and leads to an interesting study of the current rationale of smelter location.

Any such study must be suited to specific examples, but certain common factors have been changing, and these will be discussed here in general terms.

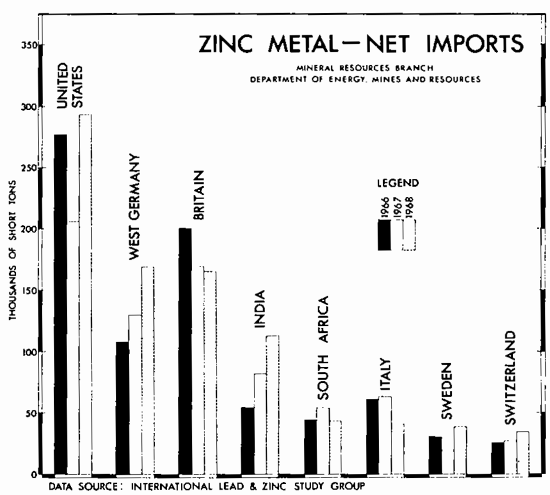
(a) *Transportation.* Large bulk carriers combined with rapid loading and unloading facilities have diminished the transportation cost differential between zinc concentrates and metal to the point where the cost of transportation is a less-important variable than formerly.

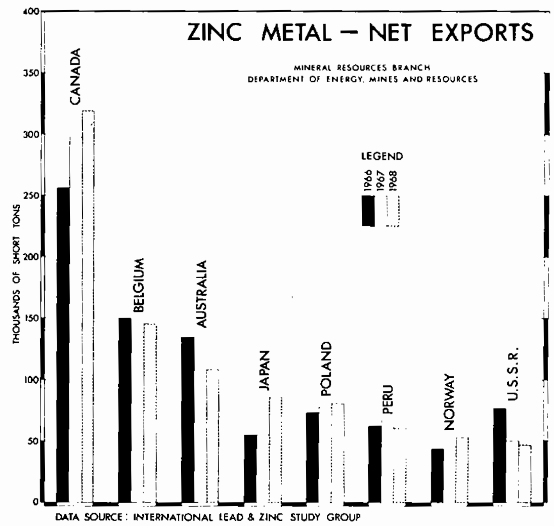
(b) *Smelter size.* Technical and economic developments have dictated an increase in the unit size of zinc smelters. About 60,000 tons of metal production a year is the minimum capacity being considered for initial design, and 100,000 tons is common. Concentrates to feed plants of this size must be assured for 20 to 30 years with an allowance made for possible expansion. This is beyond the capability of many



individual mines, limiting the number of smelters that could be built to serve single mines. A side issue is that the consumption of zinc has increased sufficiently to allow smelters to be sited so as to serve a local market.

(c) *Customer service.* The nonferrous metal industry is introducing processes to allow the transfer of molten metal to nearby casting, galvanizing or rolling plants to save remelting expenses. This can only be done in industrialized areas.





(d) *Energy supply.* As undeveloped hydro-electric power sources become increasingly scarce, new electrolytic zinc plants must depend on electricity from fossil- or atomic-fuelled power stations. The optimum output from such stations is far in excess of what can be consumed by even a 100,000 ton zinc plant. Other base loads are required, obtainable in heavily industrialized areas.

(e) *Incentives.* Governments at the national or municipal level sometimes offer incentives in a variety of ways to encourage industries to locate in their area of jurisdiction.

(f) *Legislation.* Government regulations pertaining to taxes, duties, quotas, pollution and mineral policies are becoming increasingly apparent in smelter location.

(g) *Byproducts.* The main byproduct of zinc smelting is sulphur, usually in the form of suphuric acid. Normally, 2 tons of sulphuric acid are produced for every ton of zinc metal. It is not economic to store sulphuric acid in large quantities or for long periods of time, or to move it long distances. The sulphuric acid is usually used in nearby chemical plants, but its disposal can be a limiting factor on smelter design and operation.

If this line of reasoning is being followed to locate smelter sites, why then, are no smelters being constructed in the United States? The answer appears to be that tax laws, pollution laws, interest rates, and lack of government incentives and pressures do not encourage the construction of new American zinc plants that would have to rely on imported concentrates.

Referring again to the graph on page 18 it can be expected that metal production will be influenced by consumption and availability of concentrates. It is possible that a shortage of concentrates may mean that from 1972 zinc demand may exceed supply and the gap could increase until about 1975-76 when large new mines supplies will be available. The shortfall could be made up by releases from the United States government stockpile, which contains some 580,000 tons of surplus zinc.

Smelter capacity will probably not reach the amounts indicated because: (a) construction of new smelters will either be stretched out or deferred; and (b) older, labour-intensive plants will be retired from service in deference to modern, efficient plants with a large capital debt outstanding.

CONSUMPTION

From 1959 to 1969, world consumption of zinc has grown at an average rate of about 5½ per cent a year. It is likely, however, that this rate may be slowed somewhat in 1970 and 1971 due to measures being taken in North America to combat inflation by causing a slowdown in business activity. This cooling-off of the economy could be repeated in Europe and Japan in 1971, but by 1972 consumption increases of 5 per cent annually may again be anticipated.

In the United States in 1969, about 43 per cent of the slab zinc consumed was used for diecastings, 34 per cent for galvanizing, 13 per cent for brass, 4 per cent for rolled zinc, and the remainder for chemicals, zinc oxide or zinc dust. Not included in these figures is about 120,000 tons of zinc made into zinc oxide directly from concentrates. By comparison, in Europe and Japan, the usage of zinc for diecastings and galvanizing in the auto industry, though growing, has not reached the levels common in North America. Manufacture of brass consumes the most zinc in many European countries, closely followed by galvanizing, diecasting and other uses. In Japan, galvanizing uses 53 per cent of the zinc, followed by diecasting, brass and other uses. Japan follows the United States and Europe in consumption of zinc metal and is perhaps the fastest growing market.

TABLE 9

United States Consumption by End Use, 1968-69
(short tons)

	1968	1969P
Galvanizing	481,817	448,889
Brass products	161,906	175,229
Zinc-base alloy	562,946	557,047
Rolled zinc	48,943	46,917
Zinc oxide	34,937	41,447
Other uses	43,150	42,358
Estimated undistributed consumption	–	51,000
Total	1,333,699	1,362,887

Source: U.S. Bureau of Mines Mineral Industry Surveys, Zinc Industry in December, 1969.
PPreliminary; – Nil.

OUTLOOK

As a summary of some of the observations in this review, it is anticipated that world metal production capability will tend to be concentrated to an ever-increasing extent in large, modern, capital-intensive smelters sited close to markets. For the next five years, it would appear that, with more-than-adequate smelter capacity available, metal production will be controlled by consumption and the availability of mine output, not by the rated capacity of the smelters.

ZINC USES

Zinc, when fresh, is a silver-blue metal that becomes coated with an impervious grey oxide film when exposed to the atmosphere. It has a relatively low melting point, making it a leading metal for diecastings; good resistance to atmospheric corrosion combined with the third-highest place in the galvanic series of metals, resulting in its use in galvanizing; solubility in copper, making possible the manufacture of brass; inherent ductility and mallability, allowing it to be wrought and rolled, and adding these properties to its alloys.

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 in automobiles. Galvanized reinforcing rods are now in use in the construction industry, and galvanized structural members used in bridge construction 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. 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 constituent 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. From research being conducted, improved diecasting alloys are being introduced that will permit smaller castings to be made and speed up the diecasting process. 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

Galvanizing. Work was continued on the fundamental study of the kinetics of the galvanizing process being made at the Mines Branch (Department of Energy, Mines and Resources) with the co-operation of the Canadian Zinc and Lead Research Committee and the International Lead Zinc Research Organization.

Major work was devoted to bringing the hydrogen-atmosphere reaction apparatus to full operational status. This involved numerous trial runs to improve on the operation of various components and functions, to establish a working cycle, to make some preliminary full-scale runs and, more recently, to refine experimental control to the point of eliminating the remaining oxidation contamination of the galvanizing melt. Condensation of zinc vapour in cooler parts of the reaction chamber is an associated problem. Following tests in hand involving hydrogen bubbling of the melt, the best compromise which can be made between the oxidation and condensation problems will be adopted so that work on the formal experimental program can proceed.

A paper entitled, "Electron-Probe Microanalysis of Alloyed Galvanized Coatings", has been submitted for presentation at the Ninth International Galvanizing Conference to be held in Dusseldorf, Germany, in June 1970. This relates to a previously completed phase of the galvanizing research at the Mines Branch.

Zinc Alloy Development. Further experiments on the occurrence of porosity in superplastically-deformed Zn-Al alloys has shown that under the conditions of testing used, a wide range of binary compositions (8-20 per cent Al) show porosity and it is considered that this would be a serious objection to practical applications of this forming method for these alloys.

Two additional wrought, creep-resistant zinc alloys (Cominco 3130 and 3330) have been fatigue tested using the R.R. Moore Type machine and endurance limits have been determined.

A program of work has been started to determine the reason for the large difference in impact strength between wrought and cast Zn-Al alloys. A series of specimens of Zn-12 per cent Al with various amounts of hot work have been prepared to show this effect and the changes in impact properties have been correlated with changes in microstructure.

An attempt has been made to determine the mechanism of expansion of zinc alloys when corrosion tested in wet steam at 95°C (200°F). The results are being assessed.

Work on the effects of lead contamination on the corrosion resistance of cast zinc alloys has been limited to a closer investigation of the effect of lead on the grain size. It has been found that 0.05 per cent Pb results in very coarse, columnar B (Zn-rich) grains in cast Zn-12 per cent Al alloy, but that the effect decreases with decreasing lead content and is virtually absent at 0.005 per cent Pb. It is considered that the grain-coarsening effect may provide clues as to the distribution of lead and possibly its effect on corrosion.

PRICES

The Canadian price of Prime Western Zinc, f.o.b. Toronto and Montreal during 1969 was as follows:

Jan. 1 to Jan. 14	–	13.50 cents per lb
Jan. 15 to Apr. 30	–	14.00 " " "
May 1 to Sept. 3	–	14.50 " " "
Sept. 4 to end of year	–	15.50 " " "

The average for the year was 14.59 cents per lb.

The United States price, Prime Western, East St. Louis was as follows:

Jan. 1 to Jan. 8	–	13.50 cents per lb
Jan. 9 to Apr. 30	–	14.00 " " "
May 1 to Sept. 3	–	14.50 " " "
Sept. 4 to end of year	–	15.50 " " "

The Canadian price used in the calculation of Canada's zinc production was 15.23¢ Canadian.

This was the average Prime Western price plus 0.64 cent and the equivalent of the High Grade price.

The overseas producer basis price, at which Canadian and United States zinc sold outside of North America is priced, remained at the 1968 level of £114.33 a long ton until May 5, when it was raised to £121. A further rise to £130 a long ton occurred on October 8. The London Metal Exchange quotation fluctuated from a low of £112¼ to a high of £136-1/8 a long ton. As of January 1, 1970, the LME will quote its prices in terms of metric tons instead of long tons.

The supply-demand-stock situation during 1970 will probably be such that any price changes that occur will be on the downward side.

TARIFFS

The following Canadian and United States tariffs apply for zinc in its various forms:

CANADA Item No.		British Preferential	Most Favoured Nation	General
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, blocks, 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%
34800-1	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, 1969	15%		
	On and after Jan. 1, 1970	13%		

(Further reductions on this item will occur on Jan. 1, 1971 and on Jan. 1, 1972)

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

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) which is the principal mineral source of these two elements. Canada's use and consumption of imported zirconium metal, zirconium alloys, and zircon mineral concentrates have been increasing but, as yet, no domestic sources of the mineral have been developed.

Canada's imports of zirconium alloys were 208,695 pounds valued at $4.5 million in 1969 compared with 220,165 pounds valued at $6.3 million in 1968, and 125,898 pounds valued at $3.2 million in 1967. The increase in 1968 and 1969 over the 1967 imports was due to delivery 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 an important degree of integration with completion 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 developments. The unique process developed by Eldorado, which 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 foundry moulding, 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 production of baddeleyite (ZrO_2) exceeded Australian production of zircon. Australia's production of zircon concentrates in 1968 was 332,956 tons with a zircon (ZrO_2SiO_2) content of 329,252 tons. Preliminary figures, subject to revision, reported by the Bureau of Mineral Resources, Geology and Geophysics, Canberra, indicate production of about 414,000 tons of zircon concentrates and export of about 358,000 tons in 1968.

The United States is believed to be 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 published but United States imports of zircon concentrates, reported by the Bureau of Mines, were 59,900 tons in 1968 and an estimated 97,000 tons in 1969.

*Mineral Resources Branch.

TABLE 1

Canada, Zirconium Imports, 1968-69

	1968		1969p	
	Pounds	$	Pounds	$
Imports				
Zirconium alloys				
United States	200,692	5,891,000	203,039	4,459,000
Sweden	3,799	98,000	3,575	64,000
Japan	–	–	1,792	5,000
France	15,557	271,000	289	7,000
Italy	117	1,000	–	–
Total	220,165	6,261,000	208,695	4,535,000

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

Japan imported 66,232 tons of zircon concentrates from Australia in 1968, nearly double its supply from that source in 1967. Three Japanese metals firms, Kobe Steel, Sumitomo Metal Industries, and Mitsubishi Metal Mining planned to start or expand production of zirconium alloy cladding tubes to meet the requirements of the several nuclear power installations planned by Japanese utilities.

The Phosphate Development Corporation, a goverment-controlled company mining apatite at Phalaborwa in the Transvaal, Republic of South Africa, began producing byproduct baddeleyite (ZrO_2).

TABLE 2

Australian Zircon Production, 1960-68
(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	317,724r	313,962r
1968	332,956r	329,252

Source: Australian Mineral Industry, Quarterly Review.
rRevised.

TABLE 3

Australian Exports of Zircon Concentrates, 1967-68
(short tons)

	1967	1968
United States	70,870	64,340
Japan	62,704	66,232
Britain	34,627	44,552
Netherlands	23,885	. .
Italy	23,268	. .
France	16,299	28,455
Canada	10,993	. .
Germany (F.R.)	9,755	. .
Spain	6,191	. .
Belgium	4,938	. .
Others	13,310	94,476
Total	276,840	298,055

Source: Australian Mineral Industry, Quarterly Review.
. . Not available at time of publication.

PRODUCTS AND USES

The principal use of zircon is in steel and iron foundry moulds, mould facings and cores, and as milled flour for mould and core washers, especially in the steel foundry production of castings with 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 "
Fe_2O_3	0.15 "
Al_2O_3	0.15 "

Zirconium is used for other refractory applications as zircon sand and as zirconia (ZrO_2), prepared in 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.

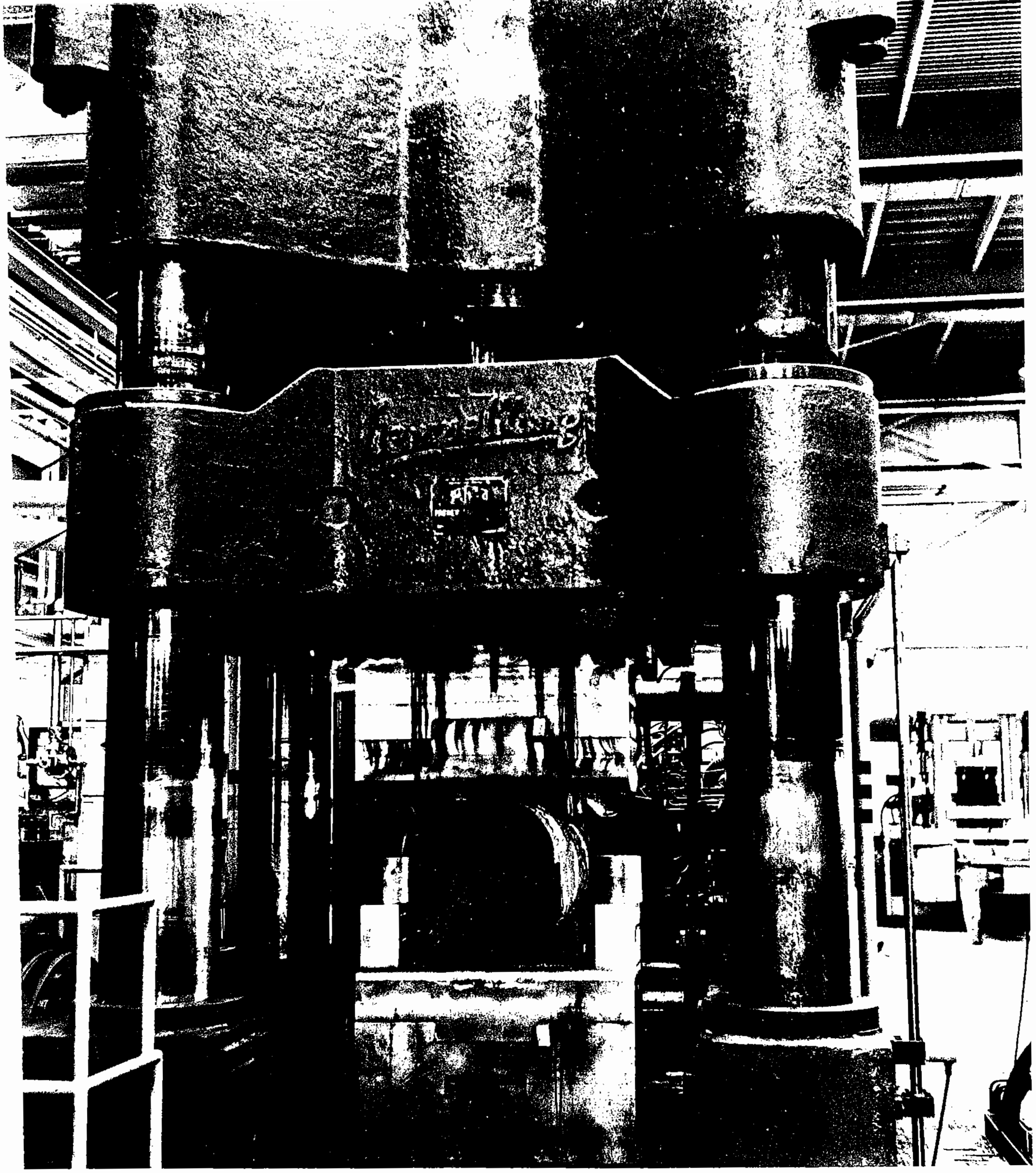
PRICES

	U.S. $ Dec. 1969
Zircon ore[1]	
sand, per long ton, c.i.f. U.S. ports, bags, 65% ZrO_2	70.00
Camden, N.J., bulk, 60% ZrO_2 per short ton	66.50–68.00
Starke, Fla., domestic, bags	56.00–57.00
Zirconium[1]	
per pound, f.o.b. shipping point, sponge, powder, platelets, low hafnium	7.00–14.00
commercial	5.00–10.00
Hafnium[2]	
sponge, per pound	75.00
rolled bar, plate, per pound	120.00

Sources: [1]*Metals Week;* [2]*American Metal Market.*

TARIFFS

Item No.		British Preferential	Most Favoured Nation	General
CANADA				
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, forgings, 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 1/1/69)	free	5%	15%
92845–4	Zirconium silicate (effective 1/1/69)	free	free	free



A RED HOT ZIRCONIUM METAL INGOT weighing approximately 3,500 pounds in Eldorado Nuclear's 2,500 ton forge. The ingot will be forged to billet sizes suitable to fabricators of various sizes of tube or mill products. (Photo courtesy Eldorado Nuclear Limited)

UNITED STATES

601.63	Zirconium ore (including zirconium sand)	free
629.60	Zirconium metal, unwrought, other than alloys, waste and scrap (duty on waste and scrap suspended on or before 6/30/71)	
	On and after Jan. 1, 1969	12%
	" " Jan. 1, 1970	10%
629.62	Zirconium, unwrought alloys	
	On and after Jan. 1, 1969	12%
	" " Jan. 1, 1970	10%
629.65	Zirconium metal, wrought	
	On and after Jan. 1, 1969	14%
	" " Jan. 1, 1970	12.5%
422.80	Zirconium oxide	
	On and after Jan. 1, 1969	8%
	" " Jan. 1, 1970	7%
422.82	Other zirconium compounds	
	On and after Jan. 1, 1969	8%
	" " Jan. 1, 1970	7%

Further tariff reductions on the above zirconium items will occur on Jan. 1, 1971 and Jan. 1, 1972.

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.

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