MINERAL REPORT 14

CANADIAN MINERALS YEARBOOK 1965

MINERAL RESOURCES DIVISION

DEPARTMENT OF ENERGY, MINES AND RESOURCES

OTTAWA

1967

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1967

Foreword

This issue of the **Canadian Minerals Yearbook** describes the Canadian mineral industry in 1965. With the exception of the General Review (an over-all study of the industry) the fifty-nine commodity reviews were issued as separate pamphlets during 1966 to provide advance information to the interested public.

The **Yearbook** is the official annual record of the growth of the mineral industry in Canada and is preceded by similar reports under various titles dating back to 1907 and earlier. Those wishing to refer to earlier reports should consult departmental catalogues.

Most of the basic statistics on Canadian production, trade and consumption were collected by the Dominion Bureau of Statistics. Company data were obtained directly from company officials or from corporate annual reports, combined with information obtained by authors on systematic field trips. Market quotations were mainly from standard marketing reports issued in Montreal, London or New York.

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

W. Keith Buck
Chief
Mineral Resources Division

November 1966.

Editor: V. Donnelly

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Readers wishing more recent information than that contained in the present volume should obtain the 1966 series of preprints: complete set available from the Queen's Printer, $5. Individual copies are available from the Distribution Office, Mineral Resources Division, Department of Energy, Mines and Resources, Ottawa, at 25¢ each.

All photographs by George Hunter, Toronto.

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General Review

This summary of the Canadian mineral industry in 1965 introduces and supplements the mineral industry commodity review series that begin on page 23. The summary includes a brief description of the Canadian economy in 1965 and its behaviour in the past decade and a half. A descriptive analysis of the mineral industry's progress during the year and its performance compared to the economy as a whole forms the main part of the review, which also contains an appraisal of developments in mining technology and new techniques used in exploration and development and a discussion on mineral prices and trade. A summary of the most important events of the year in the mining industry across Canada is included and the review closes with a short section showing both the importance of the mining industry among the primary industries and the growth of the net value of mining compared with total industry in Canada and in the separate provinces.

A statistical summary of the Canadian mining industry is made in tables at the end of the volume.

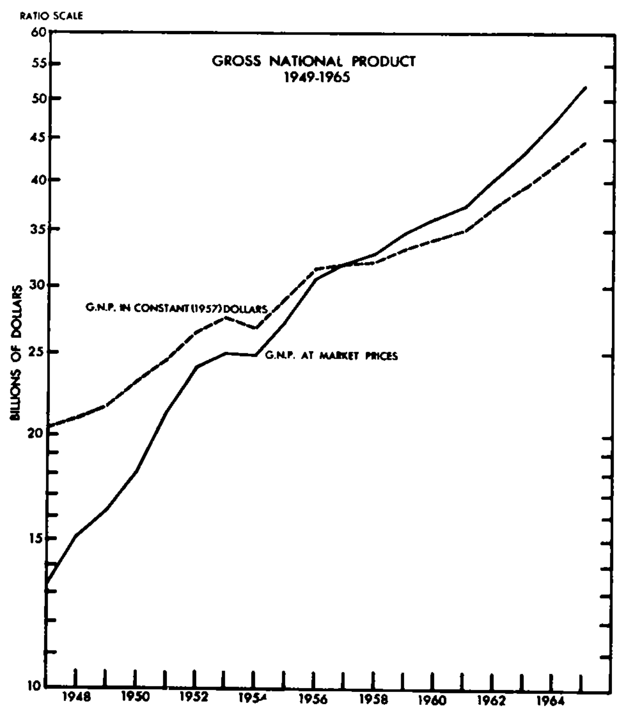

Figure 1

A BRIEF REVIEW OF THE CANADIAN ECONOMY

The economic expansion that started in 1961 continued through 1965. National income, or Gross National Product (GNP), rose 9.7 per cent to a record of $52 billion. Prices increased by about 3 per cent, giving a net gain of 6.7 per cent. This upturn in the economy is the longest in Canada's history and has seen the GNP rise by more than $14 billion in four years, which is 8½ per cent a year in current dollars, or more than 6 per cent in real terms. The changing rate of growth in GNP is shown in Figure 1.

Gross National Expenditure (GNE) is numerically the same as GNP and is divided into five sectors: Personal Expenditures on goods and services, Government Expenditures on goods and services and fixed capital formation, Fixed Capital Formation by Business, Change in Inventories and Net Foreign Trade. Of these sectors the Fixed Capital Formation by Business normally shows the most year-to-year fluctuation, and is most affected by business conditions. Annual fixed capital formation by business* remained virtually unchanged from 1956 to 1962 at about $6.8 billion. This sector may be divided, as in Figure 2, into Non-Residential Construction plus Machinery and Equipment, and New Residential Construction. In 1962

*DBS *National Accounts, Income and Expenditures* (annual).

fixed capital formation in the non-residential construction and machinery sector started to rise and in 1963 it reached $5.4 billion, the level of the previous record that had been attained in 1957. Fixed capital formation in this sector continued to increase rapidly in 1964 and last year grew at more than 16 per cent to reach a total of more than $8.2 billion. This represents an over-all growth rate of more than 12 per cent a year from its level of $5.2 billion in 1961, at the start of general economic upturn. Investment in residential construction increased in 1965, to reach an all-time high of $2.1 billion, but the rate of increase was below the average of 10 per cent a year that the industry has experienced since 1961.

A substantial part of the increase in GNE in 1965 compared with 1964 came from personal expenditures on goods and services, which increased by $2.4 billion, to $32 billion. This was coupled with a rise in the labour force of 3 per cent, from 6.9 million to 7.1 million persons. At the same time there was a fall in the absolute number of unemployed, from .32 million to .28 million. The unemployment rate, at 3.9 per cent, was the lowest for many years. Total labour income in 1965 rose about 11 per cent to $26 million.

The increase in consumer spending led to a sharp increase in imports. At the same time the rate of growth of merchandise exports declined and the result was a virtual balance in the merchandise sector of the current account in the Canadian balance of international payments. This is illustrated in Figure 3. The deficit in the non-merchandise sector of the current account increased by $.13 billion to $1.24 billion: this sector includes international payments by Canadians of travel expenses, interest, dividends, shipping charges, etc. The total deficit on current account

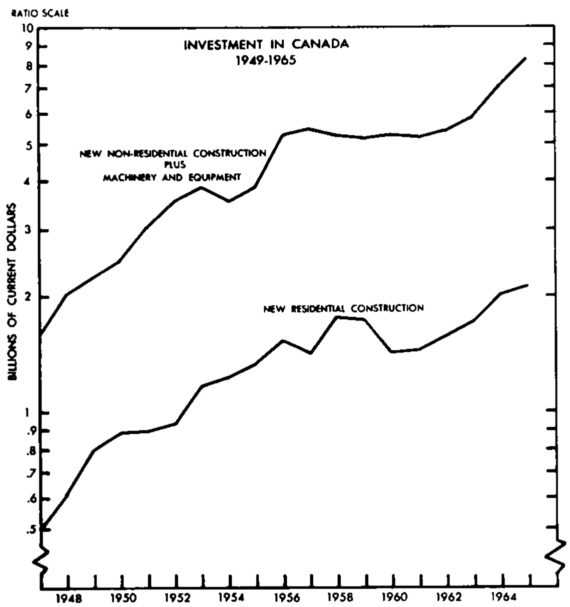

Figure 2

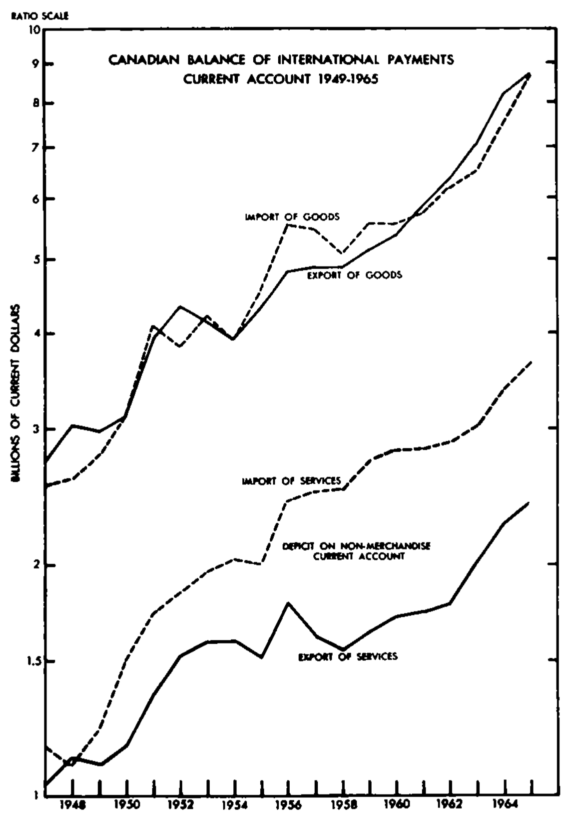

Figure 3

is balanced by a surplus in the capital account.

A REVIEW OF THE MINERAL ECONOMY

Canadian mineral production increased in value by 10.3 per cent in 1965 to set a record of $3,752 million[P].

The mineral industry in 1965 continued the strong advances in each of its three sectors – metallic minerals, industrial minerals and mineral fuels – that have been experienced since the slight decline in 1958. Industry progress was characterized by growth of output both regionally and by commodity, preparation for production of several large mineral projects, the beginning of commercial production from some large projects and expansion of others, and a continuing high rate of success in discovery of mineral deposits of economic importance.

[P] Preliminary.

Each of the three sectors of the industry recorded new production highs with the metallics sector registering the largest increase, advancing 13 per cent to $1,928 million[P]. Industrial minerals production increased 6.8 per cent to $736 million[P] and mineral fuels production increased 8.1 per cent to $1,087 million[P] (Figure 4). The index of physical volume of mineral production increased to over 365 (1949 = 100) from 346 in 1964. The per capita value of mineral production was $191.73[P] compared with $176.14 the previous year.

The relatively large increase in value of metallics output in 1965 was the result of both price and quantity factors. Prices for the major base metals were firm and in some cases higher. Output of iron ore and base metals was high as new facilities started production and some existing facilities were expanded. Marked advances were made in lead with a gain in output value of about 63 per cent, zinc nearly 30 per cent, nickel 15 per cent and copper of nearly 20 per cent. Nickel regained first place from iron ore as Canada's leading metallic mineral. Several copper, copper-zinc and copper-nickel mines started production in 1965 and others were being developed or planned for production. The year heralded Canada's emergence as a major molybdenum-producing country surpassed only by the United States and probably Russia. There was higher output of a number of other metals that are recovered mainly as byproducts of base-metal operations. Output of gold and uranium declined from 1964, a trend that has been in evidence for several years.

[P] Preliminary.

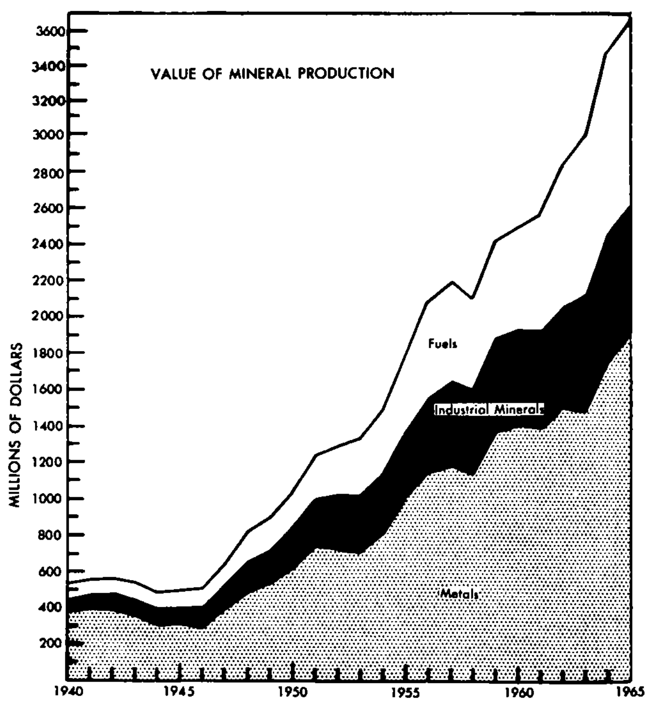

Figure 4

The outstanding development in the industrial mineral sector of the industry again was related to production gains and announced mine development plans for potash production in Saskatchewan. Asbestos output, following five successive years of production records, declined slightly to $140 million. The value of shipments of elemental sulphur recovered from the processing of natural gas, also set a new record at $23.5 million, 26 per cent more than the previous year. The continuing high production of structural materials, which with nonmetallics comprise the industrial minerals sector, kept pace with the high rate of all types of construction. The cement industry continued to expand facilities and to build new plants so that production capacity at the end of 1966 will be 69.3 million barrels a year, 21 per cent above that at the end of 1964. Cement output in 1965 was valued at $145 million to lead all industrial minerals.

Crude petroleum makes up the largest portion of mineral fuel output with value of crude production in 1965 being $725 million, an increase of $51 million from the previous year. Natural gas production of almost 1.5 trillion feet was worth $193 million and liquids recovered from it had a total value of $93 million, both setting new records. Coal production in 1965 was about 11.6 million tons valued at $76 million, a level maintained in recent years by a massive government aid program.

Ontario remained Canada's leading mineral-producing province with output valued at $986 million being 26.4 per cent of the total mineral output. It was followed in order by Alberta with 21.4 per cent, Quebec 18.9, Saskatchewan 8.7, British Columbia 7.5, Newfoundland and Labrador with 5.9 and Manitoba with 4.9 per cent (Figure 5). Ontario's proportion of mineral output to total output continued to decline although it still maintained a substantial lead over Alberta. All provinces increased their mineral output value in 1965 with Ontario, Alberta and Newfoundland and Labrador registering the largest absolute gains.

The value of mineral exports in the crude and fabricated stages amounted to $2,782 million in 1965, an increase of 7.7 per cent over 1964, and accounted for 32.6 per cent of all Canadian exports. Exports of nonferrous metals in the crude and fabricated state accounted for 52 per cent of all mineral exports, nonmetallics, including fuels, accounted for 25 per cent and iron and products accounted for the remainder.

The proportion of mineral exports shipped to the United States was 58.3 per cent. In the separate categories the proportions shipped to the U.S. were: iron and products, 74 per cent; nonmetallics and fuels, 79 per cent; and nonferrous, 41 per cent.

CANADA'S MINERAL PRODUCTION 1965
3,752 MILLION DOLLARS

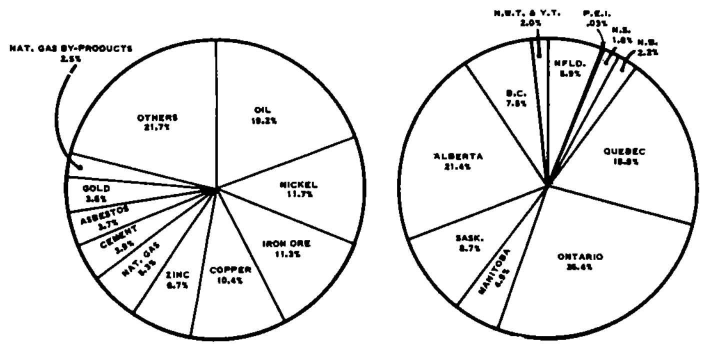

Figure 5

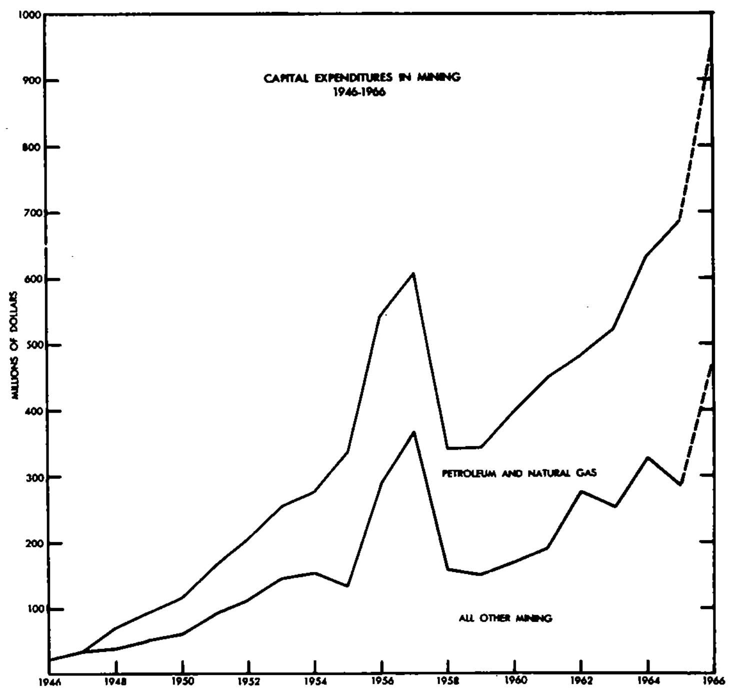

Figure 6

Mineral Production

Figure 1 shows the growth of GNP in the period 1949 to 1965, and Figure 5 shows the growth of mineral production. During the period the population of Canada expanded from about 13½ million to about 19½ million people. These series are brought together on a ratio scale in Figure 7, which shows the steady growth in GNP per head at an average rate of 4.8 per cent a year, and the faster growth of 6.6 per cent in mineral production per head.

For comparison, the table below shows the Gross National Product and the value of Mineral Production per head in 1965, for both Canada and the United States.

Value per Head in 1965

	Gross National Product	Mineral Production
Canada ($ Can.)	2,653	191
United States ($ U.S.)	3,139	63

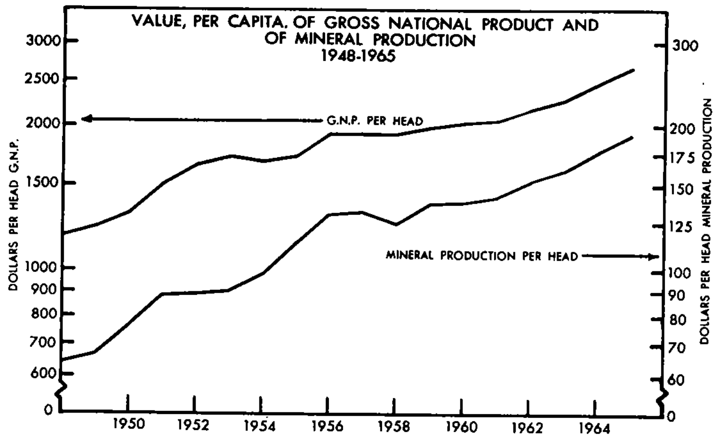

Figure 7

Growth in the Canadian industrial economy and its major sectors may be seen in Figure 8. The composite Index of Industrial Production shows an average annual growth of 5 per cent in the period 1949 to 1965. The growth rates for Electric Power and Gas Utilities, and for Mining are 10.4 per cent and 8.5 per cent respectively. The rate of growth of the manufacturing index is 4.5 per cent.

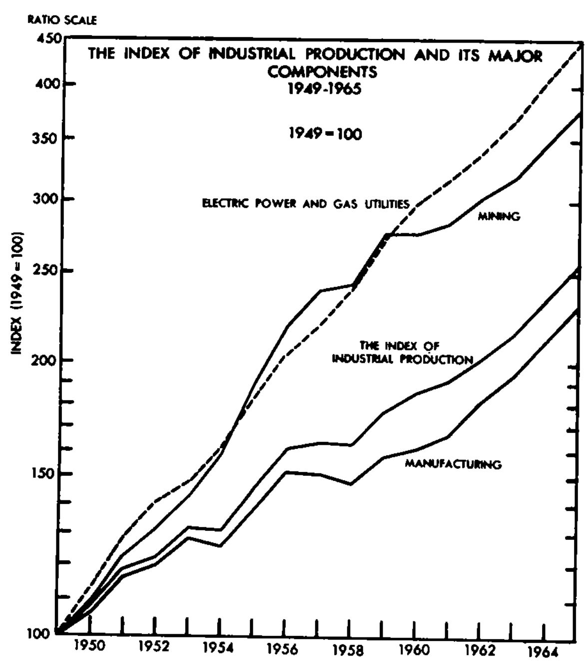

Figure 8

Figures 9 and 10 provide a comparison between output and factor inputs for the mining and manufacturing industries in the period 1949 to 1965. The measure of output for each sector is the Index of Industrial Production for the sector, and these are shown in Figure 8.

In general the behaviour of both industries has been similar. Both show an increase in labour productivity in the period, as can be seen in Figure 9 where the curves represent the ratio:

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

and are thus a measure of production per employee, rather than per man-hour or man-day. However both the mining series and the manufacturing series employ the same concept and Figure 9 demonstrates that labour productivity is rising in both sectors, faster in mining than in manufacturing.

While labour productivity may be rising, Figure 10 shows a more or less horizontal long-term trend for the ratio:

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

Investment in new plants and equipment is a highly variable statistic, as was demonstrated in the case of the mining industry, in Figure 6. Annual investment in any one year is a function of many variables, including the state of the economy when the investment decision is made, the state of the economy the previous year, and the expected state in the following year. Thus

* Published directly by the Dominion Bureau of Statistics.

**The 'Index of Investment, by Sector' was derived from the DBS publication *Private and Public Investment in Canada* using the appropriate price indexes for new construction and new machinery and equipment.

the production/investment ratio for the mining industry shows a steady decline from 1949 to 1956 as investment expanded faster than production. However, in 1958 investment was reduced abruptly, while the index of production remained steady. Since that time the ratio has changed little, indicating a period of relative stability in the mining industry, as determined by investment measured in real terms, and output. The production/investment ratio for manufacturing has been slightly downward. This suggests that the real value of output had declined slightly per dollar invested.

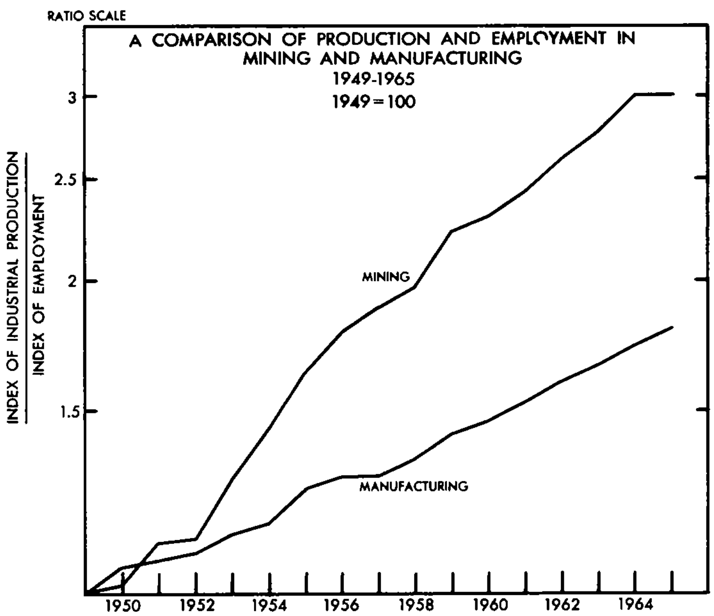

Figure 9

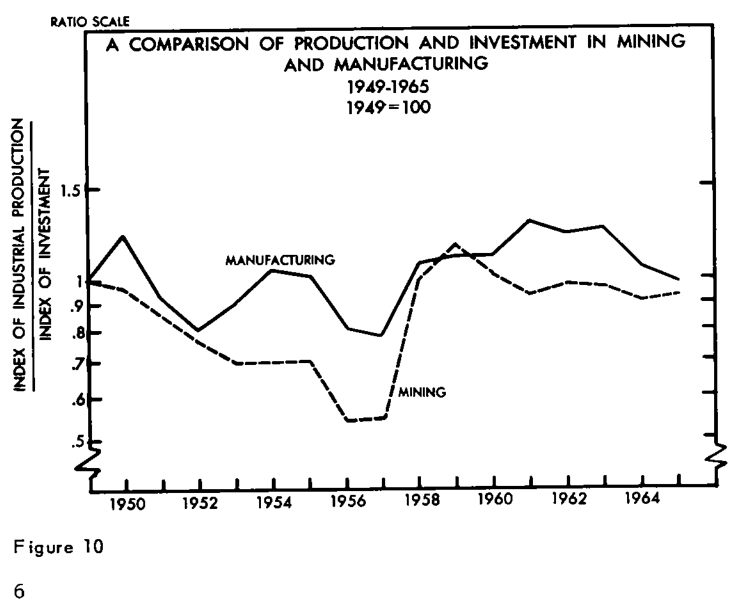

Figure 10

Mineral and Metal Prices

Mineral and metal prices directly determine the revenue of mining companies and greatly influence the prosperity of any nation that has a large mineral sector in its economy. However, while Canada plays an important role in world mineral supply Canadian mining companies, in most cases, face an industry price structure that is beyond their control. In 1965, Canadian mining companies and the Canadian economy in general benefited from mineral and and metal prices that were generally firm, in response to worldwide buoyant economic conditions. Continued growth in industrial output and business activity resulted in fuller use of productive resources which, in turn, put pressure on factor prices. Prices of most Canadian minerals either remained steady or rose.

Increases in the demand for copper led to a continuation in the price rises that had started in 1964, following a period of price stability. The difference between the free market price on the London Metal Exchange (LME) and producers' contract prices widened during the year. The U.S. domestic producers' price rose from 34 cents a pound to 36 cents in May. This price was raised to 38 cents in November, but the increase was rescinded following the announcement of the release of 200,000 tons of copper from the strategic stockpile. Overseas producer prices rose from 32.5 cents (U.S.) to 36 cents in May and 38 cents in October. The price on the LME rose from 49 cents (U.S.) in January, to 70 cents in December. The Canadian domestic price of copper followed the price changes of foreign producers, from 35 cents (Can.) at the beginning of the year, to 40.75 cents at the end of the year.

Lead and zinc prices in North America did not change in 1965. The Canadian price of lead remained at 15.5 cents

(Can.) a pound, f.o.b. Toronto and Montreal; the U.S. price remained at 16 cents (U.S.). The LME settlement and cash sellers' price fluctuated from 16.6 to 21 cents (Can.) a pound early in the year, fell to 12.8 cents in July, and rose to 15 cents by the end of the year. The Canadian and U.S. price of zinc remained 14.5 cents (domestic currency) a pound, f.o.b. Toronto and Montreal, and East St. Louis, respectively. The producer basis price (outside North America) was £110 a long ton (14.8 cents (Can.) a pound).

The list price of aluminum remained unchanged in 1965 at 24.5 cents (U.S.) a pound. Also unchanged were the prices of antimony, molybdenum, nickel, potash, selenium, sulphur and tellurium. The Canadian price of cadmium fell by about 20 per cent, but the prices of other mineral products rose. Asbestos prices for selected, lower-priced fibres rose by as much as 10 per cent, bismuth prices went up 90 per cent, and tungsten prices were up by about 50 per cent during the year. The average price of tin in 1965 was 178 cents (U.S.) a pound, compared with 175 cents the previous year. The day-to-day price fluctuated between a low of about £1,200 to a high of more than £1,600 a long ton on the London Metal Exchange (150 cents (U.S.) to 200 cents a pound). Mercury prices rose almost continuously in 1965, from $475 (U.S.) a flask in January to a high of $725 to $775 a flask in June. The price at the end of the year was $535 to $540.

Canadian iron ore producers supplying markets in Western Europe and Japan continued to face the downward pressure on prices they have experienced for some years. However, in North America the Lake Erie Base Price remained unchanged, at $10.55 a long ton, Mesabi non-Bessemer grade. The quoted price of Lake Superior pellets grading 63 per cent iron was 25.2 cents (U.S.) a long ton unit, or approximately $15.88 a long ton, delivered to rail of vessel at Lower Lake Ports. This price has not changed for some years. There was no change in Canadian domestic crude oil prices.

Mineral Trade

The value of exports of all major mineral commodity groups except uranium increased in 1965. Iron ore shipments increased three-fold to the European Common Market countries (EEC)* but declined slightly to the United States and the United Kingdom. The value of aluminum exports was up by more than 12 per cent, chiefly to the U.S. market. Copper exports rose by more than 6 per cent, the increase going mainly to Europe. Nickel exports rose more than 9 per cent, most of the increase going to the U.S. and Norway; the value of shipments to the U.K. were down. The value of fuel exports was up by more than 5 per cent. Exports of fuels to the U.S. were up by more than the total increase in exports, the difference coming from greatly reduced shipments to the European Free Trade Area (less the U.K.)**. Mineral trade to this area returned to normal after unusually large exports of gasoline to Sweden in 1964.

United States import quotas on lead and zinc, which had been in effect since 1958 and which had restricted U.S. imports to 80 per cent of the annual average of commercial imports for the period 1953-57, were rescinded in October 1965. As a result the value of Canadian lead and zinc exported to the United States rose sharply, from $54 million in 1964 to $77 million in 1965. With the inhibiting action of the quotas removed, 1966 should see a further increase in lead-zinc exports to the U.S.

* Belgium, France, Germany, Italy, Luxembourg and The Netherlands.

**Austria, Denmark, Norway, Portugal, Sweden and Switzerland.

The value of Canadian mineral exports rose about five-fold in the period 1950 to 1965. This is an average growth rate in excess of 11 per cent a year. Total merchandise exports for the same period grew at 7 per cent a year. The relation between them from 1949 to 1965 is shown in Figure 11. In this diagram the vertical scale is logarithmic; on such a scale a straight line implies a constant, compound rate of growth. Thus Figure 11 may be used to compare the rate of growth of mineral exports with the rate of growth of total merchandise exports.

Exports of all the major commodities in this mineral trade show an absolute increase during this period, although there has been considerable change in the relative proportion of each to total mineral trade. This is demonstrated in Figure 12. Iron ore, after the spectacular rise from 4 per cent of mineral trade in 1954 to 14 per cent in 1955, the first full year of shipments from Labrador-Quebec, has levelled off in the 12-to-13 per cent range. Similarly, the fossil fuels rose from less than 1 per cent of trade in 1950-52, to more than 16 per cent in 1962, and have settled at 15 per cent since then. The rapid proportional growth of iron ore and fuels had been at the expense of the other commodities, which show some percentage decline in their shares of mineral exports in the period 1950-65: aluminum 18 to 13 per cent, copper 13 to 10, nickel 19 to 14 and asbestos 11 to 6 per cent. Lead-zinc's share of the export market fell from about 18 per cent to 4 per cent in the early 1960's, but has since risen to nearly 8 per cent, with the coming on stream of the Bathurst and t plants. The story of uranium is shown dramatically in Figure 12. From 2 per cent of mineral exports in 1955 to more than 20 per cent in 1958 and 1959 and back to 2 per cent in 1965.

change as demand for atomic power rises in the 1970's.

MINING TECHNOLOGY, 1965

Advances in mining technology that took place in Canada during 1965 are reviewed in this section. In addition to those mentioned, many operating improvements are continuously being incorporated in any mining plant. They generally do not gain the prominence given entirely new changes in technique but they contribute largely to cutting costs, improving safety and speeding operations.

Production and Mining Methods

The tonnage of ore mined and rock quarried has risen from 87.7 million tons in 1950 to 256.7 million tons in 1963 and further increases are to be expected.

In metal mining operations in 1964, 72.4 million tons of ore came from open pits and 63.5 million tons came from underground. This is the first time that the tonnage of ore from open pits exceeded the tonnage from underground.

Exploration

The most spectacular exploration effort of 1965 resulted in the discovery, following IP surveys and follow-up drilling of anomalies, of the Pyramid Mining Co. Ltd. lead-zinc orebodies in the Pine Point area on the south shore of Great Slave Lake.

The variety of improvements in exploration devices produced in Canada and abroad continues to increase* and as developments occur they are rapidly adapted to practical use. For instance, direct measurement of the first-vertical derivative of the total magnetic field has been made possible by the use of high-sensitivity magnetometers that record the difference in output from two sensing heads separated by a constant vertical distance. This development eliminates the effect of diurnal variation which is greater in northern latitudes than in more southerly locations.

*For a more technical discussion see: Peter Hood, 'Mineral Exploration Trends and Developments in 1965'. *Canadian Mining Journal*, February 1965.

By greatly increasing the power on the transmitting system of its Mark V, INPUT airborne EM prospecting unit, a Toronto-based company believes it can locate orebodies at depths between 350 and 700 feet, depending on their size. The same company has announced the completion of development on a new high-sensitivity, gamma-ray spectrometer for use in light aircraft.

Data from an experimental aeromagnetic survey in southern Alberta were reduced semi-automatically.

A new, portable seismograph for shallow-depth refraction and reflection surveys was announced by a Toronto-based company during 1965. The same company disclosed details of its Hydrosonde 2A marine profiler.

Further advances were made in geochemical exploration techniques. Some of the methods employed by the Geological Survey of Canada were described in published papers.

Mining Methods

Several improvements in mining methods during 1965 resulted from more widespread use of cemented tailings fill. In the mines of The International Nickel Company of Canada, Limited (INCO), a block cut-and-fill mining method was developed. In the new method, a timbered slusher drift is surrounded with cemented tailings fill. Following development of boxholes in the fill, a top sill is developed 60 to 75 feet above the undercut. Longholes are used to mine to a slot at one end. All broken ore is removed and the block is filled with a mixture comprised of one part cement to thirty parts tailings. The procedure is repeated on the next block above.

At Falconbridge Nickel Mines, Limited, thickness of cemented tailings floors in cut-and-fill stopes was in-

Tonnage of Ore Mined and Rock Quarried in Canada, Selected Years, 1950 to 1963
(millions of tons)

Ore Source	1950	1960	1961	1962	1963
Metal Mines	45.9	101.6	99.4	114.3	123.9
Non-Metal mines	17.7	42.0	47.0	52.2	58.1
Stone quarries*	34.1	55.8	59.7	62.5	74.7
Total (other than coal)	87.7	199.4	206.1	229.0	256.7

Source: Dominion Bureau of Statistics, *General Review of the Mining Industry*. *Includes stone quarried for manufacture of cement and lime; does not include sand and gravel.

Ore Production* from Metal Mines, 1950-64
(millions of short tons)

	Underground*	Open Pit**	Total	Ratio, Underground to Open Pit
1950	35.4	5.6	41.0	6.3
1960	69.2	24.8	94.0	2.8
1961	64.2	29.3	93.5	2.2
1962	62.4	33.2	95.6	1.9
1963	60.2	57.3	117.5	1.1
1964	63.5	72.4	135.9	0.9

* Compiled from company reports of tons shipped or milled. Data presented here may not correspond with DBS reports owing to a different method of compilation. Where exact data were lacking, estimates were made. **Excludes waste.

creased to 12 inches from 5 inches as a result of test work during the year. The ratio of cement to tailings was changed from 1:6 to 1:12. Less blasting damage to the floor and savings in labour and material were reported.

Improved methods of drilling and blasting, back arching and rockbolting, and the availability of cemented tailings fill which aids later pillar recovery has resulted in re-introduction of shrinkage stoping in some areas formerly mined by cut-and-fill stoping. INCO is one of the leaders in re-assessing the applicability of shrinkage stoping.

Drilling and Blasting

During 1965, a trend towards larger-diameter drill holes in underground mining appeared to be developing. Extensive testing of these concepts are underway in the Sudbury area.

After extensive testing, success in development of noise suppression devices has been achieved in the mines of The Consolidated Mining and Smelting Company of Canada Limited (COMINCO).

A Canadian manufacturer has introduced a Venturi bit which is said to rapidly clear chips from the hole by means of a high-velocity air stream. The wings of the bit have a large clearance to allow for removal of debris blown from the bit face.

Advances in blasting have been made mostly in areas related to handling and loading of ammonium nitrate - fuel oil (AN–FO). In one location, AN–FO has been conveyed for a distance of 1,000 feet, thereby greatly simplifying the handling problem. Finer grain sizes of AN have been adapted in some locations to increase sensitivity to electric cap detonation. Fine NCN has been developed by COMINCO for secondary blasting. The well known Anodet blasting cap for AN–FO has been improved and designed for rotation blasting. Known as the Anodet Long Delay, it is now available in 16 periods.

Drifting and Tunnelling

Improvement of self-propelled jumbos continues and they appear to be making a come-back against air leg drills for lateral driving. Two men readily handle three drills with less fatigue and hazard.

One of the long tunnels being driven in Canada is the 11.6-mile, 12×14 foot Granduc tunnel through granodiorite. Equipment is comprised of a seven-drill jumbo, an electric loader with 1¼-cubic-yard bucket, 10-ton battery-trolley locomotives, and twenty 10-ton capacity side – dump cars. Advances in excess of 60 feet per shift have been reported.

Raising

Changes in raising practice included successful development of raise-boring machines at INCO mines. About 2,000 feet of 48-inch diameter raises were completed during the year. Bored raises are completed in two stages. In the first stage a 9 7/8-inch pilot hole is drilled downward with a tricone bit. A reaming tool which replaces the bit is pulled upward to complete the raise.

At Falconbridge, a raise borer was used successfully to produce 4-foot diameter raises through norite.

There were further extensions in use of drop-raising techniques and use of raise cages and raise platforms became more firmly established.

Shaft Sinking

The 4-foot diameter 3,000-foot shaft which was being bored at Lynn Lake was stopped at a depth of 2,800 feet and the bottom 200 feet were completed with a raise climber from the 3,000-foot depth. A deflection in the 12¼-inch pilot hole at 2,800 feet was responsible for the change in plan.

Canadian shaft sinking procedures are improving as a result of experience in the Saskatchewan potash mines. Shafts in these areas are circular and concrete lined. In the Allan Potash Mines shaft which was excavated without blasting, a new Canadian sinking record of 471 feet in a month was established for a 16-foot diameter shaft. In the Alwinsal Potash of Canada Limited mine, a seven-deck sinking stage is in use. No blasting is done and excavation is with paving breakers and two Cryderman shaft muckers. Concreting is continued simultaneously with excavation.

Sinking of the deepest single mine shaft in North America, the Creighton No. 9 shaft, was begun at the Creighton mine of INCO. Depth will be 7,150 feet. It will be circular, 21 feet in diameter and completely lined with concrete. A shaft of this depth for single-stage hoisting has been made possible by improvements in hoisting ropes.

Materials Handling

Further applications of rubber-tired loading-hauling equipment to underground development were noted at Mattagami and elsewhere.

In the Eldorado mine, a remote control system was installed to permit one-man tramming. The same result was achieved at the Renabie mine by automating dump and ventilation doors.

Automated hoisting continues to gain over manually controlled systems. One source reports that 70 per cent of new hoist installations are automated.

Support

Led by the major mining companies and by academic and government groups, a greater awareness of rock mechanics and its influence on mine design is being gained by mine operators. Noticeable results appear in improved selection of mining methods, in preplacement of supports and in improved techniques of rock bolting.

Use of concrete in shaft linings is rapidly increasing as is use of cemented tailings fill, as noted previously.

Open-Pit Mining

The trend towards larger shovels and haulage units continued. Aluminum bodies on haulage vehicles have made some headway.

A large variety of rubber-tired articulated loaders have appeared, providing greater mobility where this can be employed to advantage.

Open-pit mine operators are making extensive use of computers for simulation of pit operations during the planning stage. Improved equipment selection and better pit design are visible results.

Manpower

Occupying the attention of mine operators through the year has been the overriding problem of personnel shortages. Despite rapid expansion and unprecedented prosperity in the mining industry, the shortage of personnel continues to become more critical. All classes of employees are in short supply, from general labour through the skilled trades to professional categories. Mining companies, professional societies and academic institutions are seriously concerned and searching for solutions to the problems.

Working conditions in the mineral industry continue to become more attractive. Less physical effort is required of labour as equipment develops. Noise suppression, improved ventilation and better recreational facilities are transforming the working and living environment for mineral industry personnel.

HIGHLIGHTS IN THE MINING INDUSTRY IN 1965

The value of mineral production was up in 1965, in all the provinces and territories in Canada apart from Yukon Territory. A number of new mines were brought into production which contributed to this increase, and planned developments suggest that the trend will continue.

In British Columbia two new molybdenum-producing mines started production, and were instrumental in raising Canadian production six fold over the previous year's total. Two further, large molybdenum properties are under development in British Columbia, and are expected to be in production in 1966 and 1967, respectively. An iron ore producer, under development, is expected to increase the province's output by nearly one-half, to 3 million tons in 1966. Exploration activity for base metals was very strong throughout the year. Encouraging results were obtained by diamond-drill exploration of large, low-grade copper deposits east of the Alaskan Panhandle and north of Stewart, in north-central British Columbia, and in the Highland Valley.

Regular shipments of lead-zinc ore and concentrates were started from the Pine Point Mines Limited property on Great Slave Lake, in the Northwest Territories as the 6,000-ton-a-day concentrator started operation. Another company in the Pine Point area announced, late in the year, that diamond drilling had indicated a potential orebody on its property. Of significance to future mineral output in the Yukon were the announcements that the Clinton Creek asbestos deposit, about 120 miles north and west of Whitehorse, would be developed for production; that New Imperial Mines Ltd. may begin production of copper from its property southwest of Whitehorse; and that substantial lead-zinc resources had been encountered in exploration of the Vangorda area near the British Columbia border.

The major discovery in Alberta in 1965 was at Rainbow Lake, in the northwest of the province, where a discovery well and two adjacent wells intersected an apparently very rich oil and gas field. Exploration and development drilling in the province set a new annual record, and the value of elemental sulphur produced from natural gas was up by about 25 per cent.

Potash production in Saskatchewan was up 65 per cent from the previous year, with three companies in production. Two other companies were sinking shafts, and three more had announced and started work on major potash projects. At year's end an additional company was expected to announce the start of a project soon. Apart from the three producers, these developments include the sinking of 12 shafts, of which four are in progress, and the erection of seven new potash refineries, of which one has been started. All these operations are expected to be in production by 1969. The capital cost of all the potash developments in Saskatchewan will have totalled \$600 million by 1970, and the productive capacity of these mines and refineries will be about 12 million short tons of product (KCl) or 7 million short tons of K_2O equivalent. World potash production capacity in 1965 was estimated at 12.4 million short tons, K_2O.

In Manitoba, The Inter national Nickel Compan of Canada, Limited (INCO carried out development wor at the Birchtree and Soa mines, where production i scheduled for 1968. Shaf sinking for underground de velopment and exploratio was started by Sherritt Gordo Mines, Limited on its Lyn Lake property.

INCO also has a mine-development program under way in Ontario that should see four new mines in production in the Sudbury area. The company also announced expansion programs at two existing Sudbury area plants, the development of the Little Stobie mine, and the building of a new 25,000-ton-a-day mill. Near Kirkland Lake, the new ore pellet plant of the Jones & Laughlin Steel Corporation began full-scale production. Caland Ore Company Limited's screening and pelletizing plant on the Steep Rock Range was completed.

In Quebec, copper production rose by more than 10 per cent, and should continue to rise as three new mines that started operation in 1965 reach full operation. In addition to these new producers (one near Sherbrooke in the Eastern Townships; one in Poirier twp., north of Amos; and one near Belleterre) the concentrator at Gaspé Copper Mines, Limited was expanded from 7,500 tons to 11,000 tons of ore a day and the capacity of the mill at Orchan Mines Limited was increased to treat ore from the nearby New Hosco Mines Limited property.

In Newfoundland, mine output has grown rapidly, with iron ore making the main contribution. In 1965, Wabush Mines started shipments of concentrates from its 5.3-million-ton-a-year facility at Wabush, Labrador, of which 4.9 million tons a year is pelletized at the plant of Arnaud Pellets, an associated company, at Pointe Noire, Quebec. Iron Ore Company of Canada produced about 6 million tons of concentrate at its Carol operations, near Labrador City, and pelletized about 5 million tons at the nearby plant of Carol Pellet Company, an associate company. The balance was shipped as concentrate. Production capacity of the pellet plant is being increased to 8 million tons a year and may be increased later to 10 million tons a year. In addition one new copper mine started production in Newfoundland, during the year, and another was being developed for production in 1966.

MINERALS LEAD IN PROVINCIAL ECONOMIES

Economic Indicators

The foregoing description of mineral industry activity in each of the provinces and territories indicates that the year 1965 was one of great progress in which almost all parts of Canada experienced mineral industry growth. The following analysis is concerned with events and trends since 1950 leading up to today's large scale mineral activity and also with the relative importance of the mineral industry in each provincial economy.

Figure 14 – 'Canada Mineral Production, 1950-1965' – illustrates the extent of growth in each of the provinces since 1950 and affords a means of comparing the relative size of the various provincial mineral industries. The provincial analyses in this section are intended to show that, notwithstanding the difference in the magnitude and growth rates of the various provincial mineral

Value of Mineral Production by Provinces, 1920 to 1965
(millions of dollars)

	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Yukon	N.W.T.
1965P	220.5	1.0	66.6	83.9	704.7	986.2	182.0	327.3	799.4	279.2	13.3	72.9
1964	182.1	0.8	66.1	48.7	684.5	901.6	173.9	292.2	735.9	268.7	15.2	18.1
1963	137.8	0.8	66.3	28.3	540.6	873.8	169.6	272.4	669.3	261.1	14.4	15.9
1962	101.9	0.7	61.7	21.8	519.5	913.3	158.9	240.7	566.5	235.4	13.1	17.5
1961	91.6	0.6	61.7	18.8	455.5	943.7	101.5	216.0	473.5	188.5	12.8	18.1
1960	86.6	1.2	65.5	17.1	446.2	983.1	58.7	212.1	395.3	186.3	13.3	27.1
1959	72.1	4.5	62.9	18.1	440.9	970.8	55.5	210.0	376.2	159.4	12.6	25.9
1958	65.0	–	62.7	16.3	365.7	789.6	57.2	209.9	345.9	151.1	12.3	24.9
1957	82.7	–	68.0	23.1	406.1	748.8	63.5	173.5	410.2	178.9	14.1	21.4
1956	84.3	–	66.1	18.2	422.5	650.8	67.9	122.7	411.2	203.3	22.2	15.6
1955	68.5	–	67.1	15.7	357.0	584.0	62.0	85.2	326.0	189.5	14.7	25.6
1950	25.8	–	59.5	12.8	220.2	366.8	32.7	36.0	135.7	138.9	9.0	8.1
1945	*	–	32.2	4.2	91.5	216.5	14.4	22.3	51.7	64.1	1.2	0.5
1940	*	–	33.3	3.4	86.3	261.5	17.8	11.5	35.1	74.1	4.1	2.6
1930	*	–	27.0	2.4	41.2	113.5	5.5	2.4	30.4	55.0	2.5	–
1920	*	–	34.1	2.5	28.9	81.7	4.2	1.9	45.6	39.4	1.6	–

* Newfoundland not included prior to 1949 as it joined Confederation in 1949.
P Preliminary.

industries, almost without exception the mineral sector has been a leading growth industry in each provincial economy.

A useful tool in economic analysis at the provincial level is the concept of "net value". It is a measure of the value added in the production process and, therefore, a means of avoiding inter-industry duplication inasmuch as all intermediate goods and services are deleted. This statistical measurement of production is available for analyses of the primary industries – agriculture, forestry, fishing and trapping, mining (including oil and gas), and electric power and for the secondary industries – manufacturing and construction. Net value thus provides a means of comparing the growth and size of the mineral industry at the provincial and national levels with other sectors of the economy.

The following examination is directly concerned only with the mineral industry at the primary level; the mineral industry, of course, makes a significant contribution to the economy through the various smelting, refining and fabrication activities which constitute major components of manufacturing in most provinces. The mineral industry is also of great importance in the construction sector of the economy and in many of the tertiary industries such as transportation and trade. It is, therefore, important to note that the prominent position that mining at the primary stage has in most provincial economies is, in turn, diagnostic of the impact it is making in other sectors and, in turn, on an entire provincial economy.

To provide perspective for examination of provincial trends, reference is first made to net value indicators for Canada as a whole (Figure 15). All provincial charts contain the same four indicators for the period 1950-64. The vertical scale on the left side of each chart is a net value index computed on a 1946-49 base, with the average of the four years taken as 100. Plotted against this scale are the two indexes: a net value total for all primary and secondary industries, including mining, and a net value for mining only. It will be seen on examination of all charts that, with one or two exceptions, the mining index has led the total index throughout Canada since 1950 which is a measure of the dynamic characteristic of mineral development in the Canadian economy. The third line on the chart relates to the scale on the right side: this line shows mining as a per cent

Percentage Contribution of Provinces to Total Value of Mineral Production in Canada, 1950-65.

	1950	*1955*	*1960*	*1965*
Ontario	35.1	32.5	39.4	26.4
Alberta	13.0	18.2	15.9	21.4
Quebec	21.1	19.9	17.9	18.8
Saskatchewan	3.4	4.7	8.5	8.7
British Columbia	13.3	10.5	7.5	7.5
Newfoundland and Labrador	2.5	3.8	3.5	5.9
Manitoba	3.1	3.5	2.4	4.9
New Brunswick	1.2	0.9	0.7	2.2
Northwest Territories	0.8	1.5	1.1	2.0
Nova Scotia	5.6	3.7	2.6	1.8
Yukon Territory	0.9	0.8	0.5	0.4
Prince Edward Island	—	—	—	—
Canada	100.0	100.0	100.0	100.0

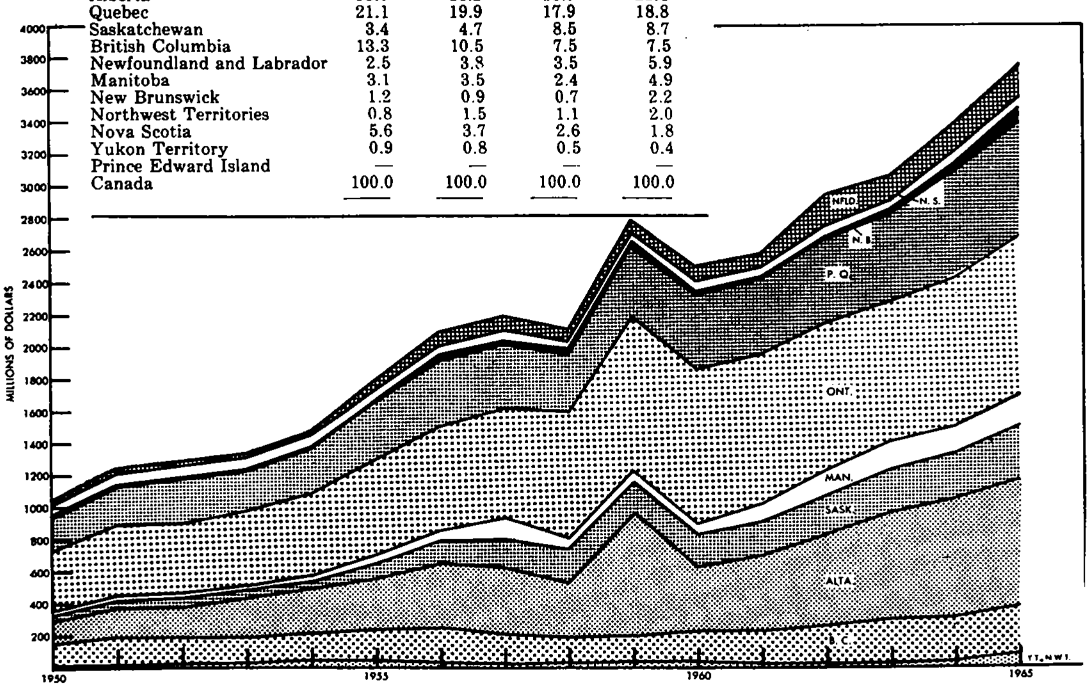

Figure 14

of the value of total primary production consisting of agriculture, forestry, fishing and trapping, mining and electric power. Here again, mining exhibits its growth characteristic since most provincial analyses reveal a rising percentage for the mining sector. The fourth line shows agriculture as a per cent of the value of total primary production and provides a means of comparing the importance of mining and agriculture and the growth trends of each.

Canada

Figure 15 shows that mining has been a leading rather than a lagging industry for the country as a whole since the immediate postwar period.

A few events in the Canadian economy can be highlighted as background to the subsequent references concerning individual provinces.

An assessment of economic growth since 1950 must have regard to the 1946-49 period of transition from war to peace during which time all industries were undergoing readjustments. During this period, the sharp reduction in government spending was offset by a major increase in personal and business expeditures after the removal of wartime restrictions. As a result, the total expenditures in the economy declined only slightly after the war from the wartime peak of 1944, and by 1949 had risen again to that level. There was an equally smooth transition in the labour market. By 1949-50, almost all sectors had risen to the output levels of wartime peaks. Thus in this transition period, the the economy as a whole maintained the wartime gains in output and employment. It was, however, a period of price increase following the removal of wartime price controls and the related mineral price increases accounted for a considerable portion of the growth in production value. During the period 1946-49, the value of mineral production almost doubled whereas the volume index only rose by one third. At the same time, extensive mineral resource development got underway and by 1950, the production value increases were beginning to reflect this resource expansion.

The period 1950-56 was one of outstanding growth in the mineral industry and in the economy as a whole. On a per capita basis, the Gross National Product (GNP) moved ahead at an average annual compound rate of 6.4 per cent, as measured in current dollars, and mineral industry per capita output value at the much higher rate of 9.8 per cent. However, there was a subsequent decline in the national output per head and this index of economic growth remained below the 1956 peak until 1962 whereas the per capita value of mining continued to rise after a slight retraction in 1958.

The reasons for the rapid growth in the mining industry during the first six or seven years of the 1950's will be seen in the references to mineral developments at the provincial level.

For the economy as a whole, there were several forces at work making for an outstanding period of growth. One of the dynamic growth elements was government spending in the early 1950's related to defence expenditures following the outbreak of the Korean war. The other principal growth element in the economy was the sustained construction boom. The mineral industry responded to the need created by the Korean war for defence materials and it was a vital factor in the construction industry expansion. The 1950-56 growth period was also characterized by an export boom due mainly to the expansion of the resource industries, in particular the mineral industry, reflecting the attention being given in the United States to the scarcity of strategic raw materials. The mining industry accounted for much of the new capital investment in facilities to increase production to meet world demand. The extent of the mining industry expansion is indicated in Figure 15.

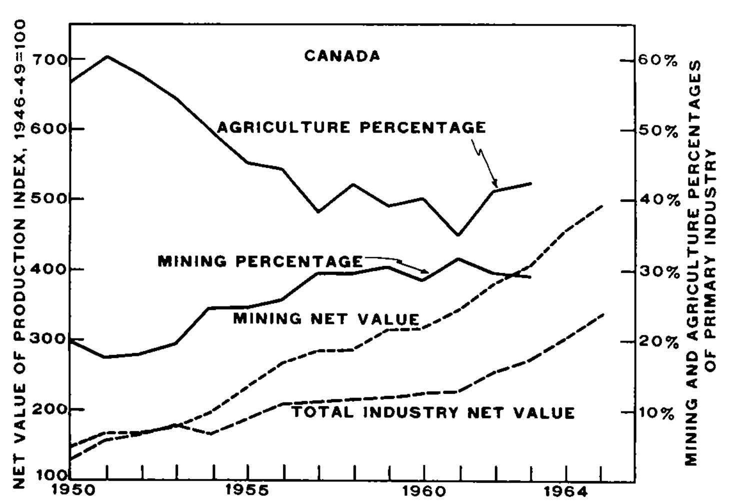

Figure 15

In 1957 there was a halt in economic expansion with the slackening of world demand and the related slight decline in mineral production in 1958 was the only reversal in the entire period of rapid mineral growth which had commenced in 1946.

The extent of the slowdown in Canadian economic growth in the period 1957-61 is indicated by the fact that the average annual per capita increase in GNP (in current dollars) was only 1½ per cent. However, mineral output did move ahead somewhat faster, at an average annual per capita rate of 3½ per cent, illustrating that at a time of recession the mineral industry is still a dynamic force helping to retard the extent of economic decline.

In 1961 the Canadian economy began a recovery which has continued unabated and in this new period of growth the mineral industry has been one of the most dynamic sectors. Figure 15 shows that the index of mining net value has been growing much faster than the total industry net value since 1953. On a 1946-49 base, the mining net value index is now well over one third greater than the total industry index. The trend for mining as a percentage of total primary industry has also been upward, having risen from 20 per cent in 1950 to well over 30 per cent; at the same time the agriculture percentage has declined from about 60 to 40 per cent. These percentage trends show the dramatic change in the relationship of the two primary industries with mining's overall growth almost as great as agriculture's decline notwithstanding the favourable wheat export situation since 1962. Thus, as indicated by growth in net value and the changing composition of the primary sector, mining is now the leading growth industry of the primary sector.

In turning to a brief examination of mineral industry performance in each of the provinces for the period 1950-1964, the assessment in each province is made against the background of certain major events and trends: the Korean war of 1950, the two or three pauses in economic advance in the 1950's, devaluation in 1962, the major oil, gas, iron ore, uranium and non-ferrous mineral resource developments, and the overall growth of the country's population and economy. Of paramount importance, too, is Canada's position in world mining, a topic that was dealt with in 'The Canadian Mineral Industry in 1964 and World Position 1954-63'* to which reference may be made for an outline of world mining events that have affected Canadian mineral developments in recent years.

British Columbia

Mineral production value in this province in the period 1950-64 did not increase steadily; in fact, after a sizeable increase in 1951 there was a decline to 1954 followed by an increase over two years and a subsequent decline to a level in 1958 below the 1953 value. Since 1958, however, there has been good progress, particularly since 1961.

The present boom in the British Columbia mineral industry, which started from the low production level of 1958, has been highlighted by the expansion of the copper, iron ore, oil and gas industries, although there have been marked gains for most of the 35 or more mineral commodities produced in the province, with the important exception of gold. Increasing diversification, as illustrated by rapid development of the new molybdenum industry, has also been a key factor in British Columbia's recent rise to new prominence as a mineral producer. While forestry remains the most important primary industry in the province, the indicators of Figure 16 point to mining's return to prominence in the provincial economy while agriculture continues its relative decline.

Alberta

The amount of the value increase in Alberta mineral production in the period 1950-64 was greater than that of any other province. There were minor setbacks in production growth in 1953 and

* *Canadian Mining Journal* February 1965, and Mineral Information Bulletin MR 79, Dept. of Mines and Technical Surveys.

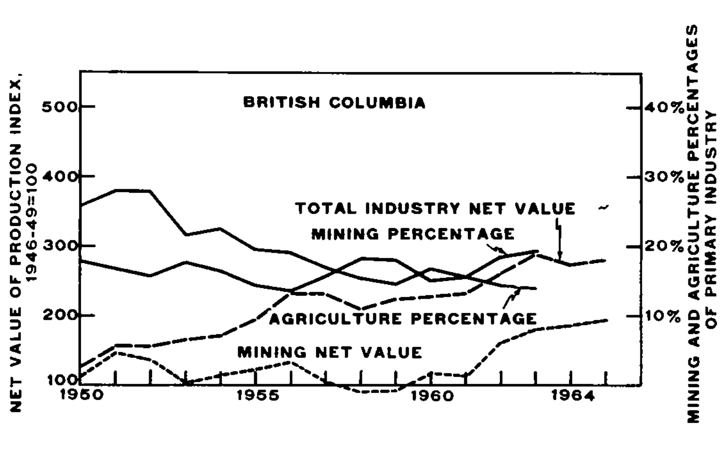

Figure 16

1958 but otherwise the expansion of the mineral economy has proceeded at a rapid pace, the production value increase in the period being almost six-fold. Crude oil, natural gas and natural gas byproducts are the major components in Alberta's industry. In 1950, they accounted for 63 per cent of total value; in 1964, 92 per cent. During the same period coal output declined to one quarter its 1950 value and its value is now less than that of sulphur. Structural materials output has kept pace with the expanding economy of the province, the value increase being almost four-fold.

The remarkable expansion of the oil and gas industry has had a widespread effect throughout the Alberta economy and accounts for the marked changes in the economic indicators shown in Figure 17. In 1950, mining's percentage of the net value of all primary industry was only one third of agriculture's; it is now one quarter greater.

Saskatchewan

The mineral production record for Saskatchewan shows very little change until 1954. Since then, there has been good progress except for a pause in 1959 and in 1960. The overall increase in value in the period 1950-64 was eight-fold. The expansion that got underway in 1954 was due to a doubling in crude oil production in that year. In 1955, a new growth element was introduced with the opening up of uranium deposits in the Lake Athabasca area. The production of crude oil and uranium expanded rapidly through to 1958, while copper reached its maximum in 1956 and zinc declined somewhat from its 1952 peak. In 1959 and 1960 crude petroleum gains were small and uranium began its decline from its 1958 peak of \$59.8 million to \$16.6 million in 1964. Notwithstanding this decline, Saskatchewan mineral output began to move ahead in 1961, due mostly to an upswing in crude oil production. In 1962, another new growth element entered the Saskatchewan mineral industry with the commencement of potash production on a continuing basis. In 1964 crude oil and potash accounted for three quarters of the value of the province's mineral output. There is every indication that these two mineral commodities will continue to be the leading growth sectors of Saskatchewan's mineral economy for many years. The changes in the industry are well indicated by the relative decline in importance of copper and zinc which in 1964 accounted for 8 per cent of total output value in contrast with 65 per cent in 1951. However, the renewed activity in base metal exploration gives promise of a more diversified industry when these two metals regain some of their past prominence. The overall growth of the mineral economy has been significant as shown by the trends in Figure 18.

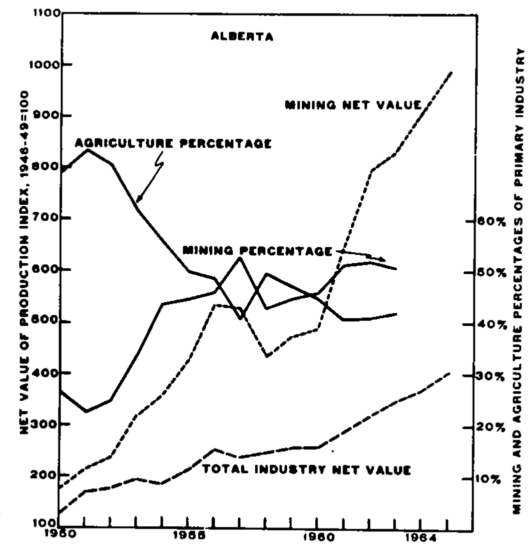

Figure 17

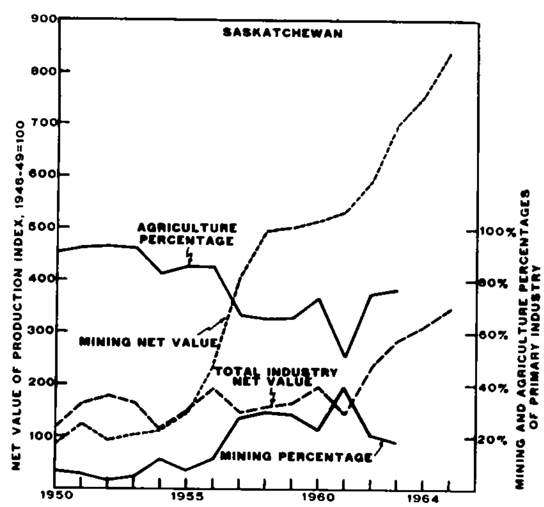

Figure 18

Manitoba

From 1950 to 1954 there was very little change in the annual value of Manitoba's mineral production. After a marked increase in 1955, the value remained near this new level until 1961 when there was again a significant increase. Since then, production has been on the uptrend. The 1964 output value was slightly more than five times the 1950 value, although still relatively small at $175 million compared with Saskatchewan's $286 million and Alberta's $747 million. Unlike Alberta and Saskatchewan, the crude oil industry has not been a major factor in Manitoba's mineral production growth. Crude oil production, which commenced in 1951, reached a maximum of $15.5 million in 1957 and has since declined. The 1955 boost in mineral output value came about as a result of the opening up of the Lynn Lake nickel deposit in 1954. The 1961 boost in mineral value was again the result of new nickel production, this time from the Thompson mine. Some increases in copper and zinc and the large increase in nickel have accounted for most of Manitoba's production growth in the 1960's. In 1964, these three metals accounted for over four fifths of the province's total mineral output; nickel alone accounted for almost two thirds of the total. Figure 19 indicates that the recent growth in mineral output is making an impact, even in a province in which agriculture is so important.

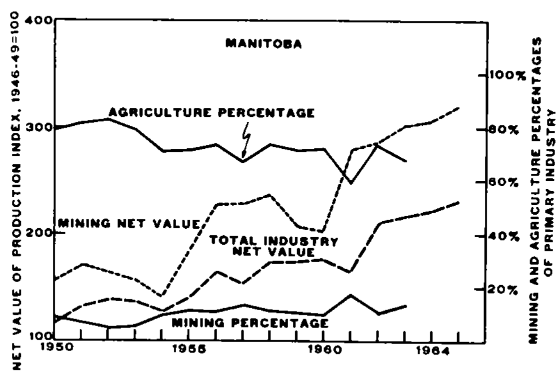

Figure 19

Ontario

The production history in Ontario since 1950 is one of almost continuous growth during the 1950's, with a particularly large annual increase in 1959, followed by a decline from 1960 to 1963, and finally a reversal of this trend in 1964 which raised production back up to the 1961 level. The 1960 peak was not exceeded until 1965. The over-all increase from 1950 to 1964 was somewhat less than three-fold. Nickel was one of the leading growth minerals in the 1950's, its output value rising from $112 million in 1950 to $243 million in 1957 when, because of the curtailment of purchases for the U.S. stockpile, production growth was arrested. With the loss of Cuban nickel to the western world, Ontario nickel production reached an all time high in 1960, not exceeded until 1965. Copper output also increased steadily until 1957, when a price reduction brought about a decline in output value. With increasing volume, the 1956 peak was again reached in 1960. To 1964, there was little change in quantity or value. The gold output trend has been generally downward but silver output climbed steadily in the 1950's and, after a pause in the early 1960's, moved ahead in output value as a result of a price increase. Iron ore production began to increase in the mid-1950's and, after some slow-down in 1960, again resumed a good growth trend. Among the non-metallics, salt has been consistently increasing at a moderate rate. The structural materials tripled in value in the 1950's and have been an important mainstay of the Ontario industry. The mineral commodity which had the greatest effect on Ontario mineral production trends in the period 1950-64 was uranium: a peak of $268 million was reached in 1959 but the subsequent decline to $109 million in 1964 retarded Ontario's overall production growth in the early 1960's. New base metal and iron ore developments in 1963 and 1964 should shortly raise the mineral industry indicators in Figure 20 back

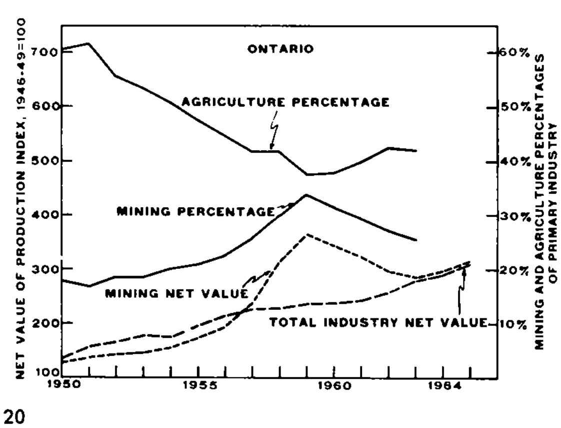

Figure 20

up to the trend directions of the 1950's. Notwithstanding the slowdown in mining in the early 1960's, the industry has increased in relative importance in the primary sector since 1950 whereas agriculture has declined.

Quebec

During the period 1950-64 there was a three-fold increase in the value of Quebec's annual mineral output. The periods of best growth were 1954-55 and subsequent to 1960; in fact the increases in output value from 1961 to 1964 was as great as for the much longer period of 1950 to 1960. In the early 1950's, only zinc, asbestos and the structural materials showed signs of growth. In 1954, iron ore production commenced in Quebec-Labrador and the value of production advanced rapidly from \$3.8 million in that year to \$65.8 million in 1957. There were subsequent annual increases and decreases but since 1961 production value has been consistently on the uptrend as plant facilities in the Lac Jeannine area have been built or expanded. From the first production in 1954, iron ore has been Quebec's leading growth minerål and in 1964 accounted for one quarter of total mineral output. Zinc production declined to one third its 1951 high in 1959; subsequently, there was a small increase but with the commencement of production from new mines in the Matagami district in 1964, zinc moved rapidly ahead of gold to become Quebec's third most important metal. Copper output increased rapidly in the mid-1950's, in response to U.S.A. stockpile requirements and increasing European demand but the 1956 peak in value was not again reached until 1964 because of lower unit prices although volume continued at high levels. The recent higher prices and the increased production with the opening of Matagami area mines raised copper output and value to a new record in 1965 but still second to iron ore. Asbestos has been another growth mineral – tonnage rose by 50 per cent and value doubled in the period 1950-64. Progress made in recent years in developing asbestos occurrences in Ungava gives promise of continuing growth for the province's asbestos industry. The four growth minerals – iron ore, copper, zinc and asbestos – now account for about 60 per cent of Quebec's mineral output. The three-fold increase since 1950 in the value of structural materials production has also given strong support to the province's mineral economy. Figure 21 illustrates the growing importance of minerals in Quebec's economy and that mining's increase has been as steady as agriculture's decline.

New Brunswick

The growth in New Brunswick's mineral production only started in 1962. Until the early 1960's, the province's mineral output had not exceeded the peak of \$23 million reached in 1957 when the Bathurst area was briefly in production. The increase in 1964 alone was as much as the all-time growth to 1962. Until the mid-1950's, coal accounted for at least half of total mineral output value, most of the rest being the value of structural materials. In 1962, with the start of base metals production from the Bathurst area on a continuing basis, zinc, copper and lead re-entered the province's mineral list and in 1964 these three growth minerals accounted for half of a greatly increased value of output. The indicators of Figure 22 are now beginning

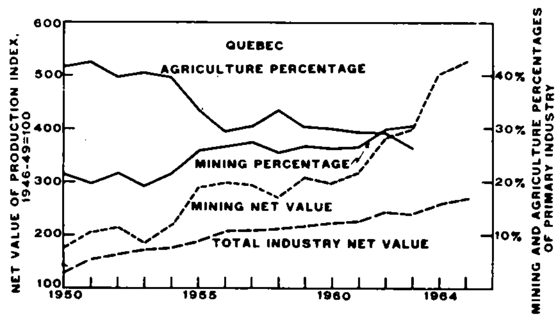

Figure 21

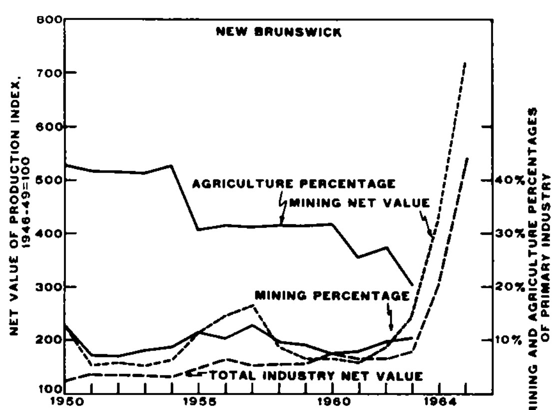

Figure 22

to show an upward trend in favour of the mineral economy as a result of the Bathurst mineral development while agriculture is on a gradual downtrend.

Nova Scotia

Of all provinces, Nova Scotia showed the least change in total mineral output value in the period 1950-1964. Coal declined in importance from 85 per cent of total value in 1950 to 65 per cent in 1964. The decline in coal output was compensated for by increases in gypsum, salt and structural materials output. The indicators of Figure 23 reflect the static condition of the province's mineral economy. Notwithstanding the lack of growth in total mineral value, due to the decline in the coal industry, there has been an appreciable expansion of the structural materials and the non-metallics sectors.

Newfoundland and Labrador

The province's mineral output increased more than sevenfold during the period 1950-64, with the increase of the last two years being greater than for 1950 to 1962. Iron ore now accounts for about three quarters of Newfoundland's mineral output. Copper, zinc and lead are the other principal metals. The commencement of iron ore production in Labrador in 1954 marked the start of the growth of the province's mineral economy. Iron ore expansion in the early 1960's, the commencement of asbestos mining near Baie Verte in 1963, and of copper-zinc production in 1964 in the same area are the principal events which have accounted for the mineral industry's progress in the 1960's. The large increase in mineral output in recent years has made a major impact on the province's economy, as indicated by the growth trends shown in Figure 24. Mining now accounts for about 60 per cent of total primary industry net value.

Yukon Territory and Northwest Territories

Although there was some growth in Yukon mineral production in the early 1950's, there has been little change in total value in recent years. In 1950, gold accounted for well over one third of total value but its importance has steadily declined to less than one fifth. Silver now accounts for about one half of Yukon's mineral output compared with less than one third in 1950. There have been minor increases in lead and zinc. Exploration activity has been rising and the favourable results in such areas as the Whitehorse copper-belt give promise of an improvement in the outlook for the industry which has recorded very little progress in the past 15 years. The mineral industry of the Northwest Territories tripled its output value in the mid-1950's due to an increase in gold output and the start of uranium production in 1954.

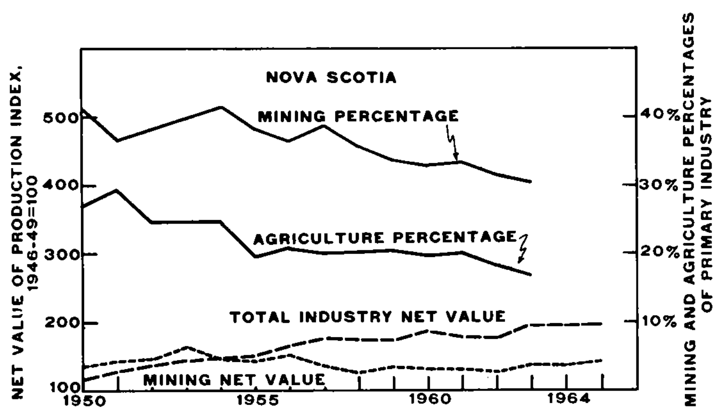

Figure 23

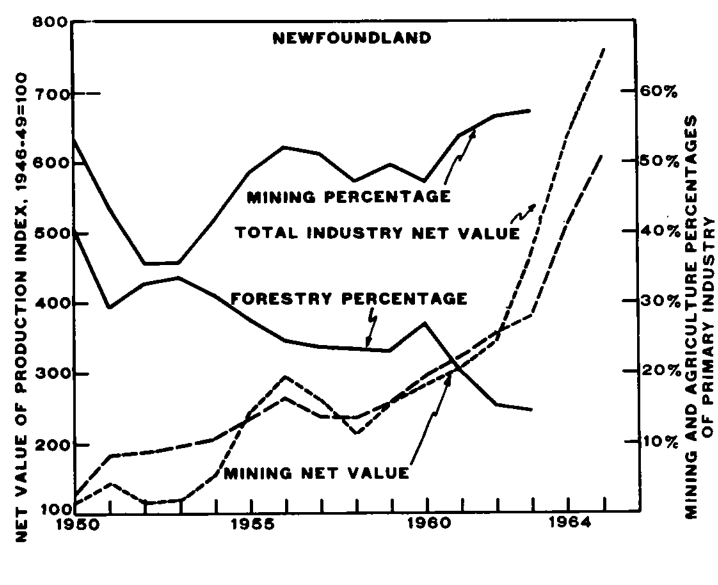

Figure 24

In the early 1960's output value declined to the level of the early 1950's because of the closing down of uranium production at the end of 1960, although gold output remained relatively steady. Figure 25 points to the dominant position of mining in the economy of the Yukon and Northwest Territories; despite some downtrend, mining still accounts for about four fifths of the net value of total primary production. There will be a marked upswing in the mining and total industry indexes commencing in 1965 with the start of zinc-lead production from Pine Point deposits.

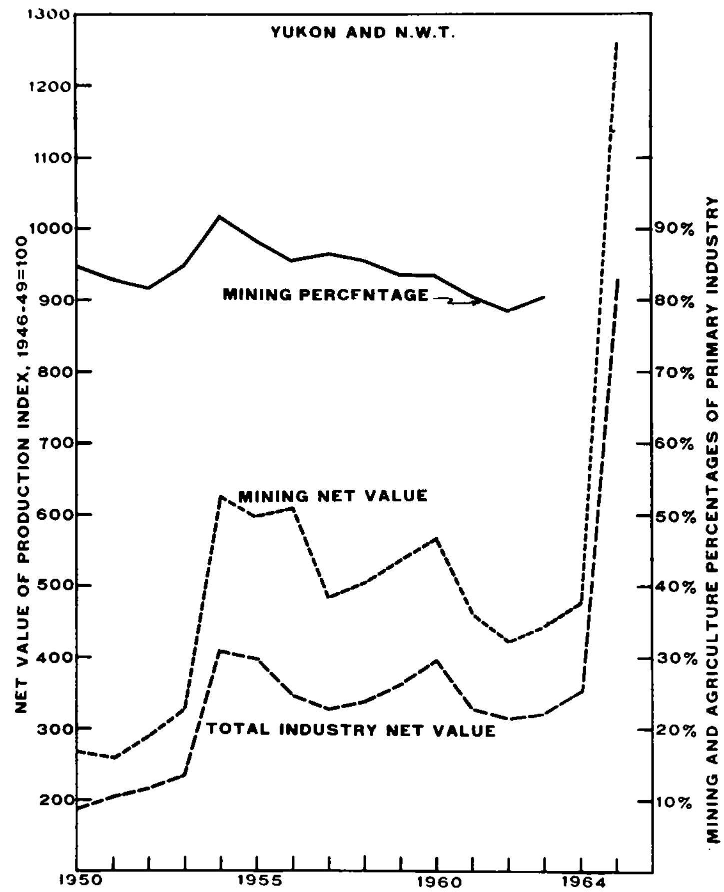

Figure 25

Abrasives

D.H. STONEHOUSE*

Canada is a major producer of crude artificial abrasives but its output of natural and refined abrasive grains is insignificant. It is the world's largest producer of crude silicon carbide and crude fused alumina, the two most commonly used artificial abrasives. However, Canada's requirements for most types of abrasive grains are met by imports, as is a large proportion of its consumption of secondary abrasive products.

Almost all minerals, mineral assemblages and many man-made materials may be used as abrasives. However, only those with the most suitable physical properties for each general type of use are normally in demand. Abrasives have numerous industrial applications and include materials which are employed for their cutting, grinding, polishing, gripping or wear-resistant properties. In general, they may be classified by origin (natural or artificial) and by degree of abrasiveness. The high-grade type includes diamond, corundum and the principal artificial products, silicon carbide and fused alumina. Quartz and feldspar are examples of the low-grade type. Mild abrasives include lime and diatomite. They commonly have a small particle size and are used for polishing and scouring.

Practically all the natural abrasives produced in Canada are from operations established primarily to supply materials for non-abrasive purposes. Although statistics are not available, output of these commodities is valued at about $100,000 a year. It includes silica and beach sand, iron oxide, feldspar, granite and grindstone. In addition, large tonnages of sized ores are used as grinding media in autogenous and pebble grinding. These media perform the role of an abrasive during grinding but eventually become pulverized and utilized as an ore, rather than as an abrasive. Imports of natural abrasives are large and in 1965 amounted to $7.1 million of the $18.1 million total for all abrasives imports. Almost all ($6.5 million) consisted of industrial diamond and diamond dust, practically all of which came from the United States. However, a substantial proportion of these diamonds is re-exported, practically all to the United States. Not included in import statistics are small quantities of materials such as diatomite and iron oxides which are brought into the country for use as abrasives, or some quartz imported for sand blasting. The quantity of exported natural abrasives is insignificant.

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*Mineral Processing Division, Mines Branch

TABLE 1

Abrasives — Production, Trade and Consumption, 1964-65

	1964		1965[p]	
	Short Tons	$	Short Tons	$
Production				
Artificial abrasives				
Crude silicon carbide[1]	85,433	11,398,000		
Crude fused alumina[1]	148,339	16,134,000		
Abrasive wheels and segments	..	10,605,000		
Other products[2]	..	12,801,000		
Total	..	50,938,000		
Imports				
Natural and artificial abrasives				
Diamonds, industrial	..	6,198,213	..	5,971,484
Diamond dust	..	473,105	..	565,862
Pumice, lava and volcanic dust, crude or ground	10,876	159,720	10,532	176,920
Abrasives, natural, n.e.s.	4,430	369,030	6,218	427,116
Abrasives, artificial, crude and grains, n.e.s.	10,150	3,320,162	10,543	3,534,818
Abrasive wheels	..	2,465,410	..	2,941,589
Abrasive stones and blocks	..	537,145	..	461,517
Abrasive paper and cloth	..	1,922,482	..	1,816,896
Metal shot	..	1,211,829	..	1,519,613
Abrasive basic products, n.e.s.	..	817,458	..	693,717
Total		17,474,554		18,109,532
Exports				
Natural and artificial abrasives				
Abrasives, natural, n.e.s.	193	12,335	143	10,502
Fused alumina, crude and grains	155,686	17,366,131	177,287	20,159,149
Silicon carbide, crude and grains	81,059	10,625,294	90,902	12,243,784
Abrasive paper and cloth		394,127		375,594
Abrasive wheels and stones		315,672		172,895
Abrasive basic products, n.e.s.	..	1,083,129		1,294,710
Total		29,796,688		34,256,634
Re-exports				
Abrasives, natural, n.e.s.		1,509		} 1,710,594
Diamonds, industrial		1,860,827		
Diamond dust or bort		374,729		
Abrasive basic products		69,770		182,776
Consumption				
Abrasives, natural and artificial, in the production of artificial-abrasive products				
Natural-abrasive grains:				
garnet	188	53,000		
emery	28	6,000		
quartz or flint	112	7,000		
other	11	1,000		
Total	339	67,000		

Table 1 (cont.)

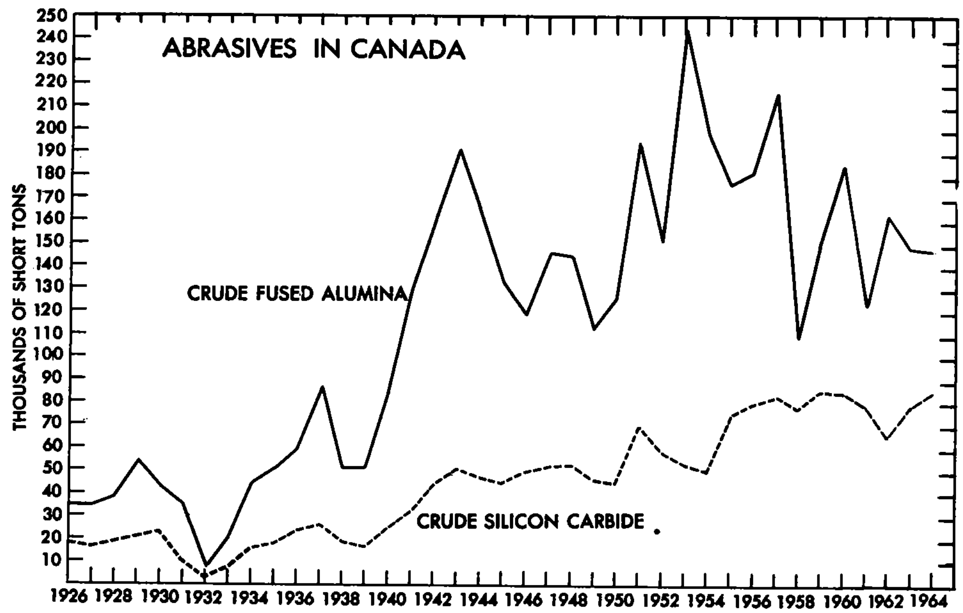
Consumption (cont.)	1964		1965P	
	Short Tons	$	Short Tons	$
Artificial-abrasive grains for wheels, paper, etc.:				
fused alumina	3,208	1,055,000		
silicon carbide	3,305	875,000		
Total	6,513	1,930,000		

Source: Dominion Bureau of Statistics

[1] Includes material for refractories and for other nonabrasive purposes.

[2] Includes abrasive cloth, paper and tile, sharpening stones and files, artificial pulpstone, boron carbide, fused magnesia and firesand.

P Preliminary; .. Not available; n.e.s. Not elsewhere specified.



Canada produces a substantial quantity of crude artificial abrasives. In 1964 this amounted to 148,339 tons of crude fused alumina valued at $16.1 million and 85,433 tons of crude silicon carbide valued at $11.4 million. The 1964 production represented 87 and 65 per cent, respectively, of the North American output of crude fused alumina and silicon carbide. About one quarter of the former and one tenth of the latter are used for nonabrasive purposes. Plant shipments are dependent on the export demand and virtually all the crude product is shipped to the United States. The demand for fused alumina fluctuates greatly from year to year whereas that for silicon carbide is more stable and has been generally increasing since 1939. Metallic abrasives, such as shot and grit, are also produced but are not reported separately in statistics.

Manufactured abrasive products, other than crude artificial abrasives, are also made in Canada. These consist of abrasive wheels and segments which, in 1964, were valued at $10.6 million, and of other products valued at $12.8 million including such items as abrasive cloth and paper, abrasive tile, artificial pulpstone and some nonabrasive products. Total value of Canada's artificial abrasives industry during 1964 was $50.9 million, an increase of $5.8 million over the previous year.

Over 60 per cent of the total value of abrasives imports is represented by artificial abrasives at a value of about $11 million. These consisted of refined grains, wheels, stones and other shapes, cloth, paper and metal shot. Refined grains accounted for the largest value and nearly all of this product came from crude silicon carbide and fused alumina that had been produced in Canada and exported to the United States for processing. Exports totalled $34.3 million in 1965 and included all the crude silicon carbide and fused alumina produced during that year, most of which went to the United States. Other exports included paper, cloth, wheels and stones.

PRODUCERS

Quartzite for sandblasting is produced by Dominion Industrial Mineral Corporation at St. Donat de Montcalm, Quebec; by Nova Scotia Sand and Gravel Limited near Shubenacadie, Nova Scotia; and occasionally by Selkirk Silica Co. Ltd., Selkirk, Manitoba. Small shipments of feldspar for use in soaps and cleansers are made from Buckingham, Quebec, by International Minerals & Chemical Corporation (Canada) Limited. Finely ground silica is sold for the same purpose by Industrial Minerals of Canada Limited, St. Canut, Quebec. Bog iron oxide is processed for use as crocus and jeweller's rouge by The Sherwin-Williams Company of Canada, Limited, at Red Mill, Quebec. Grindstones are manufactured from sandstone at Sackville, New Brunswick, by H.C. Read.

Although not considered products of the abrasives industry, ores used in pebble and autogenous grinding temporarily perform as natural abrasives. Like most others, they result from materials required mainly for other purposes. However, they serve a twofold purpose, initially as grinding media and eventually as a semiprocessed ore. In Canada, many ores are subjected to this type of comminution.

Canada's production value of crude artificial abrasives by far outweighs that of the natural variety. Practically all shipments of artificial abrasives consist of crude fused alumina and crude silicon carbide. They are produced by six companies at four plants in Quebec, and at four plants in Ontario. These plants and their products are listed in Table 2 and have experienced no major changes in recent years. Their products go mainly to the United States but small quantities are exported

TABLE 2

Canadian Producers of Crude Artificial Abrasives

Producer	Location of Plant	Product
Canadian Carborundum Company, Limited	Niagara Falls, Ont. Shawinigan, Que.	Fused alumina Silicon carbide
Electro Refractories & Abrasives Canada Ltd.	Cap de la Madeleine, Que.	Silicon carbide
The Exolon Company	Thorold, Ont.	Silicon carbide Fused alumina
Lionite Abrasives, Limited	Niagara Falls, Ont.	Silicon carbide Fused alumina
Norton Company	Chippawa, Ont.	Silicon carbide Fused alumina
	Cap de la Madeleine, Que.	Silicon carbide
Simonds Canada Abrasive Company Limited	Arvida, Que.	Fused alumina

to the United Kingdom and to a few other countries. Consequently, the output from these plants is dependent on the demand in these countries, particularly on the degree of metal fabrication taking place.

Significant amounts of abrasive wheels, segments, stones, paper and cloth are also produced in Canada. Most of these are produced in southern Ontario, although Quebec and British Columbia supply small amounts.

CONSUMPTION AND USES

Consumption statistics for natural and artificial abrasive grains are incomplete, but diamonds represent by far the largest part of the consumption value. For 1964, Table 1 gives the consumption value and amount of most natural and artificial abrasives used in the production of abrasive products. This does not include the quantity consumed for final use as loose grains.

Abrasives are employed universally and in numerous applications. Although each abrasive product has many possible applications, its versatility normally is limited by cost and performance. As a result, the numerous grades of each type provide a preferred abrasive for every use.

All minerals and rocks can be used as natural abrasives but only a few are in demand. The application of ores in pebble and autogenous grinding has already been mentioned. Natural and synthetic diamonds are employed in grinding, cutting and boring metallic and nonmetallic materials and in polishing glass. Emery is used in bonded and coated abrasives and in abrasive surfaces for floors of concrete, masonry and asphalt. Corundum may be employed in bonded shapes or loose grains for grinding and polishing. Silica and beach sand are used in sandblasting, silica flour in soaps and cleansers, and silica sand in coated abrasives. Garnet serves mainly in coated abrasives and as loose grains for sandblasting and polishing. Feldspar is used in soaps and cleansers, and iron oxide and diatomite are ingredients in polishes. Other industrial minerals are consumed for less common abrasive purposes.

Fused alumina and silicon carbide are the most popular artificial abrasives. Because they are both high-grade types, they compete in many applications. In the form of loose grains, they have similar applications and are used for grinding, polishing, sandblasting and for providing 'nonslip' surfaces on concrete and masonry structures. When bonded, fused alumina is used in the metalworking, woodworking and leather industries. Silicon carbide is also bonded into wheels, sticks, stones, rubs, etc., and used to abrade metal, industrial mineral products, rubber, leather and wood. In coated abrasives, fused alumina and silicon carbide are used in the metalworking, woodworking and leather industries.

PRICES

Canada does not produce refined grains for the production of manufactured abrasive products. Consequently, in 1964 the following average prices per short ton were for imported abrasives used at abrasive products plants:

Fused alumina	$330
Silicon carbide	264
Garnet	282
Emery	214

Lightweight Aggregates

H. S. WILSON *

During 1965 the construction industry achieved another peak of $9.9 billion, an increase of 14.9 per cent over the 1964 value of $8.6 billion. Table 1 shows the percentage change in value of the various types of construction from 1964 to 1965, and the percentage of the total represented by each type.

The various lightweight aggregates are used mainly in construction, particularly in types other than residential. Consequently, their consumption is related to changes in these types of construction.

The value of all lightweight aggregates used in 1965 increased 8.5 per cent over the 1964 value. Pumice showed the greatest increase amounting to 255 per cent over the previous year. Expanded slag increased 20.5 per cent in volume and 27.4 per cent in value. Expanded clay and shale increased 5.9 per cent in volume and 7.1 per cent in value. Exfoliated vermiculite showed an increase of 3.5 per cent in volume and 4.5 per cent in value. Expanded perlite was the only lightweight aggregate to show a decrease, which was 7.8 per cent and 5.1 per cent in volume and value.

Table 2 shows production and value of the different lightweight aggregates produced in 1964 and 1965. The accompanying graph shows the production of the four principal lightweight aggregates during the period 1954–1965.

TABLE 1

Construction in Canada, 1964–65

Type of Construction	Percentage Change 1964–65	Percentage of Total Value	
		1964	1965P
Engineering	+16.6	40.0	40.7
Residential	+ 5.7	30.2	27.7
Commercial	+21.3	9.8	10.4
Institutional	+31.5	8.9	10.2
Industrial	+14.4	7.7	7.7
Other building	+11.1	3.4	3.3

Source: Dominion Bureau of Statistics.
P: Preliminary.

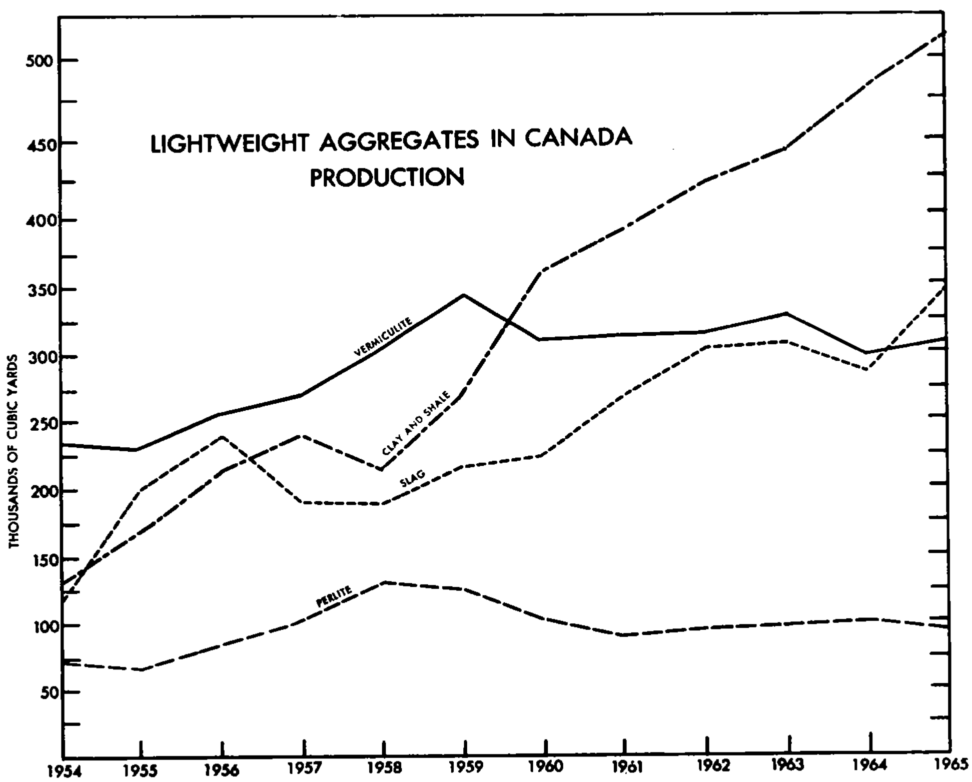
*Mineral Processing Division, Mines Branch

TABLE 2

Production of Lightweight Aggregates, 1964–65

	1964		1965	
	Cubic Yards	$	Cubic Yards	$
From domestic raw materials				
Expanded clay and shale	482,488	2,558,474	510,868	2,739,846
Expanded slag	286,840	688,834	345,515	877,313
From imported raw materials				
Exfoliated vermiculite	296,856	2,335,970	307,280	2,440,813
Expanded perlite	99,813	700,249	92,049	664,898
Pumice		38,080		135,088
Total		6,321,607		6,857,958

Source: Statistics supplied to Mineral Processing Division by producers.



SOURCES OF RAW MATERIALS AND PRODUCERS

Shales and common clays are the most widespread of the raw materials used for lightweight aggregate manufacture. Most plants obtain raw material from nearby deposits but one is supplied from a deposit 15 miles away.

Nine plants were in operation in 1965, as follows: Quebec – Laprairie; Ontario – Cooksville; Manitoba – St. Boniface (two); Saskatchewan – Regina (two); Alberta – Calgary and Edmonton; and British Columbia – Saturna Island. One plant at Lafleche, Quebec, was not in production in 1965. One plant in Edmonton, Alberta, was dismantled.

Expanded blast furnace slag is a processed byproduct of the iron and steel industry. It was produced at Hamilton, Ontario, and at Sydney, Nova Scotia.

Vermiculite is a type of hydrous mica that exfoliates when heated, to form a cellular material possessing good insulating properties. All the raw vermiculite exfoliated in Canada is imported from the United States and The Transvaal, South Africa. Five companies produced exfoliated vermiculite at 10 locations: British Columbia – Vancouver (two); Alberta – Calgary; Saskatchewan – Regina; Manitoba – Winnipeg and St. Boniface; Ontario – Toronto and St. Thomas; and Quebec – Lachine and Montreal.

Perlite is a volcanic rock that 'pops' when heated, to form a cellular product of low density. Deposits occur in central and southern British Columbia but they have not been developed commercially. Raw material is imported from the western United States for processing. Eight plants were in operation during the year: Quebec – Ville St. Pierre and Charlesbourg West; Ontario – Caledonia and Hagersville; Alberta – Calgary and Edmonton; British Columbia – Vancouver and Richmond.

Pumice, a highly vesicular material of volcanic origin, is used in its natural state as a lightweight aggregate. All the pumice used is imported from the United States since known Canadian deposits are either too small or too far from transportation facilities.

Table 3 lists the lightweight aggregate processing plants in Canada.

TABLE 3

Lightweight Aggregate Plants in Canada

Company	Location
Producing Plants	
Expanded clay	
Cindercrete Products Limited	Regina, Sask.
Consolidated Block and Pipe Ltd.	Regina, Sask.
Echo-Lite Aggregate Ltd.	St. Boniface, Man.
Edmonton Concrete Block Co. Ltd.	Edmonton, Alta.
Kildonan Concrete Products Ltd.*	St. Boniface, Man.
Expanded shale	
Aggrite (1962) Inc.	Laprairie, Que.
British Columbia Lightweight Aggregates Ltd.	Saturna Island, B.C.
Consolidated Concrete Limited	Calgary, Alta.
Domtar Construction Materials Ltd.	Cooksville, Ont.
Expanded slag	
Dominion Iron & Steel Limited	Sydney, N.S.
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. Toronto, Ont. St. Thomas, Ont.
Mid-West Expanded Ores Co. Ltd.	St. Boniface, Man.
Vermiculite Insulating Limited	Lachine, Que.
Western Gypsum Products Limited	Vancouver, B.C.
Perlite	
Canadian Gypsum Company, Limited	Hagersville, Ont.
Domtar Construction Materials Ltd.	Caledonia, Ont. Calgary, Alta.
Laurentide Perlite Inc.	Charlesbourg West, Que.
Perlite Industries Reg'd.	Ville St. Pierre, Que.
Vantec Industries Ltd,	Richmond, B.C.
Western Gypsum Products Limited	Vancouver, B.C.
Western Insulation Products Ltd.	Edmonton, Alta.
Pumice	
Miron Company Ltd.	Montreal, Que.
Ocean Cement Limited	Vancouver, B.C.

* Formerly Atlas Light Aggregate Ltd.

Table 3 (cont.)

Company	Location
Nonproducing Plants	
Expanded clay	
Featherock Inc.	St. François du Lac, Que.
Expanded shale	
Cell-Rock Inc.	Lafleche, Que.

CONSUMPTION

EXPANDED CLAY AND SHALE

Concrete blocks and precast concrete shapes accounted for 78 and 4 per cent of production in 1965, compared with 83 and 5 per cent in 1964. Cast-in-place structural concrete consumed 16 per cent in 1965, an increase of 5 per cent from the previous year. Minor uses, such as refractory products and race-track surfacing accounted for 2 per cent of production, 1 per cent higher than in 1964.

EXPANDED SLAG

In 1965, as in the two previous years, 98 per cent of production was used in concrete block. Precast concrete shapes and cast-in-place structural concrete accounted for 1 per cent of production, 1 per cent less than in 1964. One per cent was used as loose insulation and as race-track fill in 1965.

EXFOLIATED VERMICULITE

Loose insulation consumed 78 per cent of production in 1965, the same as in 1964. Plaster accounted for 11 per cent, 1 per cent less than in 1964. Seven per cent was used as aggregate in insulating concrete in 1965, an increase of 1 per cent from the previous year. Minor uses, including soil and fertilizer conditioners, underground insulation and barbecue base, amounted to 4 per cent in 1965, the same as in 1964.

EXPANDED PERLITE

The percentage of production used as plaster aggregate dropped 7 per cent, from 81 per cent in 1964 to 74 per cent in 1965. The same percentage decrease occurred from 1963 to 1964. Insulating concrete consumed 6 per cent in 1965, 3 per cent less than in 1964. Loose insulation accounted for 6 per cent in 1965. Other uses, such as in agriculture and in industrial applications consumed 14 per cent of production in 1965, an increase of 4 per cent from 1964.

PUMICE

In 1965, concrete block consumed 98 per cent of the pumice used as lightweight aggregate, and 2 per cent was used in cast-in-place concrete. In previous years, all had been used in concrete block.

PRICES

Expanded clay and shale sold at \$4.50 to \$6 a cubic yard and expanded slag at \$2.50 to \$3.85 a cubic yard. Exfoliated vermiculite sold at about 30 cents a cubic foot and expanded perlite at 25 to 35 cents a cubic foot. All prices are f.o.b. plant.

Aluminum

W.H. JACKSON*

Primary smelting capacity in Canada at the end of 1965 was 913,000 tons, unchanged from the end of 1964; an additional 24,000 tons was to be operative in the second quarter of 1966. Production was 840,346 tons, little changed from 1964's output of 842,640 tons. Smelter shipments of primary forms directly to the domestic market totalled 161,767 tons compared with 150,950 tons in 1964.

Primary export shipments of 707,512 tons had a value of $337 million. This value places aluminum third in rank of metal exports, exceeded only by iron ore and nickel. As shown in Table 1, most of the increase resulted from demand in the United States. Exports of semifabricated products rose to 26,421 tons from 18,054 tons. Total exports of aluminum and its products were valued at $371.6 million and represented 4.36 per cent of total domestic exports of $8.5 billion in 1965.

Canadian consumption at the first processing stage (Table 3), as reported by consumers, includes primary, secondary and scrap from all sources. Consumption in 1965 increased 23 per cent to 213,094 tons and reflects increases in the manufacture of rod, sheet, extrusions and die-castings.

DOMESTIC INDUSTRY AND DEVELOPMENTS

Only two companies operate aluminum reduction plants in Canada. Plant locations and capacities are shown in the accompanying map and in Table 4.

Canadian British Aluminium Company Limited had an estimated annual capacity of 105,000 tons at Baie Comeau, Quebec. Plant improvements at this smelter will permit operation at 115,000 tons annually in 1966. A planned addition of 60,000 tons will raise capacity to 175,000 tons by 1969-70.

Plants of the Aluminum Company of Canada, Limited, have a nominal capacity of 808,000 tons. An additional 24,000 tons will be operative at Kitimat in the second quarter of 1966, which will raise capacity at this smelter to 236,000 tons. A further 24,000 tons is under construction.

* Mineral Resources Division

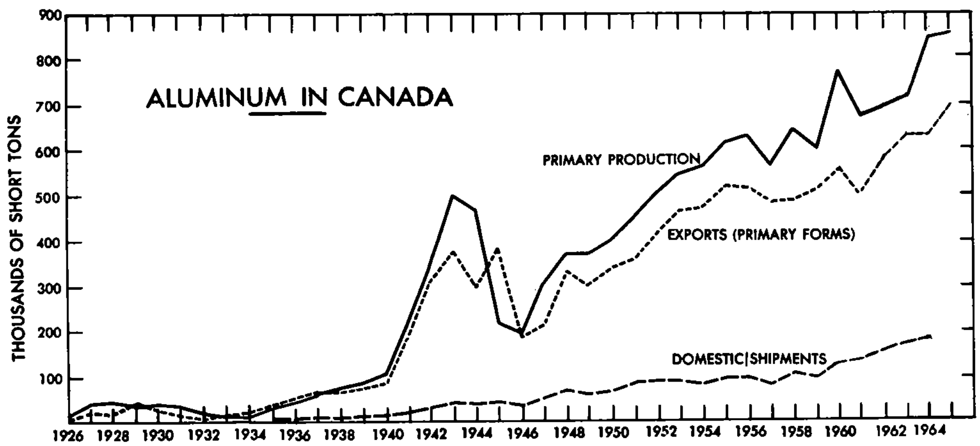


TABLE 1

Canadian Aluminum Production and Trade, 1964-65

	1964		1965P	
	Short Tons	$	Short Tons	$
Production				
Ingot	842,640		840,346	
Imports				
Bauxite ore				
Surinam	718,315	6,453,942	931,059	8,498,811
British Guiana (Guyana)	974,828	7,162,587	898,922	6,968,377
Malaysia	–	–	122,591	654,631
Republic of Guinea	57,717	244,177	85,713	381,385
United States	449	29,957	8,789	248,127
Total	1,751,309	13,890,663	2,047,074	16,751,331
Alumina				
Jamaica	486,301	29,967,771	457,589	28,201,888
United States	193,121	14,360,286	191,096	14,148,495
British Guiana (Guyana)	167,902	9,875,757	140,159	8,610,777
Republic of Guinea	23,568	1,462,731	11,023	684,755
Other countries	82	18,971	110	26,223
Total	870,974	55,685,516	799,977	51,672,138
Aluminum and aluminum alloy scrap	20,112	848,301	33,218	1,447,075
Aluminum paste and powder	280	239,457	904	571,162
Aluminum pigs, ingots, shot, slabs, billets, blooms and extruded wire bars	3,996	2,613,293	6,945	4,252,802
Aluminum castings and forgings	1,094	2,762,510	1,565	3,646,320
Aluminum bars and rods, n.e.s.	545	719,811	789	1,010,453
Aluminum plates	2,017	2,456,129	2,776	2,898,740
Aluminum sheets and strips	32,880	23,989,860	39,286	28,257,139
Aluminum foil or leaf	645	882,787	570	774,282
Converted aluminum foil		840,776		966,259
Structural shapes, aluminum	988	1,837,913	1,409	3,165,134
Aluminum pipe and tubing	349	605,764	530	815,493
Aluminum wire and cable excluding insulated	352	298,869	349	321,477
Aluminum and aluminum alloy fabricated materials, n.e.s.		3,177,558		3,635,269

Table 1 (cont.)

	1964		1965P	
	Short Tons	$	Short Tons	$
Exports				
Pigs, ingots, shot, slab, billets, blooms and extruded wire bars				
United States	254,673	115,584,395	347,990	156,388,857
Britain	189,021	96,637,849	183,548	96,446,783
Japan	24,086	11,531,008	25,944	11,996,273
Republic of South Africa	18,184	8,389,181	20,878	10,493,239
West Germany	42,332	20,433,701	17,965	8,106,420
Italy	4,353	1,919,729	14,559	6,206,346
Spain	7,911	3,409,385	11,982	5,132,231
Ireland	8,489	4,217,676	7,823	3,965,925
Argentina	5,699	2,853,144	7,536	3,841,173
Brazil	9,580	4,394,229	7,162	3,338,557
New Zealand	7,575	3,743,603	6,784	3,458,828
Belgium and Luxembourg	3,758	1,918,775	5,100	2,606,307
Sweden	7,617	3,475,623	4,904	2,419,586
Other countries	44,714	21,737,507	45,337	22,754,233
Total	627,992	300,245,805	707,512	337,154,758
Bars, rods, plates, sheet, circles, castings and forgings				
India	6,825	3,645,878	10,422	4,874,317
United States	3,527	2,400,221	6,271	4,615,074
Czechoslovakia	–	–	1,978	1,035,272
Spain	1,787	848,835	1,754	888,324
New Zealand	1,141	620,642	1,279	712,131
Portugal	483	230,252	898	501,739
Republic of South Africa	395	307,120	680	572,860
Jamaica	156	134,026	486	407,573
France	326	299,088	418	313,236
Trinidad-Tobago	63	51,825	392	303,460
Other countries	3,351	2,214,757	1,843	1,673,868
Total	18,054	10,752,644	26,421	15,897,854
Foil				
Britain	270	285,703	194	225,264
United States	52	34,956	135	95,404
New Zealand	31	33,873	44	58,698
Philippines	2	2,994	12	18,046
Other countries	24	34,543	50	64,172
Total	379	392,069	435	461,584
Fabricated materials, n.e.s.				
Nigeria	1,577	757,219	3,051	1,372,883
Mexico	472	234,837	1,365	690,659
Pakistan	608	348,385	1,346	761,350
Venezuela	675	438,071	1,078	751,527
United States	820	878,793	1,057	1,024,209
Bolivia	67	45,627	600	378,131
Republic of South Africa	140	126,840	448	273,004
Other countries	6,046	3,716,538	2,677	2,199,300
Total	10,405	6,546,310	11,622	7,451,063
In ores and concentrates (alumina)				
United States	4,726	497,515	7,273	853,087
Colombia	276	11,788	165	6,214
Other countries	39	10,635	331	42,612
Total	5,041	519,938	7,769	901,913

Table 1 (cont.)

	1964		1965p	
	Short Tons	$	Short Tons	$
Scrap				
United States	16,735	2,550,104	20,595	4,141,756
Italy	7,715	2,765,677	11,996	4,423,864
Japan	5,270	1,997,284	4,295	1,630,264
West Germany	1,735	302,077	1,224	194,223
Other countries	1,352	543,725	806	237,365
Total	32,807	8,158,867	38,916	10,627,472

Source: Dominion Bureau of Statistics.
p Preliminary; — Nil; n.e.s. Not elsewhere specified.

TABLE 2

Primary Aluminum Production, Trade and Consumption in Canada, 1956-65
(short tons)

	Production	Imports	Exports	Consumption*
1956	620,321	1,405	508,994	91,869
1957	556,715	2,122	478,670	77,984
1958	634,102	11,257	484,438	101,886
1959	593,630	852	507,290	89,000
1960	762,012	501	552,155	120,831
1961	663,173	636	487,034	135,575
1962	690,297	3,855	576,206	151,893
1963	719,390	1,954	635,187	161,833
1964	842,640	3,996	627,992	172,443r
1965p	840,346	6,945	707,512	205,282

* Producers' domestic shipments to 1959; consumer reports from 1960.
p Preliminary; r Revised.

TABLE 3

Canadian Consumption of Aluminum at First Processing Stage
(short tons)

	1962	1963	1964	1965p
Castings				
Sand	1,472	1,212	1,399	1,367
Permanent-mould	2,583	3,040	5,039r	7,509
Die	4,571	6,806	7,702r	13,202
Other	747	801	121	4,375
Total	9,373	11,859	14,261	26,453
Wrought products				
Extrusions, including tubing	41,229	40,900	41,664	48,589
Sheet, plate, coil and other (including rod, forgings and slugs)	97,792	105,160	110,338r	130,318
Total	139,021	146,060	152,002r	178,907

Table 3 (cont.)

	1962	1963	1964	1965p
Destructive Uses				
Nonaluminum-base alloys, powder and paste	1,604	1,559	2,662	3,600
Deoxidizers	1,895	2,355	2,827	3,524
Other uses	..	..	691	610
Total	3,499	3,914	6,180	7,734
Total consumed	151,893	161,833	172,443r	213,094
Secondary aluminum produced	11,422	14,995	19,342r	23,570
Receipts and inventories at plants	Metal Entering Plant		On Hand Dec. 31	
	1964	1965p	1964	1965p
Primary aluminum ingot and alloys	172,002r	186,021	63,562r	47,873
Secondary aluminum	6,597	8,110	641	719
Scrap originating outside plant	24,575	26,634	2,240	2,579

Source: Dominion Bureau of Statistics as reported by consumers, adjusted.
p Preliminary; .. Not available; r Revised.

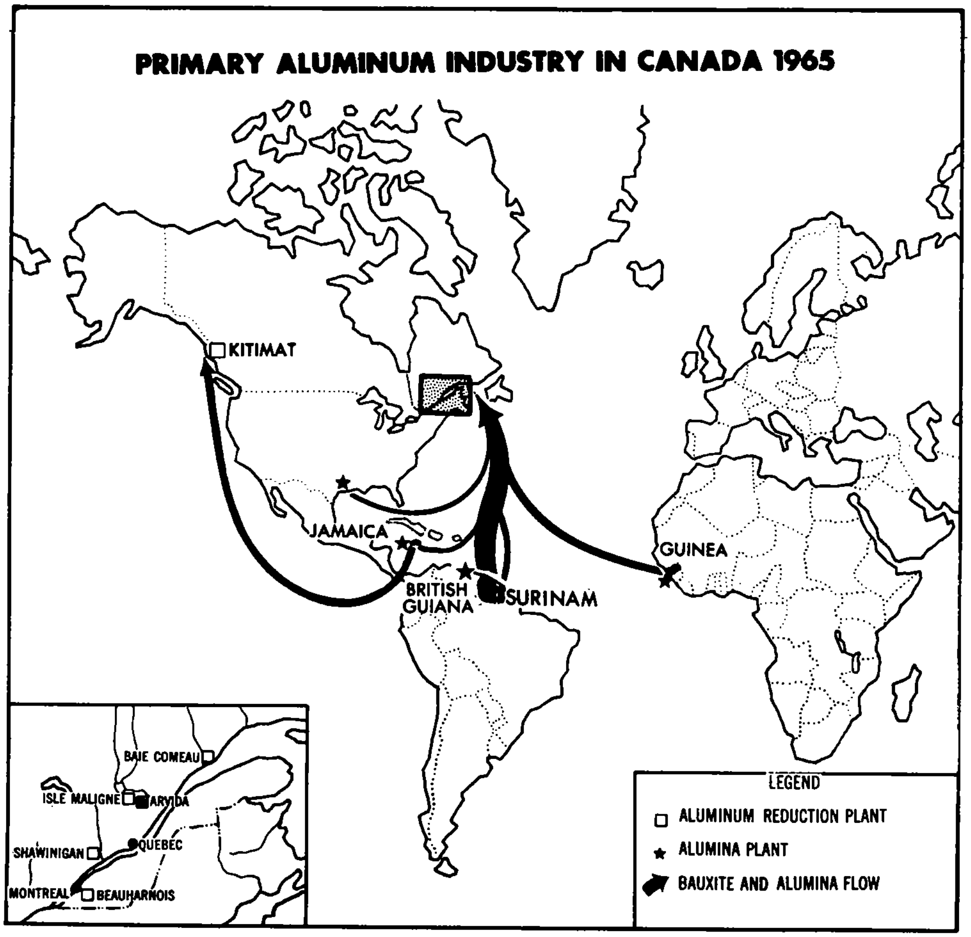


TABLE 4

Annual Capacities of Canadian Aluminum Plants
December 31, 1965

Company and Plant Locations	Annual Capacity (short tons)
Aluminum Company of Canada, Limited (ALCAN)	
Arvida, Quebec	373,000
Beauharnois, Quebec	38,000
Shawinigan, Quebec	70,000
Alma, Quebec	115,000
Kitimat, B.C.	212,000
Canadian British Aluminium Company Limited (CBA)	
Baie Comeau, Quebec	105,000
Total	913,000

At the end of 1964, ALCAN was operating in Canada at 94 per cent of its 808,000-ton capacity. In January 1965, the rate of production was lowered by the shut-down of two pot-lines at Arvida, representing 35,000 tons, and in March a 19,000-ton line at Beauharnois was shut down. During this period the company concentrated on renovation of pot-lines in some reduction plants in anticipation of renewed demand that developed during the year and which was expected to continue in 1966. ALCAN production was 728,400 tons in 1965, an average operating rate of 90 per cent, and 800,000 tons were initially scheduled for 1966.

ALCAN is the main subsidiary of Aluminium Limited. Other subsidiaries outside of Canada operated at near-capacity to produce 269,000 tons of ingot compared with 245,000 tons in 1964. Total sales of ingot products by ALCAN group companies to customers, other than affiliated plants, totalled 471,000 tons compared with 418,300 tons in 1964. Sales of semifabricated products accounted for almost 50 per cent of the tonnage produced by the group. Normal expansion of fabricating activities continued in Canada and elsewhere. The main development was a 200,000-ton rolling mill in West Germany to be built by 1968 at a cost of $70 million in partnership with Vereinigte Aluminium-Werke A.G.

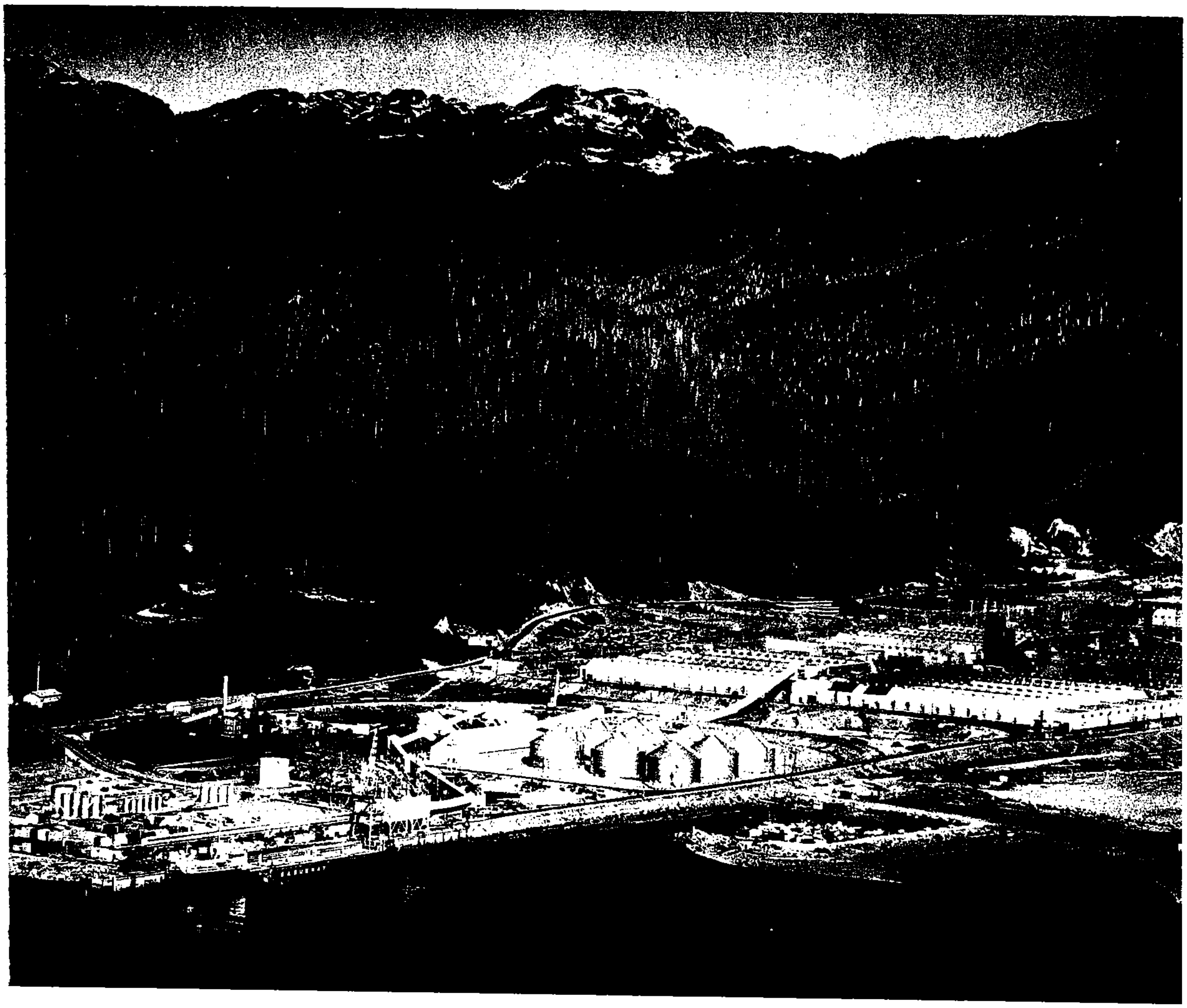
ORE SUPPLY AND TRENDS

Arvida works in Quebec has the only facilities in Canada to process bauxite to alumina. Alumina imports from Guinea and the United States are destined for the Baie Comeau smelter. Alumina plants owned by the Aluminum Company of Canada, Limited, at Kirkvine and Ewarton in Jamaica and at Mackenzie, Guyana (formerly British Guiana), supply the import needs of Alcan smelters in Canada and also sell to others. Expansion of the two Jamaican plants of Alcan Jamaica Limited to 615,000 long tons a year each will increase 1965 capacity by 360,000 tons. In 1965, all Alcan bauxite production in Jamaica was converted into alumina and 720,793 long tons of alumina were exported. The other Jamaican mines associated with Kaiser, Reynolds and Alcoa organizations export ores. Total Jamaican production was 8,514,365 dry long tons of bauxite.

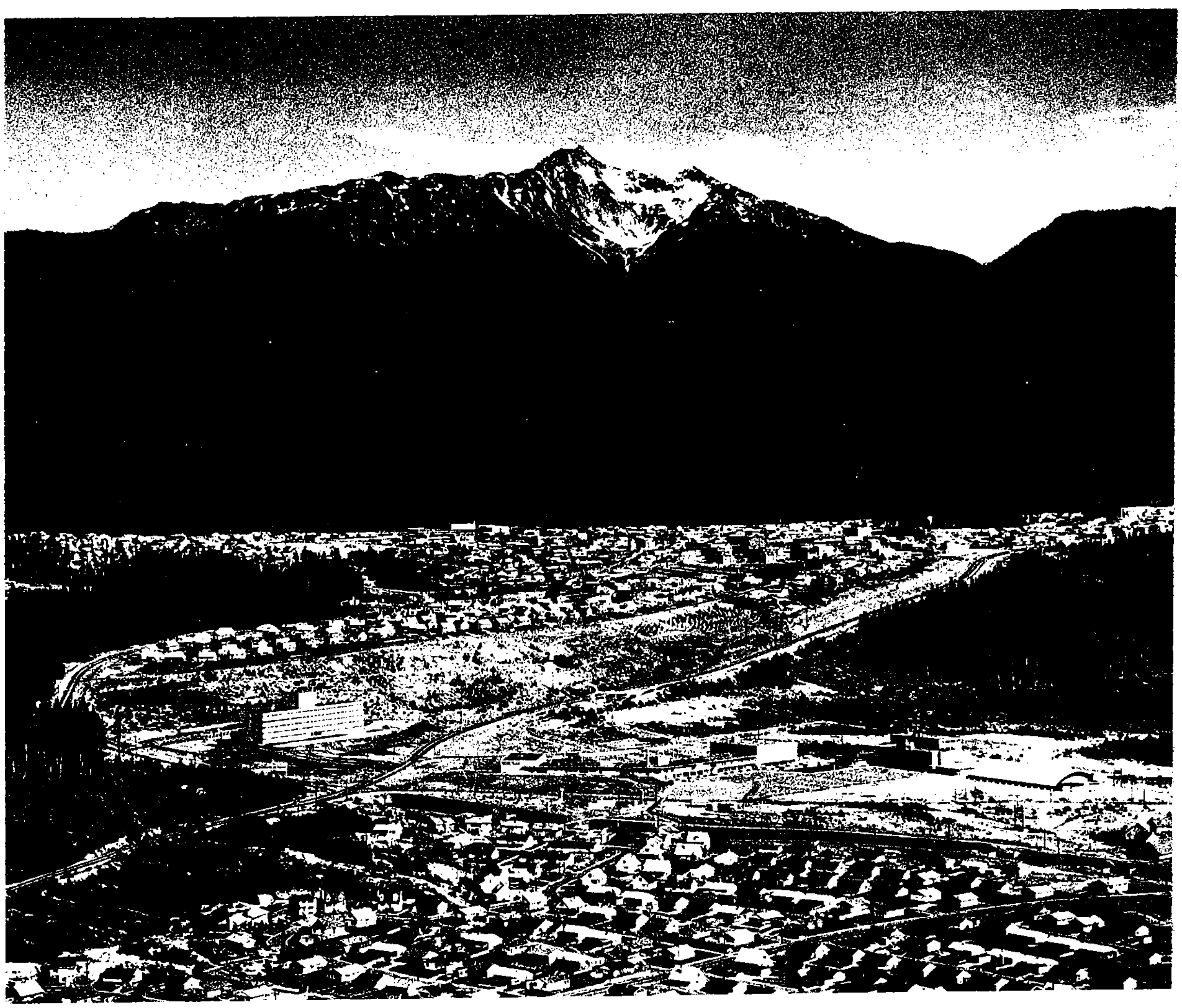
In Guyana, the Demerara Bauxite Company in 1965 shipped 821,240 long tons of dried bauxite, 485,953 tons of calcined bauxite, and 274,662 tons of alumina. Expansion plans call for increasing the output of calcined bauxite by some 30 per cent of current 500,000-ton-a-year capacity. The Reynolds Metals Company also mines bauxite in Guyana and produced 376,000 tons. The mining and processing of bauxite are the major industries in Guyana and Jamaica, which is the largest world producer of bauxite.

Major aluminum producers have exploration staffs to search for and outline bauxite reserves. Independent companies engaged in bauxite mining are rare. In general, any bauxite containing over 40 per cent alumina and less than 4 per cent reactive silica, is worthy of investigation. Transportation is a major factor in the economic assessment of any bauxite deposit but it assumes even greater importance in undeveloped regions. Clays and shales have been investigated from time to time as sources of alumina, usually in areas remote from bauxite or alumina sources. In 1965, The Anaconda Company continued investigating the economics of utilizing Georgia clays containing 30 to 33 per cent alumina and the Republic of South Africa was similarly interested. The U.S.S.R. has produced alumina from nepheline syenite and alunite for a number of years. However, the industry will continue to rely on bauxite for aluminum production. Some very large bauxite areas are known that have not been intensively developed and many of the tropical countries remain good prospecting ground for bauxite.

The Kitimat reduction works of Aluminum Company of Canada, Limited in British Columbia, with shipping facilities in the foreground.



Town of Kitimat.



The major recent developments have been in the Caribbean area and in Australia. There is no shortage of developed ore in the world.

Bauxite mining and alumina refining are developed well in advance of demand. Some developing countries such as Ghana, Guinea, India and Surinam are in the fortunate position of having both bauxite and sources of electric power. Aluminum is a key factor in their resource development and economic advance.

Bauxite is a mixture of minerals which are lateritic weathering products of rocks such as limestones, nepheline syenites, basalts, granites or clays from which silica has been leached. Generally, the metal-grade ore or concentrates contain over 40 per cent Al_2O_3 and less than 4 per cent reactive silica. The better ores are around 2 per cent. The alumina content is preferably in the form of the mineral gibbsite ($Al_2O_3.3H_2O$) which can be leached with weak caustic soda solutions at 142°C and about 10 atmospheres pressure. Boehmite ($Al_2O_3.H_2O$) and diaspore ($Al_2O_3.H_2O$) are the other aluminum minerals of commercial interest but these require stronger solutions and higher temperatures (225°C) and pressures up to 35 atmospheres. The other minerals in a particular deposit such as kaolinite and halloysite are undesirable as is quartz if it is sufficiently fine-grained to react significantly. Phosphates, manganese minerals and, in particular, oxides of iron and titanium complicate recovery but are not as serious as the silica content or the proportions of aluminous minerals which determine whether the Bayer or Combination process is used.

The main requirements for alumina plants, in addition to ore, are heat and caustic soda at lowest cost in relation to transportation.

The relative costs of the materials at the plant coupled with capital and tax considerations determine alumina plant locations. The general trend has been to establish new plants near sources of ore. Efficient alumina plants attempt to maintain purity of the calcined product at 99.6 per cent Al_2O_3 or better.

Quite different considerations affect smelter locations than affect alumina plant locations. The main process items of operating cost per ton of metal produced are 16,000 kilowatts of electricity at prices ranging from 1.5 to 6 mills, 0.6 ton of petroleum coke which sells f.o.b. refinery for about $9.50 a ton, two tons of alumina, and transportation of metal to markets. Higher power costs can be justified if a smelter is located close to markets which generally affect the competitive position of other producers located in remote areas. Tariffs as well as corporate affiliation influence the economics of smelter construction.

E & MJ Metal and Mineral Markets quotes the following prices f.o.b. Atlantic ports per long dry ton. For bauxite: abrasive grade, 87 per cent minimum Al_2O_3, less than 7 per cent SiO_2, $27.05 to $28.80; refractory grade, 88 per cent minimum Al_2O_3, $36.25. These two grades are calcined products from which the combined water has been driven off. Chemical-grade bauxite is dried and crushed but not calcined. It is worth $13.95 a long ton with 60 per cent Al_2O_3, 6 per cent silica and 1½ per cent iron. It comes mainly from Surinam and Guyana from selective mining or beneficiation operations. Metal-grade bauxite is not quoted and prices are subject to negotiation between buyer and seller. Canadian import data record port-of-origin prices of $4.50 and $5.50, respectively, for bauxite from Guinea and Malaysia, $9.12 for Surinam and $7.75 for British Guiana. Grades are not specified in import data. Ore contracts normally call for a fixed price with bonus or penalty clause for impurities such as silica. Similarly, metal-grade alumina is subject to long-term contracts based on a basic price with escalation clauses related to the price of metal. Again import data suggest that going prices range from $62 to $74 a short ton, port of origin. Alumina is white powder, and is the raw material for aluminum production. It is used in papermaking, in the production refractories, and in abrasives. The chemical industry uses it to produce aluminum fluoride, aluminum sulphate, and aluminum chloride. Activated aluminas are used for drying liquids and gases but its main use in the chemical industry is as a catalyst carrier.

WORLD DEVELOPMENTS

Free World production of aluminum in 1965 was around 5,563,000 short tons out of total world production of 7,005,000 tons. For 1966, the outlook is for record production which will be close to capacity and in rough balance with consumption. Projections of demand suggest an average increase of 7 to 8 per cent annually for the next few years.

Having just recovered from the effects of overexpansion in the nineteen-fifties, aluminum producers have been cautious in scheduling new smelter construction. The trend has been to expand, modernize and otherwise improve efficiencies at existing plants. New construction is well publicized and competitors can gauge market patterns and advance or retard planning accordingly. For several years surplus capacity resulted in unsatisfactory returns on invested capital at the mines and smelters. To maintain productivity and local price structures, companies not normally exporters sold on export markets, resulting in strong competition. The basic need for markets caused an acceleration of the trend to integrate production and fabricating facilities. At the same time the need for metal at lowest cost resulted in some fabricators entering the smelting business. In the process, the aluminum industry became truly international in character. North American producers invested capital and technology in fabricating plants around the world, particularly in Europe, and European producers have invested in America.

Using the United States as a standard for comparison of aluminum consumption in relation to 1964 Gross National Product, Japan and the United Kingdom, both of which are exporters of fabricated products, are well developed markets. Canada ranks slightly behind them. Of the industrialized countries, the European Economic Community (EEC) and Australia offer the best opportunities for market development in terms of 1964 GNP. Subsequent plans announced for increased fabrication in the two areas appear adequate to fill the gap. For the rest of the world, particularly the countries emerging into industrialization, current consumption is fairly well developed in relation to purchasing power. The latent demand in these countries can only be realized as output in goods and services is developed and as purchasing power rises.

In the United States, shipments of products exceeded 4 million tons in 1965, a gain of 12 per cent from the previous year. Primary aluminum output was at capacity and rose almost 8 per cent to 2.75 million tons. About 527,000 tons of new metal were imported and 27,500 tons of U.S. Government stockpiled metal was sold back to the producers. Secondary alloy ingot contributed another 515,000 tons to supply. U.S. exports of primary were 206,959 tons in 1965. The relatively low export figure reflects the strong domestic market. At year's end, the eight companies producing primary aluminum had a combined annual capacity of 2,789,000 tons and an additional 371,000 tons was under construction. The movement of hot metal by truck or train directly from primary or secondary smelters to consumers up to 300 miles away, is a growing trend in the United States. There is a worthwhile saving in remelt costs but most Canadian smelters are not in locations favouring a spread of this technique.

The United States has had a short-term disposal program for its aluminum stockpile in the last two years but only 135,000 tons of metal were sold, most of it being purchased by the major aluminum producers at market prices. Stockpile objectives have been reviewed periodically. The stockpile objective for aluminum is now 450,000 tons. In November, a disposal program covering a 10- to 15-year period was announced for 1,448,483 tons declared surplus to stockpile needs. Congressional approval would be needed for disposals in excess of 730,000 tons. Defence needs for 1966 were estimated to be from 300,000 to 400,000 tons, about 150,000 to 200,000 tons higher than in 1965. The disposal plan called for the aluminum producers to purchase 150,000 tons in 1966 and between 100,000 minimum and 200,000 tons maximum thereafter each year depending on defence requirements.

The policies of the Australian government and the favourable investment climate in Australia resulted in extraordinarily rapid development of that country's immense bauxite resources. Alcoa of Australia operates a 40,000-ton smelter at Port Henry based on bauxite from Western Australia. Its alumina plant at Kwinana will be enlarged from 210,000 to 410,000 tons. In the Weipa area, 2½ million tons of bauxite will be produced annually by 1967 from leases in Weipa, Queensland. Half of it will feed the Gladstone alumina plant which is exceeded in size only by the project in Surinam. In the same area, Alcan's leases are conservatively estimated to have reserves of 75 million tons. The first ore shipments from them will be to Japan. The location of the Queensland deposits suggests that low-cost power sources and related smelters may be ultimately developed in New Zealand and, possibly, New Guinea. Comalco Industries Limited has announced expansion of its Bell Bay smelter in Tasmania from 54,000 tons to 71,500 tons a year by the fall of 1967. Aluminium Limited announced that a 30,000- to 40,000-ton smelter costing $25 million will be constructed near Newcastle by 1969. A subsidiary company is the largest fabricator in Australia with a fabricating capacity of some 35,000 tons.

Australian consumption in 1964 was 64,000 tons. By 1969, Australian capacity will be a minimum of 141,500 tons of primary aluminum. If expansion plans are fully implemented, Australia will be in the position of having capacity in excess of domestic needs. In mid-1965, the price of ingot in Australia was about 1.8 cents a pound higher than the world export price.

Within the EEC there were a number of developments. In Greece, an associate member, an 80,000-ton smelter was to be operative in April 1966 while in Italy a 110,000-ton smelter is to be constructed in Sardinia by 1968. Surinam, also an associate member of the EEC, had initial production in July from a 200,000-ton alumina plant. By mid-1967 capacity will be 800,000 tons. The Paranam smelter of 50,000-ton capacity started October 9.

Of the EFTA countries, Norway is the main producer. Its industry is similar to that of Canada, being a major producer for export. Capacity has increased from 108,000 tons in 1955 to 349,000 tons in 1965.

Power from the Volta dam in Ghana commenced in September 1965. A smelter capable of 100,000 tons production is under construction at Tema. The first metal is expected in March 1967. Currently, the Edea plant in Cameroun is the only smelter in Africa. In Guinea, the United States Agency for International Development has agreed to guarantee the $20 million planned investment by Halco Mining, Inc., a subsidiary of Harvey Aluminum (Incorporated). A related alumina plant on St. Croix Island in the Virgin Islands was under construction in 1965. Tropical countries on the west side of Africa will probably continue to attract major development capital in the coming years. Their ore potential and hydroelectric resources have hardly been developed.

In Asia, India had a capacity of 112,000 metric tons. Japan, which produced 322,000 tons in 1965, will have additional capacity at Kambara at the end of 1967 amounting to 154,000 tons.

USES

Aluminum castings have varied end-uses such as motor parts, housings, and items for structural or decorative purposes. Extrusions are typically used in conjunction with sheet in curtain-wall systems of building construction, in the manufacture of trucks, trailer bodies, railroad cars, residential doors and windows, irrigation pipe and as tubing for lightweight furniture. Aluminum rod goes into the making of electrical wire and cable. End uses for sheet include building sheathing, cans, household utensils, foil and slugs for making collapsible tubes.

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.

In the United States, the Statistical Committee of the Aluminum Association estimates that of the 8.1 million pounds shipped in 1965, 22.9 per cent went into Building and Construction, 22.7 per cent Transportation, 13.2 per cent Electrical, 10.3 per cent Consumer Durables, 8.1 per cent Containers and Packaging, 7 per cent Machinery and Equipment, 7 per cent Exports, and 8.8 per cent to other uses.

PRICES

The export price remained constant at 24.5 cents U.S. a pound throughout 1965. In November, there was a short-lived attempt to raise the U.S. price from 24.5 cents to 25 cents a pound. The Canadian price was unchanged at 26 cents delivered.

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Bauxite and alumina	free	free	free
Aluminum and aluminum alloys, pigs, ingots, blocks, notch bars, slabs, billets, blooms and wire bars	free	1¼¢ a lb	5¢ a lb
Bars, rods, plates, sheets, strips, circles, squares, disks and rectangles	free	3¢ a lb	7½¢ a lb
	(%)	(%)	(%)
Angles, channels, beams, tees, and other rolled, drawn or extruded sections and shapes	free	22½	30
Wire and cable, twisted or stranded or not, and whether reinforced with steel or not	free	22½	30
Pipes and tubes	free	22½	30
Leaf n.o.p. or foil, less than 0.005 in. in thickness, plain or embossed, with or without backing	free	30	30
Aluminum powder	free	27½	30
Aluminum leaf less than 0.005 mm in thickness	free	free	free
Aluminum scrap	free	free	free
Manufactures of aluminum n.o.p.	15	22½	30
Kitchen or household hollow ware of aluminum, n.o.p.	20	22½	30

n.o.p. Not otherwise provided for

United States

Bauxite	50¢ per long ton (temporarily suspended)
Unwrought aluminum	
Of uniform cross section throughout its length, the least cross section dimension of which is not greater than 0.375 in., in coils	2.5¢ a lb
Other	
Aluminum other than alloys of aluminum	1.25¢ a lb
Alloys of aluminum	
Aluminum silicon	2.125¢ a lb
Other	1.25¢ a lb
Aluminum waste and scrap	1.5¢ a lb (suspended)
Wrought rods of aluminum	2.5¢ a lb
Angles, shapes, and sections, all the foregoing which are wrought, of aluminum	19% ad val.
Aluminum wire	
Not coated or plated with metal	12.5% ad val.
Coated or plated with metal	0.1¢ a lb +12.5% ad val.
Bars, plates, sheets, and strip, all the foregoing are wrought, of aluminum, whether or not cut, pressed, or stamped to non-rectangular shapes	
Not clad	2.5¢ a lb
Clad	
Wholly of aluminum	2.5¢ a lb
Other	24% ad val.
Aluminum powders and flakes	
Flakes	5.1¢ a lb
Powders	19% ad val.
Pipe and tubes and blanks therefor, pipe and tube fittings, all the foregoing of aluminum	
Hollow cast extrusion ingots	1.25¢ a lb
Other	19% ad val.
Aluminum foils not backed or cut to shape	
Etched capacitor foil	17% ad val.

Antimony

D.B. FRASER *

Antimony is a minor constituent of certain lead-zinc ores in Canada. It is recovered in the form of antimonial lead derived from lead smelting operations. There has been no production of antimony metal or regulus in Canada since 1944. Primary output in 1965, expressed as the antimony content of antimonial lead alloys, was 1.2 million pounds compared with 1.6 million pounds in 1964.

Canadian requirements of antimony metal and antimony oxide are imported. Statistics on metal imports were discontinued in 1964 but in earlier years the main suppliers were Communist China and Yugoslavia, which mine and refine antimony ores, and western European countries which import antimony ores and export refined metal. Oxide imports in 1965 came mainly from Britain, the United States and Communist China.

Cominco Ltd. (formerly The Consolidated Mining and Smelting Company of Canada Limited), which operates a lead smelter and refinery at Trail, British Columbia, was the only producer of primary antimonial lead. Secondary smelters recovered antimonial lead from scrap metal but information on this production is not available.

The main source of the antimonial lead produced at Trail is the lead concentrate from Cominco's Sullivan mine at Kimberley, B.C. 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 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 a marketable product.

Canadian occurrences of the principal antimony mineral, stibnite (Sb_2S_3), have been reported in widely separated locations. On occasion, over many years, several of the occurrences have been explored and partially developed but results were generally discouraging. The better known occurrences are: the Mortons Harbour mine, New World Island, Notre Dame Bay, Nfld.; the West Gore deposits, Hants County, N.S.; the Lake George property, Prince William parish, York County, N.B.; the South Ham deposit, Wolfe County, Que.; and the Stuart Lake mine, near Fort St. James, B.C. Other occurrences are on record as follows: British Columbia – near the confluence of the Tulsequah and Taku rivers in the northwestern part of the province, near Bralorne in the Bridge River district and near Slocan City and Sandon in the Slocan district; Yukon Territory – south of Whitehorse in the Wheaton River area and near Highet Creek in the Mayo district.

*Mineral Resources Division

TABLE 1

Antimony — Production, Trade and Consumption, 1964-65

	1964		1965P	
	Pounds	$	Pounds	$
Production				
Antimony content of antimonial lead alloys	1,591,523	700,270	1,232,665	653,312
Imports				
Antimony oxide				
Britain	403,700	183,269	421,100	203,126
China	110,200	34,757	121,700	58,171
United States	122,200	64,685	65,700	32,429
Belgium and Luxembourg	28,600	17,606	7,000	3,458
West Germany	45,000	30,464	—	—
Total	709,700	330,781	615,500	297,184
Consumption				
Antimony regulus in production of:				
Antimonial lead alloys	277,190		363,752	
Babbitt	72,020		48,295	
Solder	16,374		24,925	
Type metal	141,484		181,499	
Other commodities*	51,023		41,166	
Total	558,091		659,637	

Source: Dominion Bureau of Statistics.

*Includes foil, bronze, lead-base alloys, drop shot and other minor commodities.

PPreliminary; — Nil.

Yukon Antimony Corporation Ltd., which in 1964 began a re-examination of the Wheaton River deposits in the Yukon Territory, completed in 1965 the construction of access roads to the Becker-Cochran group of claims on Carbon Hill, 55 miles south of Whitehorse, and carried out a mapping and stripping program. Underground exploration was started in September. The company reported that a large number of veins and shear zones had been located on Carbon and Chieftain hills, and that exploration in 1965, which was centred on Carbon Hill, had indicated some 350,000 tons averaging 5 per cent antimony.

World mine production of antimony in 1964, as compiled by the United States Bureau of Mines, totalled 68,000 tons, about 6,000 tons more than in 1963. Antimony ores are mined in only a few countries. The largest producer is China where small quartz veins containing antimony are mined in Hunan province, south-central China. The Republic of South Africa is the next largest source, its output being accounted for entirely by the antimony-gold mine of Consolidated Murchison (Transvaal) Goldfields Development Company Limited near Pietersburg, in the northeastern part of the country. Bolivia has several antimony mines. Mexico's production of antimony ore is treated at Laredo, Texas, where National Lead Company operates the world's largest smelter of antimony ores and concentrates. A second source is the antimony recovered as a byproduct of lead ores in such countries as Canada and the United States; the amounts are relatively small compared with the recovery from primary antimony ores. A third source is the scrap lead treated at lead smelters; this secondary supply accounts for a large part of total antimony supply in large consuming countries such as the United States and Britain.

World supplies of antimony increased during 1965 because of expanded mine output in the Republic of South Africa and Bolivia, and increased exports from China. Of the 5,000 tons of antimony authorized in October 1964 for disposal from the United States government stockpile, 2,500 tons were released during the last quarter of 1964; there were no further releases in 1965.

TABLE 2

Antimony — Production, Imports and Consumption, 1956-65 (pounds)

	Production* (all forms)	Imports (regulus)	Consumption** (regulus)
1956	2,140,432	1,803,630	1,478,000
1957	1,360,731	1,794,846	1,401,000
1958	858,633	808,053	1,027,000
1959	1,657,797	1,170,796	1,135,000
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
1965P	1,232,665	..	660,000

Source: Dominion Bureau of Statistics.

*1956 and 1957 inclusive, antimony content of antimonial lead alloys, flue dust and dore slag; from 1958 antimony content of antimonial lead alloy.
**Consumption of antimony regulus as reported by consumers. Does not include antimony in antimonial lead produced by COMINCO.

PPreliminary; .. Not available.

USES

The most important use of antimony is as a hardening and strengthening ingredient in many lead alloys. Antimonial lead alloys have many uses but the main one is in the manufacture of lead storage batteries in which battery plate grids, terminal posts and other parts are made of antimonial lead containing up to 12 per cent antimony. Battery lead alloys commonly contain 3 to 5 per cent antimony. Antimonial lead alloys are used also for sheathing electric cables and in pipe and sheet. Antimony is useful in lead-base type metal for the expansion-on-solidification effect which it imparts to lead. With lead and tin, antimony is used as a minor constituent of antifriction bearing metal and solder.

Substantial amounts of antimony are used in the form of antimony oxide, which is usually produced directly from high-grade ore (60 per cent or more antimony content). Antimony oxide is used mainly as a flameproofing additive to paints, plastics and fabrics. It is also valuable in enamel coverings to which it adds hardness and acid resistance. The pentasulphide of antimony is used as a vulcanizing agent by the rubber industry and as a red pigment. Other

TABLE 3

World Mine Production of Antimony (short tons)

	1963	1964
China	16,500e	16,500e
Republic of South Africa (exports)	12,410	14,200
Bolivia (exports)	8,337	10,626
U.S.S.R.	6,700e	6,700e
Mexico	5,320	5,278
Yugoslavia	2,933	3,008
Other countries	9,400	11,688
Total	61,600	68,000

Source: United States Bureau of Mines *Minerals Yearbook, 1964.*
e Estimate.

TABLE 4

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

Product	1964	1965P
Metal Products		
Ammunition	15	*
Antimonial lead**	5,952	5,155
Bearing metal and bearings	804	807
Cable covering	49	23
Castings	50	33
Collapsible tubes and foil	53	28
Sheet and pipe	99	89
Solder	149	227
Type metal**	513	243
Other	167	107
Total**	7,851	6,712
Nonmetal Products		
Ammunition primers	17	15
Fireworks	47	30
Flameproofing chemicals and compounds	1,626	932
Ceramics and glass	1,649	1,164
Matches	*	*
Pigments	1,173	504
Plastics	1,289	592
Rubber products	492	179
Other	1,695	1,355
Total	7,988	4,771
Estimated unreported	—	4,259
Grand total	15,839	15,742

Source: U.S. Bureau of Mines *Minerals Yearbook, 1964* and Mineral Industry Surveys "Antimony in Fourth Quarter 1965".
*Included with 'other' to avoid disclosing individual company confidential data.**Includes antimony content of imported antimonial lead consumed.
P Preliminary; — Nil.

pigments have applications in the manufacture of glass and ceramics.

High-purity antimony is used in increasing amounts by manufacturers of intermetallic compounds for semiconductor use. An aluminum-antimony alloy is widely used as a semiconductor in transistors and rectifiers. Also employed by the electronics industry are alloys of antimony which exhibit thermoelectric properties.

The recovery of secondary antimony in the United States was 22,300 tons in 1964 and 22,500 tons in 1965. These tonnages, added to the amounts of primary antimony shown in Table 4, give a total use in the United States of about 38,000 tons annually.

PRICES AND TARIFFS

The United States price of antimony metal, quoted by *E & MJ Metal and Mineral Markets*, bulk, 99.5 per cent, f.o.b. Laredo, Texas, was 44.0 cents a pound throughout 1965.

The United States price of imported metal, quoted by *E & MJ Metal and Mineral Markets*, in 5-ton lots, 99.5 per cent, f.o.b. New York, 2 cents a pound duty paid, was as follows:

	(cents)
January 4	53 – 54
January 25	46 – 49
February 15	45½ – 48
July 5	45½ – 46

Canadian and United States tariffs in 1965 were as follows:

	British Preferential	Most Favoured Nation	General
Canada			
Antimony, or regulus of, not ground, pulverized or otherwise manufactured	free	free	free
Antimony oxide	free	12½%	15%
Antimony salts	free	free	free

United States	(per lb)
Antimony ore	free
Antimony metal, unwrought	2¢
Antimony alloys:	
containing by weight 83% or more of antimony	2¢
other	18% ad val.
Antimony metal, wrought	18% ad val.
Antimony, needle or liquated	0.25¢
Antimony oxide	0.6¢
Antimony sulphide	0.5¢ plus 12.5% ad val.
Other antimony compounds	0.8¢ plus 20% ad val.

Asbestos

A.A. WINER*

In 1965, for the first time in seven years, asbestos production did not show an annual increase. It dropped below that of 1964 to 1.38 million tons, valued at close to $140 million, a decrease of about 3 per cent. Quebec and Ontario reported lower outputs in 1965; however, in Newfoundland output increased by 10 per cent and in British Columbia by 26 per cent in the same period.

The Canadian production of asbestos is nearly all exported and the United States remained, as usual, the major single market by importing 50 per cent of all Canadian fibre produced in 1965, despite increased domestic production. Canadian asbestos exports reached $159 million in 1965, an increase of almost 2 per cent over 1964, and fibre shipped to the U.S. was valued at 41 per cent of the total. Asbestos fibre prices increased in 1965 for the first time in five years, which partially explains the increased value of Canadian fibre shipments.

Principal asbestos fibre imports are crocidolite from South Africa and Australia, and amosite from South Africa. In 1965 fibre imports amounted to 6,953 tons at $1,286,429.

TECHNOLOGY AND USES

Some minerals have a fibrous or pseudofibrous habit, but lack the physical or chemical characteristics that are required in a fibrous mineral for industrial use. In commerce the term 'asbestos' is applied to five silicate minerals; the most widely used is chrysotile, which is a hydrous magnesium silicate. The others are crocidolite, a sodium-iron silicate; amosite, a silicate of both iron and magnesium partly hydrated; and tremolite and anthophyllite, which are silicates of calcium, magnesium and iron.

Chrysotile provides 90 per cent of the world's asbestos fibre. The two principal modes of its occurrence are as 'cross fibre' and 'slip fibre'. In the former, individual fibres lie parallel across the vein so that the vein width is an approximate indication of fibre length. In the latter the fibres of chrysotile lie along fissures in the rock lengthwise and overlapping.

Chrysotile is mined in Canada by both open-pit and underground methods. It is prepared by a dry-milling process in which the ore is crushed, impact-milled, fiberized and separated into different grades of commercial fibre and a waste product or tailing. Although the recovered fibre is graded for the market essentially by length, other factors such as bulk volume, contained dust, and degree of openness are also important.

Because of its physical characteristics, chrysotile is an important raw material in many industrial processes. When of the proper texture, the longer fibres may be processed much as the organic staple fibres. Consequently it may be carded, spun and woven into cloths of different weights, thicknesses and qualities. These cloths are used in the manufacture of heat-resistant friction materials.

*Mineral Processing Division, Mines Branch

TABLE 1

Asbestos — Production and Trade, 1964-65

	1964		1965P	
	Short Tons	$	Short Tons	$
Production (shipments)				
By type				
Crude	236	199,965	220	
Milled fibres	664,284	107,476,342	721,267	
Shorts	755,331	37,517,136	658,723	
Total	1,419,851	145,193,443[1]	1,380,210	139,805,322[1]
By province				
Quebec	1,285,564	124,923,453	1,236,260	119,022,297
British Columbia	67,460	11,714,494	85,450	13,718,022
Newfoundland	51,315	6,355,578	56,400	6,985,140
Ontario	15,512	2,199,918	2,100	79,863
Total	1,419,851	145,193,443[1]	1,380,210	139,805,322[1]
Exports				
Crude				
France	—	—	55	45,971
Japan	78	57,415	27	20,160
United States	39	46,653	25	35,170
Other countries	97	79,555	16	14,830
Total	214	183,623	123	116,131
Milled				
Group 3				
United States	14,618	6,314,263	15,137	6,415,202
West Germany	5,152	1,989,658	2,302	898,129
Britain	3,710	1,177,778	1,737	691,895
France	3,149	1,166,375	1,352	505,809
Japan	2,127	845,878	1,165	471,129
Spain	362	137,763	432	160,350
Belgium and Luxembourg	700	291,356	309	124,451
Mexico	300	118,400	240	91,840
Austria	89	34,522	105	39,919
Australia	99	34,887	60	20,950
Other countries	4,101	1,750,428	3,342	976,875
Total	34,407	13,861,308	26,181	10,396,549
Groups 4 and 5				
United States	190,284	32,485,324	198,290	33,354,907
West Germany	44,483	7,392,193	49,366	9,124,702
Britain	46,430	7,963,788	46,199	8,170,001
France	40,133	6,718,089	38,627	6,920,990
Australia	28,134	4,462,697	32,519	5,328,609
Belgium and Luxembourg	27,120	4,723,878	32,264	6,045,157
Japan	38,330	5,130,350	27,069	3,903,939
Spain	20,137	3,488,074	17,823	3,329,219
Austria	11,375	2,016,461	15,492	2,965,672
Mexico	17,316	3,133,316	15,441	2,780,956
Other countries	132,366	23,149,384	131,506	23,565,413
Total	596,108	100,663,554	604,596	105,489,565

Table 1 (cont.)

	1964		1965p	
	Short Tons	$	Short Tons	$
Total milled fibres (Groups 3, 4 and 5)				
United States	204,902	38,799,587	213,427	39,770,109
West Germany	49,635	9,381,851	51,668	10,022,831
Britain	50,140	9,141,566	47,936	8,861,896
France	43,282	7,884,464	39,979	7,426,799
Australia	28,233	4,497,584	32,579	5,349,559
Belgium and Luxembourg	27,820	5,015,234	32,573	6,169,608
Japan	40,457	5,976,228	28,234	4,375,068
Spain	20,499	3,625,837	18,255	3,489,569
Mexico	17,616	3,251,716	15,681	2,872,796
Austria	11,464	2,050,983	15,597	3,005,591
Other countries	136,467	24,899,812	134,848	24,542,288
Total	630,515	114,524,862	630,777	115,886,114
Shorts (groups 6,7,8 and 9)				
United States	445,580	24,149,856	447,668	25,389,506
Japan	55,537	4,594,791	52,663	4,640,437
Britain	47,877	2,640,735	51,784	3,003,431
West Germany	38,651	2,105,715	36,811	2,434,777
France	27,908	1,667,306	20,120	1,243,448
Belgium and Luxembourg	19,512	1,398,374	10,836	896,088
Australia	8,678	579,990	10,476	767,863
Netherlands	13,950	832,097	10,296	565,153
Other countries	45,054	3,028,604	47,850	3,714,080
Total	702,747	40,997,468	688,504	42,654,783
Grand total, crude, milled fibres and shorts	1,333,476	155,705,953	1,319,404	158,657,028
Manufactured products				
Brake linings and clutch facings				
United States		25,371		125,315
Cuba		37,632		62,232
Lebanon		23,258		51,863
Australia		19,391		37,554
Ecuador		28,970		36,350
El Salvador		18,573		30,735
Syria		22,535		28,778
Other countries		197,791		186,945
Total		373,521		559,772
Asbestos and asbestos-cement building materials				
United States		1,084,696		778,103
Pakistan		49,376		131,484
Australia		37,154		53,028
Jamaica		7,718		32,953
Other countries		89,384		89,249
Total		1,268,328		1,084,817
Asbestos and asbestos-cement basic products, not elsewhere classified				
United States		153,344		271,737
Britain		21,209		18,805
Australia		12,782		17,883
Switzerland		56,201		17,804
Other countries		86,186		49,260
Total		329,722		375,489
Total exports, asbestos manufactured products		1,971,571		2,020,078

Table 1 (cont.)

	1964		1965P	
	Short Tons	$	Short Tons	$
Imports				
Asbestos, unmanufactured	9,218	1,647,866	6,953	1,286,429
Asbestos manufactured				
Cloth, dryer felts, sheets, woven, or felted		591,905		878,109
Packing		597,450		645,322
Brake linings		1,204,470		995,442
Clutch facings		265,393		202,865
Brake linings and facings, n.e.s.		407,247		–
Asbestos-cement shingles and siding		219,818		226,412
Asbestos-cement board and sheets		747,724		861,288
Asbestos and asbestos-cement building material n.e.s.		686,379		715,117
Asbestos and asbestos-cement basic products, n.e.s.		1,374,482		1,370,446
Total asbestos, manufactured		6,094,868		5,895,001
Total asbestos, unmanufactured and manufactured		7,742,734		7,181,430

*Does not include value of containers.
P Preliminary; – Nil; n.e.s. Not elsewhere specified.

TABLE 2

Asbestos – Production and Exports, 1956-65

(short tons)

	Production*				Exports			
	Crude	Milled	Shorts	Total	Crude	Milled	Shorts	Total
1956	717	392,983	620,549	1,014,249	560	377,044	586,317	963,921
1957	622	404,016	641,448	1,046,086	638	393,311	636,611	1,030,560
1958	605	342,562	582,164	925,331	483	318,280	547,867	866,630
1959	432	404,019	645,978	1,050,429	416	401,583	611,923	1,013,922
1960	330	483,183	634,943	1,118,456	241	458,053	610,199	1,068,493
1961	163	548,230	625,302	1,173,695	176	527,324	589,380	1,116,880
1962	205	547,447	668,162	1,215,814	182	532,020	632,468	1,164,670
1963	217	579,085	696,228	1,275,530	195	555,419	650,811	1,206,425
1964	236	664,284	755,331	1,419,851	214	630,515	702,747	1,333,476
1965P	220	721,267	658,723	1,380,210	123	630,777	688,504	1,319,404

Source: Dominion Bureau of Statistics.
*Producers' shipments.
P Preliminary.

The shorter-fibre grades of asbestos have the greatest number of uses. The present volume of asbestos classified as short-fibre far exceeds that of all other grades combined. This type is used in moulding of plastics, manufacture of floor tiling and protective coatings, in the paint industry and for other applications requiring a fibrous filler with the physical characteristics of asbestos.

The most important single market for chrysotile is the asbestos-cement industry. Asbestos is combined with portland cement for manufacture into a number of products, e.g. pipe, sheeting of all types, shingles, and millboard.

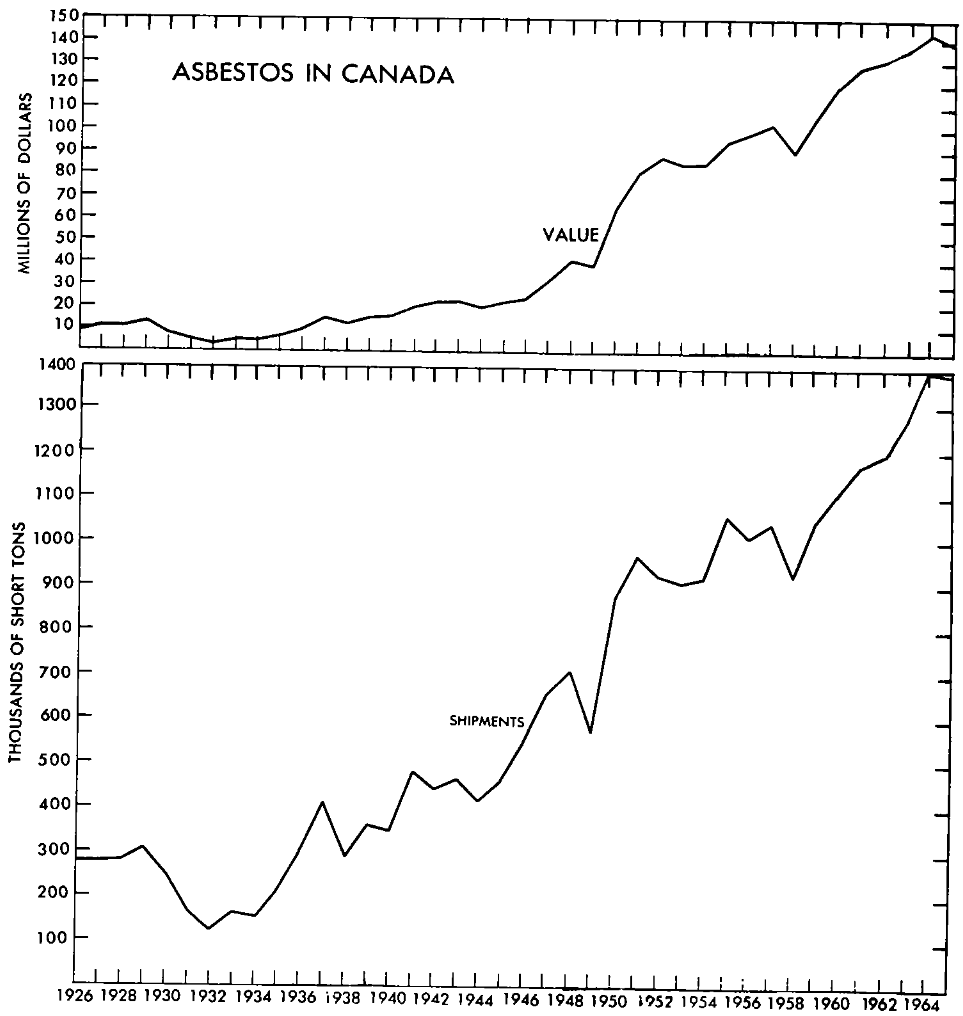
The automobile industry uses large quantities of asbestos products for parts including woven and moulded brake linings, clutch facings and pressure gaskets. Undercoating compounds provide an important use for very short grades of fibre.

In thermal insulation, asbestos is used as a kind of paper. In combination with other materials, it is also widely used in the form of preformed sections or slabs for boiler and steam-pipe covering and in oil-refinery and chemical-plant construction.

The commercial fibre recovered in northern British Columbia is low in magnetite. This is an advantage to the electrical industry in which the fibre is used to provide heat-resistant and nonconductive woven insulation.

Crocidolite, commonly called 'blue fibre', is an asbestos of the amphibole group with properties of commercial value. It is used in the manufacture of asbestos-cement pressure pipe and packing.

Amosite, a heat-resistant type of anthophyllite, is used principally in the manufacture of thermal insulation. The fibres of tremolite, actinolite and anthophyllite are usually weak and unsuitable for most asbestos uses, although there are certain uses for which their natural chemical and physical properties are suited.



PRODUCTION

Chrysotile is the major variety of asbestos used in the world and still comprises the only type produced in Canada. Although chrysotile occurs in various Canadian areas it is commercially produced only in Quebec, British Columbia and Newfoundland at present.

What are believed to be the world's largest deposits of chrysotile asbestos occur in the Eastern Townships of Quebec in a narrow band extending from east of the Chaudière River southwest almost to Sherbrooke, approximately 80 miles east of Montreal. All the producing deposits in the province are in this region. The persistence of the mineral at depth, as established by drilling, indicates that reserves are sufficient for many years.

Demand for Canadian chrysotile, particularly in the shorter grades, is expected to increase, if inflationary trends do not cause serious cutbacks in the automotive and construction industries. Canadian fibre has kept pace with the multivaried uses of the fibre. Research, better testing and stricter quality control have maintained demand for the excellent quality expected of Canadian fibre. There is no known material which has the overall remarkable special qualities of asbestos fibre. The demand for all asbestos types in the United States is expected to increase by 3 to 5 per cent annually and U.S. domestic production is expected to fill only about 10 per cent of its needs. Canada may therefore expect to continue exporting much of its production to the U.S. World production and demand for all types of fibre should continue to grow as new products are introduced. Research will become more important as competition grows and new uses for asbestos will result. Scarce, low-iron content fibre from western Canada should continue in good demand, although research has provided a beneficiated low-iron asbestos fibre suitable for specific electrical insulating uses. Russia, although a potential competitor in export markets, is expected to consume much of her own production for the present.

Crocidolite is not mined in Canada, although occurrences have been reported from the iron-ore region near the Labrador-Quebec boundary. Large commercial deposits occur in South Africa; it is also produced in Australia and in the U.S.S.R. No Canadian occurrence of amosite is known. The world amosite market is supplied from deposits in South Africa. Other asbestos minerals – fibrous tremolite, actinolite and anthophyllite – occur in Canada, but none is produced. During World War II, a small amount of tremolite was produced in eastern Ontario.

TABLE 3

Asbestos Fibre Producers in Canada

Plant	Location
Newfoundland	
Advocate Mines Limited	Baie Verte, Burlington Peninsula
Quebec	
Arthabaska County	
Nicolet Asbestos Mines Ltd.	Norbestos
Beauce County	
Carey-Canadian Mines Ltd.	Broughton tp.
Mégantic County	
Asbestos Corporation Limited	Thetford Mines (King Beaver mine) Black Lake (British Canadian mine) Vimy Ridge (Normandie mine)
Bell Asbestos Mines, Ltd.	Thetford Mines
Flintkote Mines Limited	Thetford Mines
Lake Asbestos of Quebec, Ltd.	Black Lake
National Asbestos Mines Limited	Thetford Mines
Richmond County	
Canadian Johns-Manville Company, Limited	Asbestos (Jeffrey mine)
British Columbia	
Liard M.D.	
Cassiar Asbestos Corporation Limited	Cassiar

DEVELOPMENTS

YUKON TERRITORY

Cassiar Asbestos Corporation Limited plans to bring its Clinton Creek property, 40 miles northwest of Dawson City, into production by 1968. Projected production is estimated at 40,000 tons of fibre annually and proven reserves are calculated to last 19 years.

BRITISH COLUMBIA

Cassiar Asbestos Corporation Limited is continuing exploratory work on its Kutcho Creek property, 60 miles southeast of Cassiar.

ONTARIO

Canadian Johns-Manville Company, Limited is developing an asbestos property in Reeves township, 43 miles west of Timmins. Field work has been completed and an underground shaft sunk for exploration purposes. The only production of asbestos recorded in Ontario in 1965 was from Hedman Mines Limited, east of Matheson.

QUEBEC

Asbestos Corporation Limited has indicated that production for the Asbestos Hill property in the Ungava district is set for 1970. Proven reserves are calculated at 20 million tons and initial production is planned at 100,000 tons annually. An increase in mining capacity of the King-Beaver Mine in Thetford Mines, is almost completed. Expansion of the British Canadian No. 1 mill at Black Lake by about 12 per cent has been completed and the No. 2 mill (Johnson's, Black Lake) is being studied for proposed increased production capacity. Nicolet Asbestos Mines Ltd. has enlarged their open pit in Norbestos. Canadian Johns-Manville is proceeding with its overburden removal program at the Jeffrey Mine in Asbestos, which is estimated to take 2½ years for completion. Expenditures have been authorized for increasing the production capacity.

Expansion of the Black Lake asbestos property by Lake Asbestos of Quebec, Ltd. and United Asbestos Corporation Limited has resulted in enlargement of the open-pit operation. This expansion is designed to increase ore recovery and utilize the increased mill capacity. National Asbestos is also conducting an expansion program at Thetford Mines. McAdam Mining Corporation Limited has continued drilling on its Chibougamau property.

NEWFOUNDLAND

Advocate Mines Limited at Baie Verte increased production in 1965. Installation of additional equipment has increased the yield.

WORLD REVIEW

Total world production of all types of asbestos has been estimated at 3½ million tons. Canada and the U.S.S.R. are the world's largest producers. Although U.S.S.R. production statistics are not available, it is believed that production moved ahead of Canada for 1965. Canadian production remained at about 40 per cent of the world total.

Russia exported approximately 200,000 tons of asbestos in 1964 mainly to East Germany, West Germany, France, Poland, Czechoslovakia, Bulgaria, Hungary and Japan. Estimated U.S.S.R. exports were approximately 15 per cent of their total production. In 1964 total production in the U.S.S.R. was estimated at about 1.3 million tons. Increased fibre capacity is expected in 1966 when two new mines now under development are scheduled for production.

Although reduced markets may have an effect on Southern Rhodesian exports for 1966, production for 1965 was expected to be the same as in 1964, about 153,000 tons. The Rhodesian fibre, because it is low in magnetic iron, normally finds a ready market for products used in the electrical industry.

The South African Republic is the major producer of crocidolite and amosite although some chrysotile is also mined. In 1965 production of all types was 220,000 short tons. Cape/Blue fibre production was considered satisfactory and exploration is continuing for new reserves.

The United States has increased production of chrysotile by about 15 per cent to approximately 130,000 tons, mainly because of increased production from California. Imports by the U.S. in 1965 were maintained at a high level, with Canada contributing most of the imports.

PRICES

Prices at the end of 1965 reflected the increase for certain fibre grades, specifically those in groups 4, 5, 6 and 7. Canadian prices for asbestos quoted at the end of 1965 were as follows, f.o.b. Asbestos, Que., carload lots, per short ton:

Crude No.	1	$1,410
	2	760
Fibre	3F	565
	3K	480
	3R	408
	3T	370
	3Z	345
	4A	320
	4D	215
	4H	210
	4K	210
	4M	210
	4T	190
	4Z	190
	5D	156
	5K	156
	5R	132
	6D	95
	7D	82
	7F	77
	7H	66
	7K	54
	7M	47
Fibre (cont.)	7R	$ 46
	7T	44
	7R Floats	47
	7TF Floats	47
	8S	29
	8T	23

Minimum carload quantity grades 1 to 5R inclusive, 20 tons; grades 6 to 8 inclusive, 30 tons. Add $4 per ton to above prices for less than carload lots.

Western Canadian fibre prices are quoted below in Canadian currency on a per ton, f.o.b. Vancouver basis.

Grade	
Non-ferrous spinning fibre	
AAA	$787
AA	625
A	470
Asbestos cement	
AC	325
AD	273
Shingle fibre	
AK	231
AS	190
AX	168
AY	126

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Asbestos, crude	free	free	25
Asbestos in any form other than crude, and all manufactures thereof, n.o.p.	12½	12½	25
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
Yarns, wholly or in part of asbestos, for use in the manufacture of clutch facings and brake linings.	7½	12½	25
Woven fabrics, wholly or in part of asbestos, for use in the manufacture of clutch facings and brake linings	12½	12½	30
United States			
Asbestos, not manufactured, crude, fibres and stucco and asbestos sand and refuse containing not more than 15% by weight of foreign matter	free		
Asbestos, yarn, slivers, rovings, wick, rope, cord, cloth, tape and tubing of asbestos, or of asbestos and any other spinnable fibre, with or without wire and articles of any of the foregoing	8% ad val.		
Articles in part of asbestos and hydraulic cement:			
Pipes and tubes and fittings therefor	0.3¢ per lb		
Other	0.225¢ per lb		
Asbestos articles not specially provided for	9% ad val.		

Barite

J.E. REEVES*

Canadian barite production is closely geared to exports, particularly to the United States for use in oil- and gas-well drilling. Production increased substantially in 1965; shipments, in excess of 200,000 short tons, were about 20 per cent greater than in 1964. Their value was about 27 per cent higher because of a greater proportion of higher-priced ground barite.

Exports, mainly in the crude (crushed or lump) form to the United States, increased about 18 per cent in volume and 20 per cent in value in 1965. Exports of ground barite to Trinidad were appreciably greater than in 1964. Imports, principally ground chemical-grade barite from the United States, remained small but showed a modest increase.

World production of barite has been rising gradually, indicating an increasing demand. Canada ranks fifth among the producing countries, although its consumption of barite, mainly in well drilling, is comparatively small.

PRODUCERS

Canada has substantial barite reserves. Occurrences are known in all provinces except Alberta, Saskatchewan and Prince Edward Island. Barite was produced from four deposits in 1964 – one in Nova Scotia and three in southeastern British Columbia. Production from Nova Scotia is mainly as crude barite and most was shipped to the southern United States. The output from British Columbia was shipped as crude, mainly to Alberta, for final processing.

Barium and strontium metals are produced in small amounts, principally for export, by Dominion Magnesium Limited at Haley, Ontario.

*Mineral Processing Division, Mines Branch

TABLE 1

Barite – Production, Trade and Consumption, 1964-65

	1964		1965	
	Short Tons	$	Short Tons	$
Production (mine shipments)				
Crushed and lump	160,321	1,392,100	184,294	1,715,830
Ground	8,828	182,298	18,731	451,176
Total	169,149	1,574,398	203,025	2,167,006
Imports				
United States	3,111	160,698	3,531	198,232
West Germany	95	4,158	155	7,025
Total	3,206	164,856	3,686	205,257
Exports				
United States	142,304	1,234,722	162,625	1,314,533
Trinidad-Tobago	6,048	106,560	17,606	325,718
Venezuela	8,175	69,489	4,301	35,711
Norway	–	–	500	12,620
Total	156,527	1,410,771	185,032	1,688,582
Consumption (available data)				
Well drilling	10,220			
Paints	2,023			
Glass	681			
Rubber goods	184			
Miscellaneous chemicals	158			
Miscellaneous	271			
Total	13,537			

Source: Dominion Bureau of Statistics.
– Nil.

TABLE 2

Barite – Production, Trade and Consumption, 1956-65

(short tons)

	Production*	Imports	Exports	Consumption**
1956	320,835	1,475	312,275	10,035
1957	228,048	1,831	199,785	30,094
1958	195,719	1,382	172,942	24,159
1959	238,967	1,662	221,721	22,404
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	

Source: Dominion Bureau of Statistics.
*Mine shipments. **Apparent consumption to 1958 and reported consumption from 1959.

TABLE 3

World Production of Barite, 1964-65

(short tons)

	1964	1965^e
United States	816,706	870,000
West Germany	487,884	500,000
Mexico	359,372	360,000
U.S.S.R.	220,000	..
Canada	169,149	203,000
Peru	145,934	150,000
Yugoslavia	126,694	125,000
Morocco	99,036	105,000
Other countries	945,225	..
Total	3,370,000	3,396,000

Source: U.S. Bureau of Mines *Minerals Yearbook, 1964*, and U.S. Bureau of Mines *Commodity Data Summaries, January, 1966*.
^{e}Estimate; ..Not available.

TABLE 4

Barium Compounds – Imports and Consumption

	1964		1965	
	Short Tons	$	Short Tons	$
Imports				
Lithopone (70% $BaSO_4$)	539	80,987	574	79,520
Barium carbonate	4,341	391,558	6,410	561,268
	1962		1963	
	Pounds	$	Pounds	$
Consumption				
of some barium compounds in the production of chemical and chemical products				
Barium carbonate	1,362,445	76,000	1,369,742	67,000
Barium chloride	689,662	46,000	680,226	45,000
Barium nitrate	89,823	12,000	89,243	12,000
Blanc fixe	538,154	41,000	664,365	45,000
Lithopone	710,155	67,623	611,096	64,478

Source: Dominion Bureau of Statistics.

NOVA SCOTIA

Magnet Cove Barium Corporation produces about 90 per cent of Canada's output of barite from a mine and processing plant near Walton. It is the only mine east of British Columbia. The operation is dependent on exports and, because of its location near an ocean port, is able to compete in the world's most important barite market area – the southern and eastern United States, Trinidad and Venezuela.

The company recovers barite from an underground mining operation by block caving. The barite is beneficiated at an adjoining mill and trucked to Walton for shipment. In addition, barite concentrates are recovered as a coproduct from the company's sulphide flotation plant located at the mine. At Walton, a small part of the output is ground, mainly for markets in Trinidad and Venezuela. Most of the barite is shipped as crushed concentrates to grinding plants of the parent company located adjacent the Gulf of Mexico. The product is used mostly in the United States and South America as a weighting agent in well drilling.

BRITISH COLUMBIA

Mountain Minerals Limited mines barite by open-pit and underground-mining methods from deposits near Parson and Brisco. Most of the output is shipped to the company's grinding plant at Lethbridge, Alberta, for eventual use in well drilling. The balance is sold in other provinces.

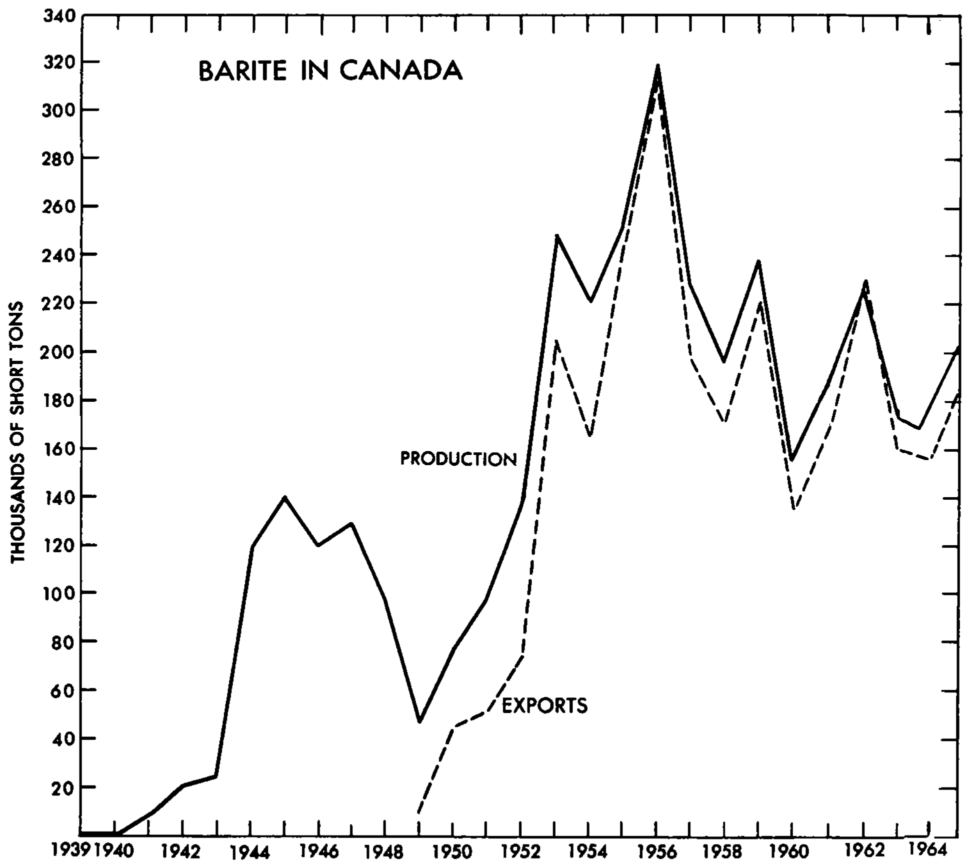
Barite is recovered from the Giant property near Spillimacheen by Baroid of Canada, Ltd., and shipped to the company's grinding plant at Onoway, Alberta, where it is ground for use in well drilling.

QUEBEC

Periodically, imported barite is ground by Industrial Fillers Limited, Montreal.

OTHER OCCURRENCES

Barite occurs at many other places in Canada and has been mined in a small way from several deposits. Some of the noteworthy occurrences are at Buchans, Newfoundland; near Lake Ainslie, Cape Breton Island; in Penhorwood and Langmuir Townships, northern Ontario; on McKellar Island, Lake Superior; and at Mile 397 on the Alaska Highway, British Columbia. Witherite (barium carbonate) occurs in a large deposit near Mile 497 on the British Columbia section of the Alaska Highway. Witherite, barylite, barytocalcite and other rarer barium minerals occur in Canada but have not been of any commercial significance. The deposits near Lake Ainslie are under development as a possible source of barite and fluorite.



USES AND SPECIFICATIONS

Barite (natural barium sulphate, $BaSO_4$) is used mainly because of its physical properties — its specific gravity of 4.5, its chemical inertness under normal conditions and, from some sources, its whiteness. Barite is used to a small extent as the main source of the element barium in the production of barium chemicals.

In 1964, about three quarters of the barite consumed in Canada was for well drilling. World consumption of barite for this use accounts for about 90 per cent of output. Its relatively high specific gravity assists in controlling fluid pressure in the well and in forcing drill cuttings to the surface. Because of its relatively low cost, it is the most commonly used material for this purpose. The barite for use in well drilling should have a minimum specific gravity of 4.20 to 4.25 (that is, contain at least 93½ per cent of the mineral barite) and a particle size of at least 90 per cent minus 325 mesh.

Second in importance is the use of barite as a filler, mainly in paints but also in the manufacture of rubber and various other products. For filler purposes, barite should have a maximum particle size of 200 mesh, should contain at least 94 per cent $BaSO_4$ and, except in some rubber products, should have a high light reflectance.

The other main use is in the manufacture of glass, wherein barite improves the workability of the melt and provides added lustre. Specifications normally require a minimum of 98 per cent $BaSO_4$, less than 0.15 per cent iron (in terms of ferric oxide, Fe_2O_3) and a particle size of essentially minus 20 plus 200 mesh.

A minor use for barite is as a heavy aggregate in concrete used for shielding atomic radiation.

The barium chemicals industry is virtually nonexistent in Canada. The more common barium compounds manufactured throughout the world and some of their applications are as follows: precipitated barium sulphate, or blanc fixe, used as an extender and pigment in paints and as a filler in paper; lithopone, a mixture of barium and zinc sulphate, employed as a white pigment in paints; barium chloride, for case hardening and the prevention of scumming on brick; and barium carbonate, used for the reduction of scumming on brick and other ceramics and in the manufacture of electronic tubes. Barium oxide, hydrate, titanate, chlorate, nitrate, sulphide, ferrite and phosphate are also manufactured. Several of the barite compounds are used as a source of barium metal. The titanate is receiving increasing attention in electronics because of its high dielectric constant and piezoelectric and ferroelectric properties. Specifications vary for barite for the manufacture of chemicals, but lump barite with a minimum of 94 per cent $BaSO_4$ and a maximum of 1 or 2 per cent Fe_2O_3 is commonly required.

PRICES

According to *E & MJ Metal and Mineral Markets* of November 15, 1965, available barite prices in the United States, f.o.b. shipping point, in car lots, per short ton, were as follows:

Chemical grade

95% $BaSO_4$, hand picked lump $18.50

96–97½% $BaSO_4$, ground, bulk (in 100 lb bags, $3 extra) $19 – 23.50

99½% $BaSO_4$, water ground, 325 mesh, 50 lb bags $45 – 49

TARIFFS

Some tariffs in effect at the time of writing were:

	British Preferential	Most Favoured Nation	General
Canada			
Crude or ground	free	20%	25%
For drilling-mud use	free	free	free

United States	
Barite	
Crude	$2.55 per long ton
Ground	6.50 per long ton
Witherite	
Crude	free
Ground	12.5% ad val.

Bentonite

J. E. REEVES*

Canada is rapidly becoming an important consumer of bentonite, largely because of its use as a binder in the pelletizing of iron mineral concentrates. Approximately 15 pounds of bentonite are required for every long ton of iron mineral pellets. By the end of 1965, capacity for the production of pellets in Canada had risen to about 15 million long tons, nearly one third of the country's total iron ore productive capacity. The amount of bentonite used annually by the iron ore industry alone has increased from less than 10,000 short tons prior to 1961 to 67,225 short tons in 1964 and an estimated 100,000 short tons in 1965. By 1968, the annual consumption in pellets should have grown to about 175,000 short tons; in the same year, the total annual consumption may reach 300,000 short tons, a nearly five-fold increase since 1961. All the bentonite being used by the iron ore industry is imported.

Bentonite has several unusual properties that make it a useful commodity. It is not strictly a mineral but rather a clay composed essentially of minerals of the montmorillonite group. These minerals have exchangeable cations, commonly sodium and calcium, in their structure. When sodium is the predominant cation, bentonite forms a gel in water and swells more readily than when calcium is predominant. Although the terms are only relative, bentonite is often roughly classified as swelling or nonswelling. Bentonite can also absorb certain substances, and can have its adsorptive property improved by activation with dilute sulphuric acid. Fuller's earth is an industrial term that refers to use rather than mineral composition, but it is commonly composed at least partly of montmorillonite minerals.

PRODUCTION AND TRADE

Although total production statistics for bentonite are not available, the Alberta Department of Mines and Minerals reported that 58,011 tons were produced in that province in 1965.

In Alberta, Magnet Cove Barium Corporation Ltd., and Baroid of Canada, Ltd., recover swelling bentonite from the Upper Cretaceous Edmonton formation near Rosalind and Onoway, respectively. It is dried, pulverized and sized, chiefly for use in drilling muds. In Manitoba, Pembina Mountain Clays Ltd. mines nonswelling bentonite from the Upper Cretaceous Vermilion River formation near Morden and processes it at Morden for various uses. Some is shipped to the company's Winnipeg plant for activation and is sold as a bleaching clay for decolourizing animal, vegetable and mineral oils. For the most part, domestic output varies with the demand of the oil- and gas-well drilling industry in western Canada.

*Mineral Processing Division, Mines Branch

TABLE 1

Bentonite — Trade and Consumption

	1964		1965	
	Short Tons	$	Short Tons	$
Imports				
Bentonite				
United States	114,446	1,055,405	181,881	1,579,820
Other countries	—	—	281	7,288
Total	114,446	1,055,405	182,162	1,587,108
Activated clays and earths				
United States	2,823	408,481	3,060	500,325
France	30	10,162	66	22,309
West Germany	—	—	22	3,203
Total	2,853	418,643	3,148	525,837
Fuller's earth				
United States	6,166	179,213	6,831	195,459
Other countries	68	5,815	29	2,162
Total	6,234	185,028	6,860	197,621
Compounds and conditioners for use in drilling mud*				
United States	12,075	1,095,322	8,054	720,530
	1963		1964	
Consumption**, available data				
Pelletizing	37,575		67,225	
Well drilling	33,932		64,379	
Iron and steel foundries	17,642		24,088	
Petroleum refining	1,790		1,343	
Ceramic products	..		507	
Paper	296		415	
Miscellaneous chemicals	291		1,286	
Other products	1,986		2,452	
Total	93,512		161,695	

Source: Dominion Bureau of Statistics.
*Includes some bentonite not otherwise accounted for. **Includes fuller's earth but not bentonite used in construction.
— Nil; .. Not available.

A large part of Canada's requirements for bentonite, including all for use as a binder in iron mineral pellets, is imported from the United States, principally Wyoming. In 1965, imports from the United States increased from 114,446 to 181,881 short tons, largely because of the iron ore industry's needs. More than one third was imported in the crude state and processed by Carol Pellet Company at Labrador City, Labrador, and Arnaud Pellets at Pointe Noire, Quebec, for use in iron mineral pellets. Small but increased quantities of comparatively higher-priced fuller's earth and expensive activated clays were also imported, mainly from the United States. A small quantity of activated bentonite is periodically exported to the United States.

TABLE 2

Bentonite – Imports and Consumption, 1956–65

	Imports		Consumption	
	Short Tons	$	Fuller's Earth (short tons)	Bentonite[1]
1956	..	1,484,124[2]	1,783	30,562
1957	..	1,536,512[2]	1,654	26,105
1958	..	980,585[2]	1,595	23,429
1959	..	1,082,593[2]	1,369	60,258
1960	..	1,590,441[3]	..	64,871
1961	..	1,528,170[3]	..	63,268
1962	..	1,524,080[3]	..	57,237
1963	..	2,005,337[3]	..	93,512
1964	123,533[4]	1,659,076[4]	..	161,695
1965	192,170[4]	2,310,566[4]	..	

Source: Dominion Bureau of Statistics.
[1]Larger survey coverage commencing 1959. Includes fuller's earth. [2]Activated clays and clay catalysts. [3]Also includes fuller's earth and clay for use in well drilling. [4]Bentonite, activated clays and earths, and fuller's earth, but not the bentonite included in materials for use in drilling mud.

.. Not available.

CANADIAN OCCURRENCES

Bentonite deposits, many of which are thick and extensive, occur in formations of Cretaceous and Tertiary age in western Canada. Those in Alberta have received the most attention because of the greater proportion of the swelling variety. The better types of swelling bentonite are found in the Upper Cretaceous Edmonton and Bearpaw formations and outcrop near Rosalind, Onoway, Camrose, Drumheller, Irvine and Dorothy.

In Manitoba, nonswelling bentonite occurs in the Vermilion River formation, and the swelling and semiswelling varieties in the Riding Mountain formation, also of Upper Cretaceous age. Both horizons outcrop at intervals from near Morden in the south to Swan River, more than 200 miles to the northwest.

In Saskatchewan, semiswelling bentonite occurs in the Tertiary Ravenscrag formation in the south-central part of the province, and in the Battle formation in the southwest and in the Vermilion River formation in the east, both Upper Cretaceous. Much of the bentonite in British Columbia is of Tertiary age and is found near Princeton, Merritt, Kamloops and Clinton.

CONSUMPTION AND USES

Bentonite is used in many ways but normally as only a small proportion of the final product. Most is used as a filler or binder; a small amount serves as an absorbent and adsorbent.

Reported consumption in 1964 (including fuller's earth) exceeded 160,000 short tons, exclusive of that used in construction – an increase of more than 70 per cent. Most consuming industries registered increases. The iron ore industry continued to be the largest single consumer, despite a sizable increase in consumption in well drilling. It should continue to be so as the expansion of pellet-making facilities continues. In 1965 Arnaud Pellets at Pointe Noire, Quebec, and Caland Ore Company Limited at Steep Rock Lake, Ontario, began production. Several other announced developments, including the expansion of capacity by Carol Pellet Company to 10,000,000 long tons of pellets a year, should raise the total annual pellet productive capacity in Canada to about 24,000,000 long tons by 1968 and the need for bentonite to at least 175,000 short tons a year.

Swelling bentonite serves as a binder under normal and high-temperature conditions in the foundry and pelletizing industries. In well drilling it acts as a lubricant, keeps drill cuttings in suspension, assists in preventing the loss of drilling fluids by forming impervious coatings on drill-hole walls and, within limits, controls the viscosity of drilling fluids. Bentonite is also used to plasticize abrasive, ceramic and refractory raw mixes; as a filler in paper, rubber, pesticides, cosmetics, medicinal products, soaps and cleaners; in the grouting of subsurface water-bearing zones; and in sealing such structures as dams and reservoirs. Bentonite slurry is effective in fire-fighting and in retaining walls of excavations prior to the placement of concrete or other structural materials.

Activated bentonite is used in decolourizing vegetable, animal and mineral oils, beverages, syrups and other liquids. It is also employed as a catalyst in the refining of fluid hydrocarbons. Small quantities of the natural nonswelling type are used as a binder.

PRICES

The U.S. price as quoted in *Oil Paint and Drug Reporter* of December 27, 1965, for 200 mesh, in bags, by car lot, f.o.b. mine, was $14 a short ton.

TARIFFS

Tariffs in effect at the time of writing included:

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Clays, not manufactured further than ground	free	free	free
Activated clays			
For refining oils	10	10	25
Not for refining oils	15	20	25

United States	
Bentonite, per long ton	81 1/4¢
Clays, artificially activated	1/10¢ a pound plus 12 1/2% ad val.

Bismuth

D. B. FRASER*

Bismuth is derived in Canada as a byproduct of certain lead-zinc, molybdenum and copper ores. It is recovered from lead-zinc ores at Trail, British Columbia, by Cominco Ltd. (formerly The Consolidated Mining and Smelting Company of Canada Limited), which produces refined metal. Bismuth is recovered from molybdenum ores in the Val d'Or district of western Quebec and from copper ores mined near Gaspé, eastern Quebec. Minor amounts are obtained from silver-cobalt ores of the Cobalt-Gowganda area of northern Ontario.

Production in 1965, according to preliminary figures, was 475,076 pounds compared with 399,958 pounds the previous year.

World production of bismuth in 1964, according to an estimate of the United States Bureau of Mines, was 7,213,000 pounds. The leading producer was Peru, with 1,635,800 pounds produced mainly by Cerro de Pasco Corporation Limited. Mexico produced an estimated 1,058,000 pounds, Japan 823,000 pounds and Bolivia 573,200 pounds. Production of the United States is not published.

Demand for bismuth increased more abruptly in 1965 than in the previous year because of increased use as a catalyst in plastics production and as an alloying metal. The price of bismuth, which from 1950 to July 1964 had been $2.25 a pound in the U.S. and was then increased to $2.35 a pound, rose in several stages during 1965 to $4 a pound.

DOMESTIC SOURCES

BRITISH COLUMBIA

The principal source of bismuth was the lead concentrate produced at Cominco's Sullivan lead-zinc mine at Kimberley. Other sources were the lead concentrates from other company mines and from custom shippers. Lead bullion produced from smelting these concentrates contains about 0.05 per cent bismuth. Bismuth is recovered as 99.9+ per cent pure metal from treatment of residues from purification of lead bullion. For use in research and in the electronics industry this bismuth is further treated to give a purity of up to 99.9999 per cent.

QUEBEC

Molybdenite Corporation of Canada Limited in the fiscal year ended September 30, 1965, milled 253,811 tons of ore and recovered 134,945 pounds of bismuth in impure metal ingots from its operations at Lacorne, 23 miles northwest of Val d'Or. Three principal steps are involved in the process. A bulk concentrate containing about 8 per cent bismuth is obtained by flotation. By leaching the flotation 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 96 per cent bismuth, minor amounts of lead and silver and traces of copper, iron and antimony.

*Mineral Resources Division

TABLE 1

Bismuth – Production, Trade and Consumption, 1964–65

	1964		1965p	
	Pounds	$	Pounds	$
Production				
All forms*				
Quebec	185,989	335,712	272,630	734,558
British Columbia	213,428	480,213	201,896	747,015
Ontario	541	703	550	700
Total	399,958	816,628	475,076	1,482,273
Consumption				
Refined metal				
Fusible alloys and solders	32,620		23,787	
Other uses**	21,056		24,492	
Total	53,676		48,279	

Source: Dominion Bureau of Statistics.

*Refined metal from Canadian ores plus bismuth content of bullion and concentrates exported. **Includes metal used in manufacture of pharmaceuticals and fine chemicals, other alloys and malleable iron.
pPreliminary.

TABLE 2

Bismuth – Production, Exports and Consumption, 1956–65
(pounds)

	Production (all forms)[1]	Exports[2]	Consumption[3]
1956	285,861	135,000	131,000
1957	319,941	143,000	55,000
1958	412,792	352,000	39,800
1959	334,736	300,000	39,700
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	47,813
1964	399,958	300,073	53,676
1965p	475,076	..	48,279.

Source: Dominion Bureau of Statistics.
[1]Refined metal from Canadian ores plus bismuth content of bullion and concentrates exported. [2]For 1956 and 1957 – refined metal; 1958 and subsequent years – refined and semirefined metal. [3]Refined metal reported by consumers.
pPreliminary; .. Not available.

TABLE 3

World Production of Bismuth, 1964
(pounds)

	1964
Peru	1,635,800e
Mexico	1,058,000e
Japan (metal)	823,000e
Bolivia	573,200e
Canada (metal)	399,958
South Korea (in ore)	440,000e
Yugoslavia (metal)	178,600e
Other countries	2,104,442
Total	7,213,000*

Source: U.S. Bureau of Mines *Minerals Yearbook, 1964*, and for Canada, Dominion Bureau of Statistics.
*Includes U.S. production, not available for publication.
eEstimate.

In September 1965 Preissac Molybdenite Mines Limited, in which Molybdenite Corporation of Canada has a substantial interest, began operating its molybdenite mill in Preissac township about 5 miles north of Cadillac, treating over 30,000 tons of ore a month. Bismuth was recovered as bismuth oxychloride. About 3 miles north of Cadillac, Anglo-American Molybdenite Mining Corporation opened a 1,000-ton molybdenite mill in August, producing bismuth oxychloride.

Gaspé Copper Mines, Limited, recovered 28,763 pounds of bismuth in impure metal ingots from the treatment of flue dust derived from copper-smelting operations at Murdochville. The bismuth plant was shut down for a considerable period in late 1965, accounting for the drop in production from the 1964 figure of 58,073 pounds.

USES

Bismuth is used 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. Because bismuth expands on solidification and imparts expansion to its alloys, it is used in making type metal. Bismuth is an important additive to aluminum alloys and malleable irons and steels in which it improves machinability. Another significant use is in the production of compounds for medical and cosmetic preparations.

In 1965 the use of bismuth as a catalyst in plastics production expanded rapidly in the United States. This heavy demand was expected to continue into 1966 because of the build-up of inventories by new plants using bismuth as a catalyst, and then to decline to the level needed to supply replacement requirements.

A thermoelectric bismuth alloy – bismuth telluride – is being used increasingly in the development of non-mechanical refrigerating units. In this type of refrigeration the thermoelectric alloy produces cold when an electric current flows through in one direction and heat when the current flows in the opposite direction.

TABLE 4
United States Consumption of Bismuth, by Principal Uses
(pounds)

	1964	1965P
Fusible alloys	688,255	783,283
Other alloys	668,659	573,844
Pharmaceuticals*	756,864	1,523,904
Experimental uses	18,551	15,275
Other uses	27,771	35,367
Total	2,160,100	2,931,673

Source: United States Bureau of Mines, *Mineral Industry Surveys, Bismuth Metal* in the fourth quarter of 1965 for 1964 data, and in the first quarter of 1966 for 1965 data.

*Includes industrial and laboratory chemicals.
PPreliminary.

PRICES AND TARIFFS

The Canadian price of bismuth in 1965 as quoted by Cominco Ltd., for bars 99.99 per cent pure per pound was as follows:

	ton lots	less than one ton
January	$2.50	$2.75
March (beginning)	2.95	3.20
March (end)	3.20	3.45
July	4.25	4.50

The prices of $4.25 and $4.50 prevailed for the balance of the year.

The United States price in 1965 as quoted by *E & MJ Metal and Mineral Markets*, per pound ton lots, delivered, was as follows:

January	$2.35
March 5	2.75
March 18	2.75–3.08
March 23	3.00
June 1	3.00–4.00
June 23	4.00

Tariffs on bismuth in 1965 were:

Canada

Bismuth metal enters Canada duty free.

United States

Bismuth metal, unwrought	1.875% ad val.
Alloys of bismuth	
Containing not less than 30% by weight of lead	1.0625¢ per lb on lead content
Other	18% ad val.
Bismuth metal, wrought	18% ad val.
Bismuth compounds	28% ad val.

Cadmium

D. B. FRASER*

Output of cadmium, expressed as refined metal produced from domestic ores and concentrates plus the recoverable content of cadmium in exported ores and concentrates, was an estimated 2 million pounds in 1965. Refined output at 948,000 pounds was down sharply from 1964 because of a drop in world consumption.

Cadmium is associated with zinc ores, occurring mainly as a sulphide intimately combined with sphalerite, the zinc sulphide. It is recovered as a minor constituent of zinc concentrates. While practically all zinc ores contain some cadmium the amount is often so small as not to be recoverable. Canadian zinc concentrates vary in cadmium content from a negligible amount up to 0.75 per cent (15 pounds) per ton of zinc concentrate.

Metallic cadmium was produced in 1965 at two electrolytic zinc plants, one at Trail, British Columbia, operated by Cominco Ltd. (formerly The Consolidated Mining and Smelting Company of Canada Limited); the other at Flin Flon, Manitoba, operated by Hudson Bay Mining and Smelting Co., Limited. At a third zinc plant at Valleyfield, Quebec, operated by Canadian Electrolytic Zinc Limited, cadmium sponge was recovered; early in 1966, facilities for the production of metallic cadmium at this plant were completed.

The world's centres of cadmium production are those countries with large zinc smelter capacity. The United States is the leading producer with an output of about 10 million pounds annually. The U.S.S.R. produces some 4 million pounds annually, and Canada about 2½ million pounds. Japan, Belgium, Australia, Republic of the Congo, Peru and Mexico are other leading producers. World production in 1965 was approximately 27 million pounds.

In contrast with the shortages of 1962 and 1963, cadmium supplies were adequate to meet world demand in 1964 and 1965. Five million pounds of cadmium were authorized for release from the United States government stockpile in June 1964 and 23,400 pounds were sold in the third quarter of that year. No further sales were made in the fourth quarter or during all of 1965. The producers' price in the United States fell from $3 a pound at the beginning of 1965 to $2.40 by June, remaining at that level for the balance of the year.

*Mineral Resources Division

TABLE 1

Cadmium – Production, Exports and Consumption, 1964–65

	1964		1965p	
	Pounds	$	Pounds	$
Production				
All forms[1]				
British Columbia	1,864,255	6,040,186	534,724	1,486,533
Quebec	236,487	766,218	290,078	806,417
Northwest Territories	–	–	240,000	667,200
Newfoundland	–	–	218,505	607,444
Manitoba	206,818	670,090	213,540	593,641
Ontario	187,609	607,853	185,000	514,300
Yukon Territory	132,222	428,399	152,000	422,560
Saskatchewan	122,734	397,658	135,600	376,968
New Brunswick	22,859	74,063	40,000	111,200
Total	2,772,984	8,984,467	2,009,447	5,586,263
Refined[2]	2,220,239		947,755	
Exports				
Cadmium metal				
Britain	1,137,725	3,726,684	839,237	2,319,932
United States	441,117	1,327,774	442,870	1,125,993
India	21,141	73,925	48,655	110,616
Poland	–	–	31,120	89,040
Other Countries	23,696	83,012	2,763	8,050
Total	1,623,679	5,211,395	1,364,645	3,653,631
Consumption (cadmium metal)[3]				
Plating	141,099		135,595	
Solders	19,914		19,618	
Other products[4]	17,115		16,345	
Total	178,128		171,558	

Source: Dominion Bureau of Statistics.
[1]Production of refined cadmium from domestic ores plus cadmium content of ores and concentrates exported.
[2]Includes metal derived from foreign lead and zinc ores. [3]As reported by consumers. [4]Mainly chemicals, pigments and alloys other than solder.
p Preliminary; – Nil.

TABLE 2

Cadmium – Production, Exports and Consumption, 1956–65

(pounds)

	Production		Exports	
	All Forms[1]	Refined[2]	Cadmium Metal	Consumption[3]
1956	2,339,421	1,932,000	1,922,685	206,000
1957	2,368,130	2,018,000	1,941,680	177,000
1958	1,756,050	1,634,000	1,263,617	170,000
1959	2,160,363	2,528,000	1,979,638	226,000
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	2,220,000	1,623,679	178,000
1965p	2,009,447	948,000	1,364,645	172,000

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. [3] Reported by consumer.
p Preliminary.

TABLE 3

World Production of Cadmium Metal

(thousand pounds)

	1964	1965^{e}
United States	10,458	9,400
U.S.S.R.	3,900	..
Canada	2,773	2,009
Japan	2,231^{e}	2,230
Belgium	1,850^{e}	..
Australia	1,045^{e}	1,050
Other countries	5,643	..
Total	27,900	27,100

Source: U.S. Bureau of Mines *Minerals Yearbook, 1964* and U.S. Bureau of Mines *Commodity Data Summaries*, January, 1966; for Canada, Dominion Bureau of Statistics.

^{e}Estimate; ..Not available.

DOMESTIC SOURCES

BRITISH COLUMBIA

The largest part of Canadian production comes from British Columbia's mines, the main source being the Sullivan lead-zinc-silver mine of Cominco Ltd.

Refined cadmium was recovered at Trail as a byproduct of lead and zinc smelting operations. Production was down sharply from the 945 tons produced in 1964, totalling 359 tons in 1965.

YUKON TERRITORY

United Keno Hill Mines Limited recovered cadmium from silver-lead-zinc ore mined at Elsa, 200 miles north of Whitehorse. The ore was treated in a 500-ton-per-day concentrator.

NORTHWEST TERRITORIES

Production of lead and zinc by Pine Point Mines Limited on the south shore of Great Slave Lake began in 1965 with the shipping of high-grade ore to British Columbia and the United States. In November, a 5,000-ton-per-day concentrator for the production of zinc and lead concentrates was opened.

SASKATCHEWAN AND MANITOBA

Production by Hudson Bay Mining and Smelting Co., Limited, Flin Flon, on the provincial boundary, was 368,208 pounds of metallic cadmium compared with 329,552 pounds in 1964. The company operated three mines near Flin Flon, and two near Snow Lake, 90 miles east of Flin Flon, milling the copper-zinc-lead ore in a 6,000-ton concentrator and recovering cadmium in an electrolytic plant at Flin Flon.

EASTERN CANADA

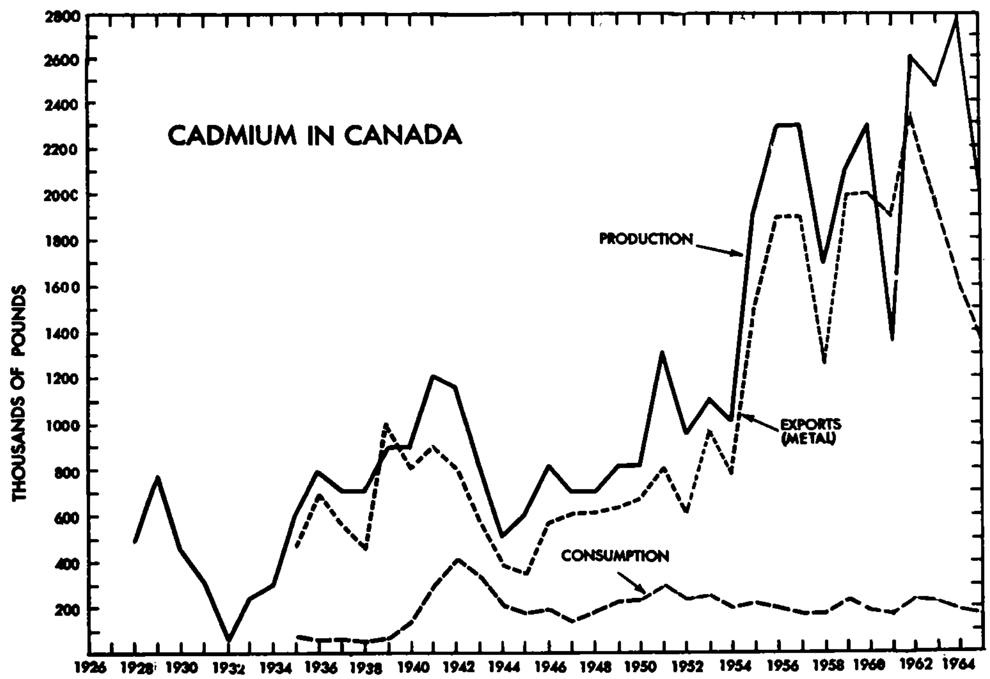
Canadian Electrolytic Zinc Limited at Valleyfield, Quebec, recovered cadmium as an unrefined sponge in treating zinc concentrates from the Matagami Lake and Noranda districts of Quebec and from Manitouwadge, Ontario. The sponge or precipitate is obtained in purifying zinc-bearing solutions preceding electrolysis. Facilities for the production of refined cadmium were completed during the first quarter of 1966.

Of the cadmium exported from eastern Canada in zinc concentrates, the cadmium content was reported only when it was paid for.

TABLE 4

Principal Mine Producers of Cadmium, British Columbia, 1965

Company	Location	Mill Capacity (short tons/day)
Cominco Ltd.	Kimberley (Sullivan mine)	10,000
	Salmo (H.B. mine)	1,200
	Riondel (Bluebell mine)	700
Aetna Investment Corporation Limited	Toby Creek (Mineral King mine)	500
The Anaconda Company (Canada) Ltd.	Britannia	4,000
Canadian Exploration, Limited	Salmo	1,900
Mastodon-Highland Bell Mines Limited	Beaverdell	100
Reeves MacDonald Mines Limited	Remac	1,200



USES

The main use of cadmium is as an anticorrosive coating applied by electroplating to steel and, to a lesser extent, to copper-base alloys. Zinc and cadmium coatings on less active metals protect the metals electrochemically as well as by physical enclosure. Other metals that are commonly used as protective coatings must be applied in greater thicknesses to give the same protection. Cadmium is preferred to zinc as a coating because it can be deposited more uniformly especially in recesses of intricately shaped parts, is more ductile, is slightly more resistant to atmospheric corrosion and can be electrodeposited with less electric current per unit of area covered. The obvious disadvantage of cadmium compared with zinc is its much higher cost, which makes cadmium vulnerable to substitution.

Cadmium-plated articles include a wide range of parts and accessories used in the construction of automobiles, household appliances, electrical equipment and aircraft.

The second-largest use is in the manufacture of pigments. Cadmium sulphides give yellow to orange colours while cadmium sulphoselenides give pink to red and maroon. Cadmium pigments are valued for their clarity and brilliance and for their chemical stability. Cadmium compounds are used also in the manufacture of vinyl plastics and as phosphors for television tubes.

Cadmium is also used in making solders, particularly of the cadmium-silver type. Fusible alloys with low melting point, of the cadmium-tin-lead-bismuth type have long been used in automatic sprinkler systems, fire-detection apparatus and valve seats for high-pressure gas containers. Owing to its high strength, high conductivity, ductility and resistance to wear, low-cadmium copper (about 1 per cent) is used in the manufacture of trolley and telephone wires. Cadmium is also used in devices to control the fissionable elements in atomic reactors. Cadmium, because it has a hardening effect when small amounts are added to silver, is used in the manufacture of sterling silverware.

Production of nickel- and silver-cadmium storage batteries is an important outlet for cadmium. These batteries have a longer life than the standard lead-acid battery, are smaller and are superior during low-temperature operation. Because of these characteristics, they are being used in airplanes, earth satellites, missiles and ground equipment for polar regions as well as in small portable items such as battery-operated shavers, toothbrushes, drills and handsaws.

PRICES AND TARIFFS

The Canadian price of cadmium, f.o.b. Montreal and Toronto, was $3.25 a pound for lots of 5,000 pounds or more at the beginning of 1965. The price dropped to $2.85 in March and to $2.60 in June, where it remained for the balance of the year.

The United States price as quoted in *E & M J Metal and Mineral Markets* was $3 a pound for 1-ton lots at the beginning of 1965. The price dropped to $2.65 on March 8 and to $2.40 on June 23, remaining at this level for the rest of the year.

Tariffs in Canada and the United States during 1965 were as follows:

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Cadmium in metal, lumps, powder, ingots, blocks, etc.	free	15	25
Cadmium, in rod, shot, or processed form	15	20	25

United States	
Cadmium in ores and concentrates	free
Cadmium metal, unwrought	3.75¢ per lb.
Cadmium metal, wrought	18% ad val.
Cadmium alloys	18% ad val.
Cadmium flue dust	free

Calcium

W.H. JACKSON*

Calcium metal is readily available in quantities and purities to suit the needs of industry. Canadian output increased slightly in 1965 to 159,434 pounds. The small output results from lack of demand, not from lack of raw material or production capacity.

Dominion Magnesium Limited is the only Canadian producer of calcium. The metal is made with the same equipment and by methods similar to those used for the production of magnesium, which is the main product of the company at its Haley, Ontario, smelter. Thorium, titanium, zirconium and small quantities of strontium and barium are also produced at Haley. The company reported that calcium shipments from its smelter were 157,875 pounds compared with 138,358 pounds in 1964.

The company produces three grades of calcium. To produce the Commercial grade, 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 1170°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 to 740°C. Higher purities are obtained by subsequent refining operations.

The Commercial grade contains 98 to 99 per cent calcium, 0.5 to 1.5 per cent magnesium, 1 per cent maximum nitrogen and 0.35 per cent aluminum maximum. The main uses are in debismuthizing lead, sulphur removal in maraging steels, and production of calcium hydride. High-purity calcium contains 99.5 per cent Ca plus up to 0.5 magnesium. It is particularly low in manganese with a maximum of 0.004 per cent, iron 0.005 per cent, nitrogen 0.025 per cent, and aluminum 0.010 per cent. Such elements as nickel, lithium, boron, sodium and cadmium are extremely minor impurities. Its normal use is as a reducing agent in the production of uranium, thorium, beryllium, and zirconium and titanium powders. The Chemical Standards grade is nominally 99.9 per cent pure and is used for experimental or pilot plant work where pure metal is required for chemicals and isotope separation. Most of the production is exported except for that used in domestic production of thorium and of lead-calcium alloys.

Of other minor metals produced at Haley barium is used as a getter in vacuum tubes, strontium for laboratories requiring a high purity, zirconium and thorium for alloying with magnesium, titanium as an alloying agent for some nickel-containing alloys, and in powder form for fuses.

World production statistics by country are not available; Dominion Magnesium is the main commercial source of calcium. Calcium is also produced in France by Société Métallurgique du Planet and in the United States by Nelco Metals Inc., Div. of Charles Pfizer Company, whose output is mainly used as a reducing agent. All use thermal reduction methods. There is also a small amount of captive production in the United States by American Smelting and Refining Company and Union Carbide Metals Company. Their processes are thought to be based on the electrolysis of calcium chloride.

*Mineral Resources Division

TABLE 1

Canadian Calcium Production and Exports, 1964-65

	1964		1965p	
	Pounds	$	Pounds	$
Production (metal)*	138,357	151,694	159,434	152,848
Exports (metal)				
United States	55,300	57,935	75,700	52,404
Belgium and Luxembourg	15,600	9,815	44,000	28,450
West Germany	15,400	14,000	15,400	15,060
Britain	9,600	13,702	10,700	18,157
Other countries	34,900	41,629	2,500	3,053
Total	130,800	137,081	148,300	117,124

Source: Dominion Bureau of Statistics.
* Smelter use and shipments.
p Preliminary

TABLE 2

Calcium Production and Exports, 1956-65

	Production * (pounds)	Exports (pounds)
1956	394,900	499,300e
1957	221,225	60,500e
1958	25,227	63,700e
1959	67,429	65,100e
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
1965p	159,434	148,300

Source: Dominion Bureau of Statistics.
*Production from 1956 to 1960 inclusive; shipments from 1961.
pPreliminary; e Estimated.

USES

Calcium can be safely handled in air but since it is reactive and has low strength, it has not been possible to develop structural uses.

The main use of calcium metal is a reducing agent in the manufacture of uranium, thorium and their compounds. The metal can also be used to reduce chromium, vanadium, zirconium, titanium and beryllium.

In nonferrous metallurgy, its uses are in debismuthizing lead in fire refining and as a lead alloy additive for storage battery grids. For the latter use an alloy comparable to one containing 9 per cent antimony contains only 0.1 per cent calcium but has better conductivity, resistance to sulphation and similar hardness. Such high-quality batteries are standard for telephone transmission systems but the use does not yet extend to automobile-type batteries where new and recycled antimonial lead is the basis of manufacturing. A similar additive application in lead alloys is to improve the strength of cable sheaths. It is also used for alloys, mainly with aluminum and magnesium, and with silver in the preparation of catalysts.

In ferrous metallurgy, calcium-silicon or calcium-manganese-silicon are the common additives. These low-cost alloys are made by reducing a charge of lime and silica in an electric furnace. The calcium helps to deoxidize, desulphurize and scavenge the steel melt, reduces the effect of nonmetallic impurities in steel and controls the size and distribution of graphitic carbon in cast iron. Higher-cost calcium metal is the only way to desulphurize without adding unwanted elements. This use for the metal is expanding where impurity control is important in the production of quality steels for bearings, tools, and high-temperature applications.

In chemical processes, it is an absorbant for oxygen, nitrogen and hydrogen in purifying argon and other rare gases. It is also used for sulphur removal in petroleum products, for high-purity chemicals and in isotope separation. The manufacture of calcium hydride by heating calcium at 750° in a hydrogen atmosphere is a major outlet for world production. It is used as a portable source of hydrogen gas. Demand varies according to changing defence requirements.

PRICES

The Canadian price quoted by Dominion Magnesium Ltd., f.o.b. Haley, Ont. was 85 cents a pound for the Commercial grade up to $3.50 a pound for the Chemical Standards grade.

United States prices for calcium of Commercial grade as quoted in *E & M J Metal and Mineral Markets* were as follows, per pound in ton lots:

Slabs, etc. to June 14	$2.05
Crowns, from June 19 to end of year	.95

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Calcium metal, pure, in lumps, ingot, powder*	free	15	25
Calcium metal alloys, or calcium metal in rods, sheet or any semiprocessed form	15	20	25

United States

Calcium metal, unwrought	15%
Calcium metal, wrought	18%

*Must be ruled to be of a class or kind not produced in Canada, otherwise the tariff governing semiprocessed forms applies.

Cement

N.G. ZOLDNERS*

The record $9.9 billion established for Canadian construction in 1965 is an increase of 14.9 per cent over the 1964 value of $8.6 billion. This continuing growth in construction is stimulating production activity in building materials. Cement production in 1965 reached another record peak amounting to 8.4 million short tons**, a 7.5 per cent increase over the 1964 production. The value of cement production, which ranked ninth in 1964 compared with all Canadian mineral production, now is seventh in importance.

Two new plants in Nova Scotia and Manitoba and major expansion of existing clinker-producing facilities in Quebec and Ontario, completed in 1965, added about 10 million barrels to Canada's annual rated capacity at a cost of over $50 million. The total rated annual capacity of the industry increased by 17.5 per cent to 67.2 million barrels. However, actual production of the industry dropped in 1965 to an estimated 73 per cent of the year-end capacity as compared with 79 per cent for 1964.

Another new plant under construction in Quebec and major expansion work at two other plants will increase Canada's production capacity in 1966 by 3.8 million barrels. Further expansion in Ontario and British Columbia and a new plant in Quebec planned for 1967 will add another 15.2 million barrels. By the end of 1967 Canada's total annual rated capacity should reach 86.2 million barrels, an increase of about 28 per cent over that of 1965.

PRODUCTION

Canada produces portland, masonry, sulphate-resistant and oil-well cements, as well as white cement from imported clinker. Most of the production is normal portland cement, although other modified types of portland cement have been produced in increasing amounts in recent years. In 1965, of the total cement amount produced, 97 per cent was portland and practically all the rest was masonry cement.

The total of cement shipped from all Canada's plants during 1965 was 8,426,971 short tons, valued at $144,582,127. Of the volume, 70 per cent was produced in the provinces of Ontario and Quebec, where about half of all the cement plants in Canada are located. No cement is being produced in Prince Edward Island, or Yukon and Northwest Territories.

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*Mineral Processing Division, Mines Branch

**1 short ton = 2,000 lb; 1 barrel = 4 bags = 350 lb; 1 U.S.A. barrel = 376 lb.

TABLE 1

Cement – Production and Trade, 1964–65

	1964		1965p	
	Short Tons	$	Short Tons	$
Production*				
By province				
Ontario	3,043,771	46,804,126	3,148,824	50,594,000
Quebec	2,631,187	41,627,483	2,870,930	45,845,120
Alberta	771,977	14,346,958	876,828	16,711,000
British Columbia	537,396	10,040,776	584,010	11,983,007
Manitoba	350,762	7,530,860	373,462	8,139,000
Saskatchewan	247,600	5,612,241	250,000	5,670,000
New Brunswick	174,238	2,908,033	174,672	2,801,000
Newfoundland	90,453	1,833,743	91,000	1,840,000
Nova Scotia	–	–	57,245	999,000
Total	7,847,384	130,704,220	8,426,971	144,582,127
By type				
Portland	7,625,517	126,518,770	8,184,110	
Masonry**	221,867	4,185,450	242,861	
Total	7,847,384	130,704,220	8,426,971	144,582,127
Exports				
Portland cement				
United States	288,206	4,538,001	316,637	4,942,692
Ceylon	8,400	127,630	18,067	266,497
Other countries	1,063	23,009	183	4,496
Total	297,669	4,688,640	334,887	5,213,685
Cement and concrete basic products, n.e.s.				
United States		306,495		322,989
Other countries		41,788		28,537
Total		348,283		351,526
Imports				
Portland cement				
United States	250	5,862	80	2,190
Portland cement, white				
United States	5,232	236,055	10,439	482,034
Japan	2,193	58,530	4,740	130,723
Denmark	4,034	119,965	2,866	84,869
Belgium and Luxembourg	2,836	86,846	2,285	68,959
Britain	4,340	136,243	1,842	53,445
West Germany	1,269	45,172	998	49,330
Other countries	1,448	42,439	131	3,960
Total	21,352	725,250	23,301	873,320
Cement, n.e.s.				
Britain	7,054	242,064	7,981	296,968
United States	2,383	205,307	3,896	247,802
West Germany	1,641	94,233	2,361	126,963
Total	11,078	541,604	14,238	671,733
Total cement imports	32,680	1,272,716	37,619	1,547,243

Table 1 (cont.)

	1964		1965P	
	Short Tons	$	Short Tons	$
Refractory cements and mortars				
United States		1,143,852		1,187,775
Ireland		42,339		360,473
Japan		—		182,254
Other countries		16,892		21,684
Total		1,203,083		1,752,186
Cement and concrete basic products, n.e.s.				
United States		231,573		230,907
Britain		2,006		20,152
Other countries		25,353		11,443
Total		258,932		262,502
Cement clinker				
United States (white)	17,317	446,921	18,759	484,353
Jamaica (normal)	—	—	15,497	112,914
Total	17,317	446,921	34,256	597,267

Source: Dominion Bureau of Statistics.

*Producers' shipments plus quantities used by producers. **Includes small amount of other cement.

Symbols: PPreliminary; — Nil; n.e.s. Not elsewhere specified.

Table 2 shows a continuous increase of Canada's cement production during the last ten years. The amount of cement produced in 1965 is about double of that produced in 1955. The slight decrease in production in 1960 and 1961 was fully recovered in 1962.

In 1965 cement clinker was produced in 21 plants containing 52 rotary kilns. Of all these plants 16 employed the wet process and five used the dry method. However, two more plants are changing from wet to dry processes. Also, one of the new plants in Quebec scheduled for completion late in 1966, will employ the dry process in its operation.

In 1964*, the raw materials consumed in the production of cement included 10,275,353 tons of limestone, 1,085,225 tons of clay, 359,988 tons of gypsum, 299,328 tons of shale, 195,408 tons of high-silica sand and 35,454 tons of iron oxide.

*1965 figures not yet available.

TABLE 2

Cement — Production, Trade and Consumption, 1955–65

(short tons)

	Production[1]	Exports[2]	Imports[2]	Apparent Consumption[3]
1955	4,404,480	168,907	517,890	4,753,463
1956	5,021,683	124,566	599,624	5,496,741
1957	6,049,098	338,316	92,380	5,803,162
1958	6,153,421	141,250	41,555	6,053,726
1959	6,284,486	303,126	29,256	6,010,616
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
1965P	8,426,971	334,887	37,619	8,129,703

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.

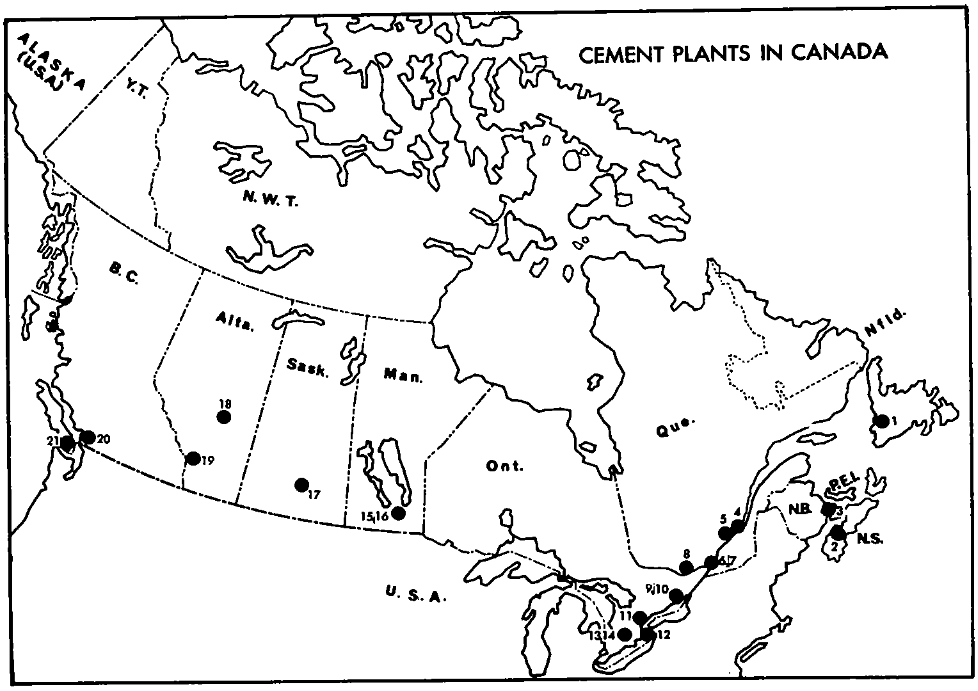


TABLE 3

Approximate Cement-Plant Capacities[1] at End of 1965

(numbers in parentheses refer to locations on the accompanying map)

Company and Location	Barrels per Year	Short Tons per Year[2]
Newfoundland		
North Star Cement Limited, Corner Brook (1)	900,000	158,000
Nova Scotia		
Maritime Cement Company Limited, Brookfield, N.S. (2)	1,400,000	245,000
New Brunswick		
Canada Cement Company, Limited, Havelock (3)	1,000,000	175,000
Quebec		
St. Lawrence Cement Company, Villeneuve (4)	4,500,000	790,000
Ciment Quebec Inc., St. Basile (5)	2,500,000	438,000
Miron Company Ltd., St. Michel (6)	6,000,000	1,050,000
Canada Cement Company, Limited, Montreal (7)	8,000,000	1,400,000
Canada Cement Company, Limited, Hull (8)	1,200,000	210,000
Ontario		
Lake Ontario Cement Limited , Picton (9)	5,000,000	876,000
Canada Cement Company, Limited, Belleville (10)	4,400,000	770,000
St. Lawrence Cement Company, Clarkson (11)	4,200,000	735,000
Canada Cement Company, Limited, Port Colborne (12)	1,200,000	210,000
Canada Cement Company, Limited, Woodstock (13)	3,400,000	596,000
St. Mary's Cement Co., Limited, St. Mary's (14)	4,250,000	745,000
Medusa Products Company of Canada, Limited, Paris (grinding only)		

Table 3 (cont.)

Company and Location	Barrels per Year	Short Tons per Year[2]
Manitoba		
Canada Cement Company, Limited, Fort Whyte (15)	5,270,000	923,000
Inland Cement Industries Limited, Winnipeg (16)	2,000,000	350,000
Saskatchewan		
Inland Cement Industries Limited, Regina (17)	1,200,000	210,000
Alberta		
Inland Cement Industries Limited, Edmonton (18)	3,400,000	595,000
Canada Cement Company, Limited, Exshaw (19)	3,100,000	542,000
Canada Cement Company, Limited, Edmonton (grinding only)		
British Columbia		
Lafarge Cement of North America Ltd., Lulu Island (20)	1,500,000	262,000
Ocean Cement Limited, Bamberton (21)	2,800,000	490,000
Total	67,220,000	11,770,000

Source: Published data and private correspondence.
[1]Not including the capacities of the separate grinding plants. [2]Calculated.

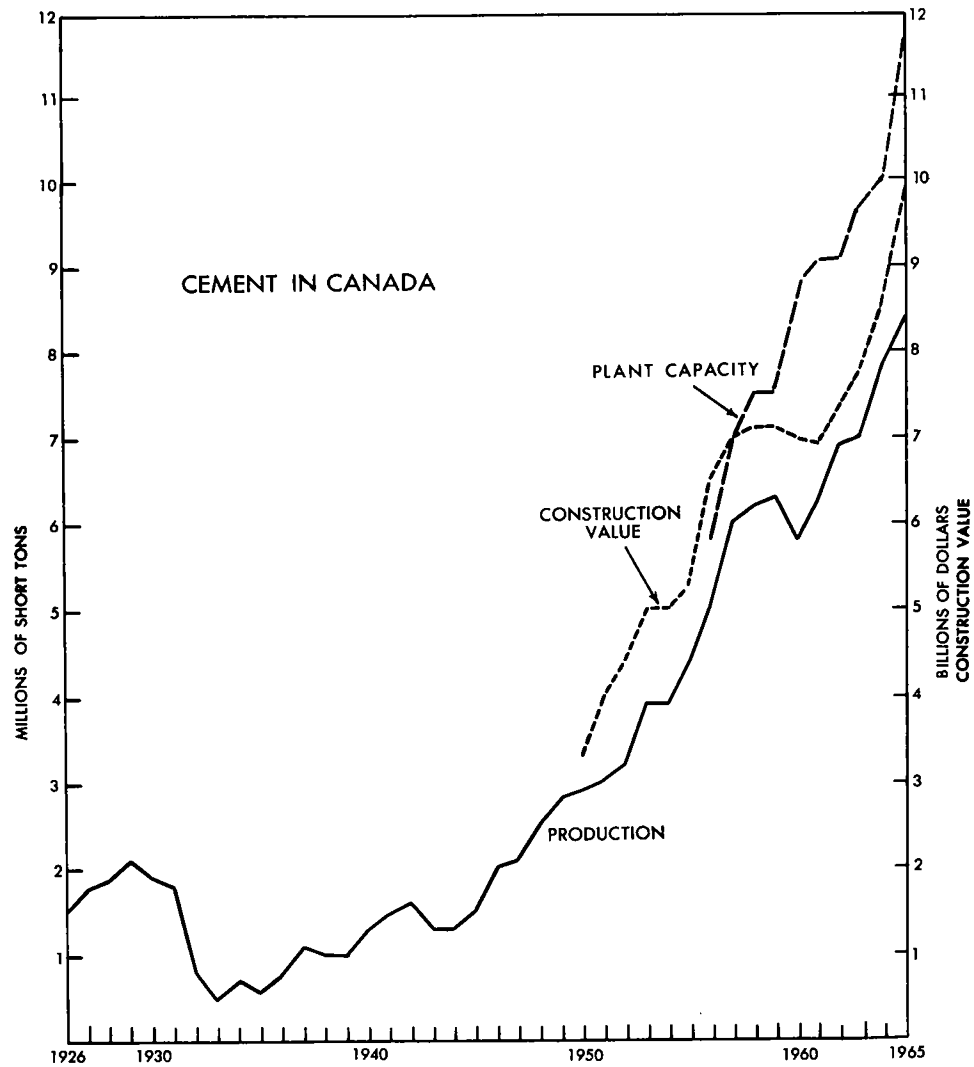
Table 4 summarizes changes in the production capacity of Canada's cement industry since 1956, showing that in the last 10 years the total rated capacity of the industry has more than doubled. In this period the average plant capacity increased by 54 per cent, whereas average kiln capacity increased by 31 per cent, indicating a trend towards more kilns per plant and higher productivity per kiln.

TABLE 4

Cement — Rated Production Capacity[1], 1956–65

			Approximate Capacity[2]		Average Capacity[2]		Production	
	No. of Plants[2]	No. of Kilns[2]	Barrels per Year	Short tons per Year	Per Plant (million bbl./year)	Per Kiln (million bbl./year)	Shipments (short tons)	As % of Year-end Capacity
1956	16	34	33,300,000	5,827,500	2.08	0.98	5,021,683	86
1957	16	38	39,200,000	6,860,000	2.45	1.03	6,049,098	88
1958	18	41	42,800,000	7,490,000	2.38	1.04	6,153,421	82
1959	18	42	42,800,000	7,490,000	2.38	1.02	6,284,486	84
1960	19	45	50,000,000	8,750,000	2.63	1.11	5,787,225	66
1961	19	45	51,800,000	9,065,000	2.73	1.15	6,205,948	68
1962	19	45	52,450,000	9,179,000	2.76	1.17	6,878,729	75
1963	19	45	54,600,000	9,556,000	2.87	1.21	7,013,662	73
1964	19	47	57,150,000	10,001,000	3.01	1.22	7,847,384	79
1965	21	52	67,220,000	11,770,000	3.20	1.29	8,426,971[4]	72
1966[3]	22	55	71,020,000					
1967[3]	23	60	86,220,000					

[1]Clinker-producing plants. [2]Year-end. [3]Scheduled to date. [4]Subject to revision.



In the last three years the industry has operated between 73 to 79 per cent of its rated annual capacity. In 1965 the production rate decreased to 72 per cent of the year-end production capacity; with several new plants under construction the production rate of the cement industry can be expected to decrease further.

In addition, Canada Cement Company Limited operates a separate clinker-grinding plant in Edmonton and is completing another at Saskatoon, which will be in operation in 1966. Medusa Products Company of Canada, Limited, grinds imported clinker at Paris, Ontario, for the production of white cement.

WORLD PRODUCTION

The growth of cement production during the 10-year period from 1954 to 1964 in the leading cement-producing countries in the world is shown in Table 5. Canada doubled its production from 3.9 million tons in 1954 to 7.8 million in 1964, remaining in twelfth place among other countries.

TABLE 5

World Production of Cement, 1954–64*
(thousand short tons)

Country	1954	1964	Production Increase (%)
United States	51,853	72,453	40
U.S.S.R.	20,932	71,539	242
West Germany	17,940	37,072**	107
Japan	11,765	36,321	209
Italy	9,656	25,177	161
France	10,741	23,490	119
Britain	13,397	18,704	40
India	4,944	11,574	134
China	5,070	10,681	111
Poland	3,751	9,657	157
Spain	4,201	9,061	116
Canada	3,926	7,847	100
Belgium	4,822	6,446	34
Other countries	51,823	106,248	105
Total	214,821	446,270	108

Source: *U.S. Bureau of Mines *Minerals Yearbook, 1964*. ***Statistical Summary of Mineral Industry, World Production*, U.K. Overseas Geological Surveys, London, 1966.

Particularly large increases in cement production during the above 10-year period were recorded by the U.S.S.R. (343 per cent) and Japan (309 per cent), indicating an upswing in construction in these countries.

Table 6 shows the amount of cement produced in different countries per capita of population. Canada with its 802 pounds per capita in 1964 has the fifth highest rating in the world with Belgium, West Germany, France and Italy leading in that order.

INTERNATIONAL TRADE

Because most countries have raw materials available for cement manufacture, they are virtually self-sufficient in normal portland cement. Only a minor proportion of world production is traded internationally. For instance, 1964 exports and imports for the world's largest producer, the United States, were 0.2 and 1.1 per cent of that country's production. For Canada these proportions were 4.0 and 0.4 per cent in 1965. Data compiled in Table 2 shows that both export and import of cement by volume has increased in Canada during the last three years.

Canada's cement export in 1965 increased by 12.8 per cent over the previous year to 334,887 tons valued at $5,213,685. Practically all of it went to the United States. Canada supplied about 40 per cent of U.S. cement imports, shipped mainly to New York State.

TABLE 6

Growth of Cement Production, 1954–64

Country	1954			1964		
	Population (millions)	Production		Population (millions)	Production	
		Short Tons (millions)	Lb per Capita		Short Tons (millions)	Lb per Capita
Belgium	8.512	4.822	1133	9.428	6.446	1368
W. Germany	49.516	17.940	725	58.290	37.072	1272
France	42.844	10.741	501	48.492	23.490	970
Italy	47.032	9.656	411	52.639	25.177	957
Canada	15.195	3.926	517	19.571	7.847	802
United States	162.409	51.853	639	192.119	72.453	752
Japan	83.419	11.765	282	97.350	36.321	747
Britain	50.225	13.397	533	54.066	18.704	692
U.S.S.R.	214.500	20.932	195	229.100	71.539	625

Canada's cement import in 1965 was 37,619 tons, or 9 per cent of cement export volume. However, the imports being mostly white and other expensive special cements from the U.S., Europe and Japan, had a value of $1,547,243, or 30 per cent of exported cement value. In addition, Canada imported refractory cements and mortars valued at $1,752,186, and 18,750 tons of white cement clinker from the U.S. and 15,497 tons of normal portland cement clinker from Jamaica, totalling in value $597,267

DEVELOPMENTS

For the third successive year the cement industry in Canada expanded considerably. This is scheduled to continue at least into 1968. In 1965 two new plants began production and construction started at another new plant; major expansion was completed at three and construction started at five established plants; the start of two more new plants and expansion of another existing plant were announced.

Nova Scotia became the ninth province to produce cement. Maritime Cement Company Limited, subsidiary of Canada Cement Company, Limited, started production in the new $14-million cement plant at Brookfield. It is a one-kiln dry process operation and has an initial rated capacity of 1.4 million barrels of cement per year. The second new plant commencing operation was the $16-million Tuxedo plant at Winnipeg, Manitoba. It is operated by the Inland Cement Industries Limited using a wet process. Its rated capacity is 2 million barrels per year.

Major expansions costing more than $22 million were carried out in 1965 on existing facilities of three cement plants. By addition of another kiln, the Villeneuve, Quebec, plant of St. Lawrence Cement Company and the Picton, Ontario, plant of Lake Ontario Cement Limited doubled their production capacities. About 2 million barrels of capacity has been added by the installation of a second kiln at the Montreal plant of Miron Company Ltd.

These additions and the two new plants raised the annual rated capacity of the industry by the end of 1965 by about 10 million barrels of cement.

The capacity of Canada's cement industry is expected to increase in 1966 by 3.8 million barrels. A new plant under construction by the Independent Cement Inc. at Joliette, Quebec, is scheduled to go into production by the middle of 1966. This will be a two-kiln wet process operation with a rated annual capacity of 2.5 million barrels. North Star Cement Limited is converting its facilities for dry processing, increasing its plant capacity at Corner Brook, Newfoundland, by about 50 per cent. Canada Cement Company, Limited, is expanding its Havelock, New Brunswick, plant by adding another kiln to double its capacity.

The addition of a new plant and expansions planned for 1967 will increase production capacity by 15 million barrels. Early in 1966 work will be started on the $35-million integrated cement and concrete products plant of the Lafarge Cement Quebec Ltd., which is building a 3-million-barrel cement plant at St. Constant, a few miles south of Montreal. St. Lawrence Cement Company plans to expand its plant at Clarkson, Ontario, by addition of a new dry-process kiln and new type of equipment. They plan to raise the annual capacity of the plant by 1967 to about 10 million barrels, making it the largest single cement manufacturing plant in Canada. Another large expansion has been announced by the Canada Cement Company for its Woodstock, Ontario, plant, where addition of a 3.2-million-barrel kiln will raise the annual capacity of the plant in 1967 to about 6.5 million barrels. Major plant expansion work in British Columbia is scheduled for completion in 1967. Lafarge Cement of North America Ltd. is expanding its plant on Lulu Island by adding another kiln of 2-million-barrel capacity per year. Ocean Cement Limited is installing a new kiln at its Bamberton plant on Vancouver Island, raising annual capacity of the plant to 4.8 million barrels.

The St. Mary's Cement Co., Limited, has announced construction of a new $22-million cement plant to be built in Darlington township, west of Bowmanville, Ontario. The 2-million-barrel plant is scheduled to produce early in 1968.

TABLE 7

Cement-plant Expansion

Company and Location	Capacity Increase (million bbl./year)	Year Started	Year Scheduled for Completion	Approximate Cost ($ million)
Newfoundland				
North Star Cement Limited	0.3[2]	1964	1966	3.5
New Brunswick				
Canada Cement Company, Limited, Havelock	1.0[2]	1965	1966	4
Quebec				
Independent Cement Inc., Joliette	2.5[1]	1965	1966	..
Lafarge Cement Quebec Ltd., St. Constant	3.0[1]	1966[3]	1967	35[4]
Ontario				
St. Mary's Cement Co., Limited, Bowmanville	2.0[2]	1966[3]	1968	22
St. Lawrence Cement Company, Clarkson	5.0[2]	1965	1967	13
Canada Cement Company, Limited, Woodstock	3.2[2]	1966[3]	1967	20
Saskatchewan				
Canada Cement Company, Limited, Floral	(Grinding plant)[1]	1965	1966	4.5
British Columbia				
Lafarge Cement of North America Ltd. Lulu Island	2.0[2]	1965	1967	..
Ocean Cement Limited, Bamberton	2.0[2]	1965	1967	2.5

Source: Data obtained from publications and private correspondence.
[1]New plant. [2]Expansion. [3]Schedules. [4]Cost of the total integrated project.
.. Not available.

Canada Cement Company expects to have its new $4.5-million clinker grinding mill at Floral, Saskatchewan, near Saskatoon, operating in the summer of 1966.

Ocean Cement Limited is adding to its facilities a new cement distribution depot at New Westminster, B.C. It will have a capacity of 39,000 barrels and is scheduled for 1966.

CONSUMPTION AND USE

Cement is a construction material and its consumption varies directly with construction expenditures. This relationship is shown on page 86. For 1966 the Dominion Bureau of Statistics has forecast another record expenditure for construction in Canada amounting to $11 billion, a noteworthy rise of 11 per cent; consequently, cement production should also attain another record in 1966.

TABLE 8

Destination of Domestic Cement Shipments*, 1965

(short tons)

Ontario	2,894,913
Quebec	2,728,792
Manitoba, Saskatchewan, Alberta and British Columbia	2,016,651
Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick	461,553
Yukon and Northwest Territories	6,664
Total	8,108,573
Exports	346,541
Total shipments	8,455,114

Source: Dominion Bureau of Statistics.
*Only direct sales from producing plants

Ontario and Quebec are by far the largest cement consuming provinces, absorbing two thirds of the volume shipped. However, the percentage increase of consumption for the Maritime and Prairie provinces in 1965 over consumption during the previous year was considerably higher than in Ontario or Quebec. The 3.5-per-cent increase in Ontario was mainly due to greater activity in general construction and highway building.

The 5.0-per-cent increase in Quebec was the result of increased construction activity in the Greater Montreal area, and large hydroelectric power development in northern Quebec. Construction of new expressway roads, bridges, tunnels and subway on Montreal Island in connection with the Trans-Canada highway and Expo '67 has greatly increased the demand for cement in 1965, which will continue through 1966 and should extend well into 1967. The Manicouagan-Outardes hydroelectric power dams have used over 170,000 tons of Modified Type 2 cement in 1965.

Cement consumption in the western provinces continues to increase due to the hydroelectric power developments in British Columbia, Saskatchewan and Manitoba. A large amount of cement is being used for soil-cement highway construction. The newly established multimillion-dollar potash industry in Saskatchewan also used large amounts of cement in 1965.

Cement is used to stabilize hydraulically placed fill in underground mines. Although it was first employed on a large scale as recently as 1962, the application has become an important outlet for producers, particularly in Ontario. This commodity is also used in the construction of permanent stope floors in underground mining. Cement is also used in grouting, in cementing oil and gas wells, in certain paints and in the manufacture of asbestos-cement products.

Statistics are not available to provide a breakdown of consumption by use. However, most cement is used in general construction. More than one third of cement output goes into the production of ready-mixed concrete. The proportion of the total consumption used for ready-mixed concrete and other concrete products has been increasing steadily in the last few years. In 1965 the output of most categories increased appreciably over 1964. In terms of the quantity of cement consumed, the 16-per-cent increase in ready-mixed concrete is noteworthy.

TABLE 9

Production of Concrete Products

		1964	1965
Concrete bricks	(no.)	103,145,400	98,550,167
Concrete blocks (except chimney blocks)			
Gravel	(no.)	133,037,916	142,608,585
Cinder	(no.)	8,512,121	6,714,592
Other	(no.)	35,304,673	46,904,439
Concrete drain pipe, sewer pipe, water pipe and culvert tile	(tons)	1,667,204	1,466,233
Concrete, ready mixed	(cu. yd.)	11,845,196	13,544,076

Source: Dominion Bureau of Statistics.

SPECIFICATIONS

Cement produced in Canada conforms to the specifications of the Canadian Standards Association. The types not covered by the association generally meet specifications of the American Society for Testing and Materials. The Modified Type 2 cement mentioned earlier is an exception; this is being manufactured by three cement companies located in Quebec according to specifications supplied by Hydro-Quebec and designed for mass concrete used in dam construction.

PRICES

Prices vary depending on supply and demand, quantity of shipment, location and type of cement. In 1965, the average value of producers' shipments for all types was $17.16 a ton compared with $16.91 in 1964. It ranged from a low of $16.03 in New Brunswick to $22.68 in Saskatchewan. The latter province has only one producer and imports all its limestone raw material.

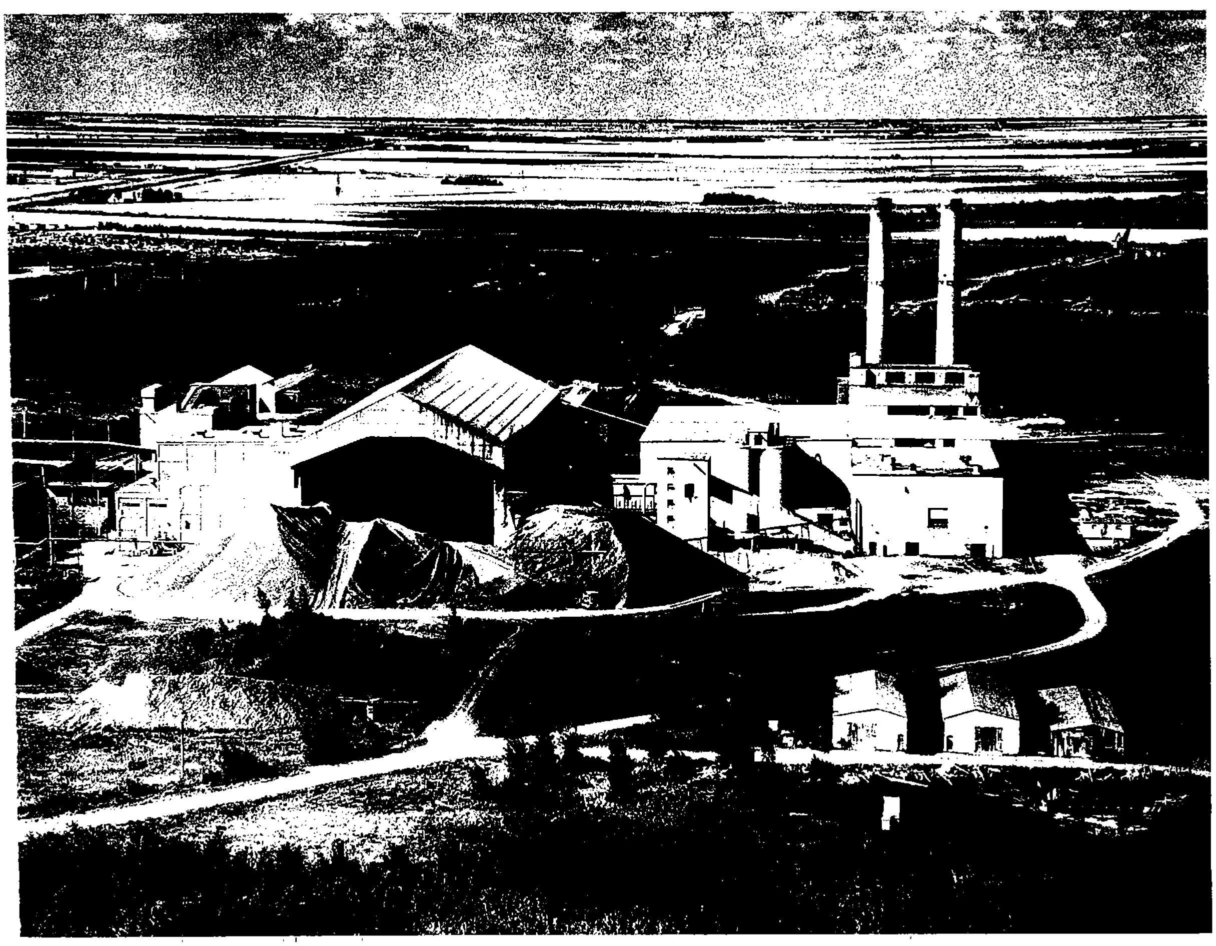
TARIFFS

	British Preferential (¢)	Most Favoured Nation (¢)	General (¢)
Canada			
Portland cement and hydraulic lime, in bulk or barrels or in casks, the weight of the barrel, bag or cask to be included in the weight for duty, per 100 lb	5	8	8
White portland-cement clinker for use in the manufacture of white portland cement, per 100 lb	2	3½	6

United States

The United States import tariff on portland, roman and other hydraulic cements and cement clinker remained 2¼ cents per 100 pounds including the weight of the containers. For white, nonstaining portland cement it is 3 cents per 100 pounds including the weight of the containers.

The Fort Whyte plant of Canada Cement Company, Limited near Winnipeg, Manitoba. Newly installed precipitators have practically eliminated dust from the stacks.



Chromium

V.B. SCHNEIDER*

Chromium content of chromium ore (chromite) imported in 1965 amounted to 35,408 tons valued at $2.5 million. This was an increase of 14,614 tons from 1964. A quantity comparison with previous years' imports is not possible because the Dominion Bureau of Statistics reported for the first time in 1964 the chromium content of imported chromite instead of the gross weight. However, imports of chromite for 1964 were the largest since 1957 when 111,453 tons (gross weight) were imported. Imports of ferrochromium in 1965 amounted to 15,336 tons, an increase of 4,854 tons from 1964. Exports of ferrochromium amounted to 205 tons valued at $35,461; most of these exports went to Britain. Because the ferroalloy industry is highly competitive and because approximately 2 tons of chromite must be imported to make 1 ton of ferrochromium, domestically produced ferrochromium has great difficulty competing with imported material.

Until recently chromite-producing countries have not been producers of ferrochromium and other chromium additives; Russia is the exception to this generalization but Russia has never been a supplier to North America and only occasionally to Western Europe. However, Rhodesia and the Republic of South Africa are developing major chromium-additive industries that are export-oriented. Improved technology has permitted the Republic of South Africa to produce low-carbon ferrochromium from its vast resources of cheap, chemical-grade chromite in the Transvaal. If production costs can be lowered, South African ferroalloy producers may possibly be able to sell low-carbon ferrochromium at a price competitive with charge chrome, which is used in basic-electric melting of stainless and other chromium steels. For some grades of stainless steel it makes little technical difference whether charge chrome or low-carbon ferrochromium are used because the excess carbon in charge chrome can be blown off in the electric furnace. However, there is a maximum amount of carbon that can be blown off and as specifications become more rigid, low-carbon ferrochromium becomes more attractive.

The only commercially important ore mineral of chromium (Cr) is chromite ($FeO. Cr_2O_3$) which has a theoretical chromic oxide (Cr_2O_3) content of 68 per cent. Chromite ores are basically a combination of oxides of chromium and iron with impurities of alumina and magnesia varying in quantity. Chromite ores seldom contain more than 50 per cent Cr_2O_3.

* Mineral Resources Division

TABLE 1

Chromium — Trade and Consumption, 1964–65

	1964		1965P	
	Short Tons	$	Short Tons	$
Imports				
Chrome in ore and concentrates				
United States	8,824	817,449	11,442	895,123
Philippines	6,542	483,055	10,645	835,582
Rhodesia	4,711	248,322	7,973	452,812
Republic of South Africa	499	19,175	3,020	115,848
Cyprus	—	—	1,898	147,477
Other countries	218	19,484	430	53,000
Total	20,794	1,587,485	35,408	2,499,842
Chromic acid (chromium trioxide)				
Britain	238	154,528	660	426,023
United States	692	418,945	607	371,343
Australia	57	28,514	42	28,934
West Germany	16	8,754	15	8,476
Total	1,003	610,741	1,324	834,776
Chromium sulphates, basic, for tanning				
United States	1,853	391,008	1,143	258,452
Britain	128	26,717	246	50,007
West Germany	28	4,897	2	516
Total	2,009	422,622	1,391	308,975
Chrome dyestuffs				
United States	51	102,658	82	158,557
Britain	28	52,412	70	109,673
West Germany	54	100,625	41	90,726
Switzerland	35	70,106	10	28,100
Other countries	20	40,913	12	24,983
Total	188	366,714	215	412,039
Ferrochromium				
Republic of South Africa	1,746	371,922	5,601	1,303,615
United States	4,573	1,201,783	4,886	1,511,656
France	—	—	1,695	550,926
U.S.S.R.	—	—	1,344	391,955
Rhodesia	3,126	935,948	1,275	365,138
Norway	921	206,484	414	75,304
Other countries	116	32,809	121	34,723
Total	10,482	2,748,946	15,336	4,233,317
Exports				
Ferrochromium				
Britain	120	29,011	118	25,049
United States	—	—	79	8,144
Other countries	52	3,588	8	2,268
Total	172	32,599	205	35,461
Consumption				
Chromite	57,734		69,105	

Source: Dominion Bureau of Statistics

P Preliminary; — Nil.

TABLE 2

Chromium – Trade and Consumption, 1956–65

(short tons)

	Imports		Exports	Consumption	
	Chromite*	Ferrochromium**	Ferrochromium	Chromite	Ferrochromium
1956	64,965		9,897	69,835	7,091
1957	111,453		10,332	70,971	7,000
1958	38,136		10,460	36,297	4,714
1959	48,678		7,514	58,532	8,150
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
1965P	35,408	15,336	205	69,105	12,903

Source: Dominion Bureau of Statistics.

* To 1963 gross weight, from 1964 chromium content. ** Not available prior to 1964.

Canada has no known deposit of commercial-grade chromium ore. During the period 1940 to 1950 some chromite was produced in the Province of Quebec; peak production, reached in 1943, amounted to 29,595 tons. The Bird River deposits in the Lac du Bonnet district of south-eastern Manitoba are large but of low grade – about 26 per cent chromic oxide and 12 per cent iron with a chromium-to-iron ratio of about 1.41 to 1. Some typical analyses of commercial chromite ores are listed in Table 4.

The major consumers of chromite in Canada are: Union Carbide Canada Limited, Metals and Carbon Division, at Welland, Ontario, where high-carbon ferrochromium and ferrochromium silicon are produced; Canadian Refractories Limited at Marelan, Quebec, about 50 miles west of Montreal; and General Refractories Company of Canada Limited, Smithville, Ontario.

The major suppliers of chromium additives in Canada are: Union Carbide Canada Limited, Chromium Mining & Smelting Corporation, Limited, Philipp Brothers (Canada) Ltd., Derby Metals & Minerals Limited, Metallurg (Canada) Ltd., Continental Ore Co. (Canada) Limited and Engelhard Industries of Canada Limited.

WORLD PRODUCTION AND TRADE

Preliminary reports indicate that world production of chromite was about 5 million tons in 1965, which compares with about 4.7 million tons in 1964. Russia, The Republic of South Africa, Rhodesia, the Philippines and Turkey supply about 85 per cent of the world's chromite requirements. Towards the end of 1965 a shortage in chromite began to develop, particularly in North America. This shortage was caused by increased production of stainless steel, and the depletion of consumer inventories that had built up during the late nineteen-fifties and early sixties. Shortage will probably become acute in 1966 because of an embargo on chromite originating in Rhodesia.

The Department of Mines of the Republic of South Africa reported in *Minerals*, October to December 1965, that chromite production in 1965 amounted to 1,038,498 tons, up from 936,468 tons in 1964; exports were 772,960 tons valued at 6 million Rand ($9 million), also an increase from 1964. Statistics on the export of ferrochromium from South Africa are not available, but the export of ferrochromium is expected to continue increasing from previous years. Domestic sales of chromite in the Republic increased some 60 per cent from those of 1964 to 203,628 tons in 1965.

United States is the largest importer and consumer of chromite. According to the U.S. Bureau of Mines, *Mineral Industry Surveys, Chromite* in January 1966, prepared March 31, 1966, imports of chromite in 1965 amounted to 1,518,337 tons. Consumption at 1,581,831 tons was the highest since 1957. The metallurgical industry, accounting for 57 per cent of the total, continued to be the largest consumer, the refractories industry consumed 29 per cent and the chemical industry 14 per cent. The Republic of South Africa continued to be the largest supplier of chromite to the United States, followed by Southern Rhodesia, the Philippines and the U.S.S.R.

TABLE 3

World Production of Chromium Ore, 1963–65
(thousands of short tons)

	1963	1964	1965[e]
U.S.S.R.	1,355[e]	1,435[e]	1,500
Republic of South Africa	873	936	1,038
Philippines	506	516	500
Southern Rhodesia	412	493	600
Turkey	313	455	635
Albania	323	342[e]	..
Iran	110[e]	128[e]	..
Yugoslavia	103	97	..
Other countries	360	318	..
Total	4,355	4,720	5,000

Source: U.S. Bureau of Mines *Minerals Yearbook, 1964*; U.S. Bureau of Mines *Commodity Data Summaries*, January 1966; Department of Mines, Republic of South Africa, *Minerals*, October to December 1965; and industry reports.

[e] Estimated; .. Not available.

In only a few countries have chromium ore resources been thoroughly explored and estimates of reserves are mostly approximations. Some important producing countries have published nothing on their reserves. In 1965, the chromite reserves of Southern Rhodesia were estimated by the Rhodesian Department of Mines at more than 600 million tons, of which some 300 million were considered to be of metallurgical grade. South Africa's reserves of chromium ore were recently estimated to be 2,000 million tons*. The U.S.S.R. and Albania, Turkey, the Philippines and Iran are known to have large economic deposits of chromite.

USES

Chromite consumed in industry is graded as metallurgical, refractory or chemical. These grades are based on physical and chemical properties but technological advances are making them increasingly interchangeable.

METALLURGICAL-GRADE CHROMITE

Metallurgical-grade chromite should contain 45 to 50 per cent Cr_2O_3 and have a chromium-iron ratio of at least 2.8 to 1. It is used for making ferrochromium alloys by electric smelting processes; they, in turn, are used for making alloy steels. Manufacturers of chromium exothermic additives may use ores of less rigid specifications than those outlined.

Several grades of ferrochromium are made. They are distinguished by their carbon and silicon content. Low-carbon ferrochromium of various grades, ranging from 0.02 to 2 per cent carbon maximum, is used in stainless and heat-resistant steels. High-carbon ferrochromium, in which the carbon content varies from 4 to 9 per cent, is used in the production of other chromium-bearing steels and alloy cast irons. Chromium greatly increases corrosion resistance in steels and hardness, strength and resistance to corrosion in cast irons.

Chromium metal is used in high-temperature corrosion-resistant alloys and in chromium-bronze, hard-facing alloys, welding-electrode tips, certain high-strength aluminum electrodes and aluminum-base hardener alloys used by fabricators and foundries making alloys. High-temperature alloys contain from 13.5 to 27 per cent chromium together with varying amounts of cobalt, columbium, nickel, tungsten, molybdenum, manganese, titanium and vanadium. High-temperature alloys are used mainly in the highly stressed parts of missiles and in gas and steam turbines, jet-engine compressor blades and jet-engine exhaust systems.

* Republic of South Africa, National Resources Development Council *Investigation Reports on the Processing of Certain Minerals in the Republic of South Africa and in West Africa*, Volume IV.

TABLE 4

Analyses of Chromium Ores

Country and Type	Per Cent						Cr: Fe Ratio
	Cr_2O_3	Total Fe	Al_2O_3	MgO	CaO	SiO_2	
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
S. Africa							
Chemical	44.50	19.20	15.02	10.04	.31	3.86	1.57:1
Philippines							
(Masinloc)							
Refractory	33.35	10.30	28.23	18.56	.45	4.58	2.2 :1

Source: *E & MJ Metal and Mineral Markets, Market Guide — Chrome*, May 30, 1966.

REFRACTORY-GRADE CHROMITE

Specifications for refractory-grade chromite are not as rigid as for metallurgical grade. Nevertheless, for brick of the best quality, the mineralogical constitution is of great importance. Because the silica content should be kept as low as possible and because refractoriness is inversely proportional to the iron content, the chromic oxide and alumina combined should not be less than 57 per cent and the iron and silica should not be above 10 and 5 per cent. The ore must be hard and lumpy and above 10-mesh size. Chromite fines are suitable for the manufacture of brick cement and chrome-magnesite brick. Bricks made from refractory-grade chromite are used extensively for lining furnaces. Chrome refractories are also used for patching brickwork and in making ramming mixtures for furnace bottoms.

CHEMICAL-GRADE CHROMITE

In chemical consumption, specifications for chemical-grade chromite are not as rigid as for metallurgical and refractory grades. Standard chemical ores contain a minimum of 45 per cent Cr_2O_3 and, within reasonable limits, iron is not a problem. The ores should not contain more than 15 per cent aluminum oxide (Al_2O_3) and 20 per cent iron oxide (FeO), or less than 8 per cent silicon dioxide (SiO_2). The sulphur must be low. The chromium-iron ratio is usually about 1.6 to 1. Fines are preferred because the ore is ground in processing to make sodium and potassium chromates and bichromates.

Sodium bichromate or its derivatives are used as pigments in the paint and dye industries, as mordants and waterproofing material in the textile industry, in the surface treatment of metals and as a source of electrolytic chromium.

Chromium plating is used extensively to produce brilliant, nontarnishing and durable finishes. Many articles such as dyes, gauges and punches are plated with a relatively thick layer to improve their wear-resisting qualities and performance. Chromic acid is the main constituent of commercial-plating solutions.

Experimental electroplating of plastics started during World War II but for a long time the problem of getting a coating of chromium to adhere to plastics was insurmountable. However, within the last few years the art of chromium plating on plastics has improved tremendously and more than 3 dozen parts in automobiles, appliances and home furnishings are now being produced.

PRICES

E & MJ Metal and Mineral Markets of December 27, 1965, quotes chrome prices in United States currency as follows:

Chromium metal, per lb, delivered			
Exothermic 98.5%, .05%C (depending on size of lot)	$ 1.15	–	$ 1.19
Electrolytic 99.8% (depending on size of lot)	1.15	–	1.19
Chrome ore, per long ton, dry basis, subject to penalties if guarantees are not met, f.o.b. cars Atlantic ports			
Rhodesian			
48–50% Cr_2O_3, 3 or 3½ to 1 ratio, lump	31.00	–	35.00
53% Cr_2O_3, 2.4 to 1 ratio, concentrate	$ 28.00	–	$ 29.00
South African (Transvaal) 44% Cr_2O_3, no ratio	20.00	–	21.50
Turkish, 48% Cr_2O_3, 3 to 1 ratio	29.50	–	31.50
Russian, 54–56% Cr_2O_3, 4 to 1 ratio	30.50	–	33.00
Ferrochromium, per lb Cr contained, carload lots, lumps, bulk, f.o.b. shipping point			
High-carbon 67–71% Cr, 4–6% or 6–8% C	0.19		
Low-carbon 67–73% Cr, 0.025% C	0.25½		
Charge chrome 63–71% Cr, 4.5–6% C	0.15		

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Chrome ore	free	free	free
Chrome metal in lumps, powder, ingots, blocks or bars and scrap of alloy metal containing chromium for use in alloying	free	free	free
Ferrochromium	free	5%	5%
Chromium trioxide for use in manufacture of tin plate	free	free	25%

United States	
Chrome ore	free
Chromium metal	10½%
Ferrochromium	
Less than 3% C	8½
3% or more C	5/8¢ per lb on Cr content
Chromic acid	12½%
Chromium carbide	12½
Chrome brick	25
Chrome colours	10

Clays and Clay Products

J.G. BRADY*

Most Canadian clays and shales used in the manufacture of clay products are low-grade common materials. Continued research has resulted in improved products from better processing techniques. Deposits of high-quality refractory clays such as china clay (kaolin), fire clay, ball clay, and stoneware clay are scarce in Canada. Consequently, a substantial proportion of these materials is imported. Known deposits are continually being developed, and new, high-quality deposits, explored. A few kaolin, fire clay, and stoneware deposits that occur in remote areas of Canada will be developed as transportation, population and industry extend into these areas. New methods of beneficiating and processing clays are being developed, which will probably overcome problems that older methods have not solved.

The term 'clay products' applies to such materials as fire clay 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, sanitary ware, 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.

Modernization and expansion of facilities in the brick, tile and whitewares industries is continuing. Modern, large-capacity plants are now in operation, which are producing high-quality clay products. Many plants are using better processing methods and automation will eventually replace some labour. A list of ceramic plants is shown in Operator's List 6, *Ceramic Plants in Canada*, which is published yearly by the Mineral Resources Division, Department of Mines and Technical Surveys.

PRODUCTION, TRADE AND CONSUMPTION

The statistics in Tables 1 and 5 show that the value of clay products made from domestic clays rose 5.8 per cent over 1964. At $41.9 million it is about equal to the previous high in 1959. The value of clay from domestic sources, including bentonite, increased by 6.7 per cent.

Table 3 lists the value of products made from imported clays in 1963. These products are principally in the whiteware category and thus contain nonplastic ingredients such as ground silica and feldspar as well as clay.

*Mineral Processing Division, Mines Branch

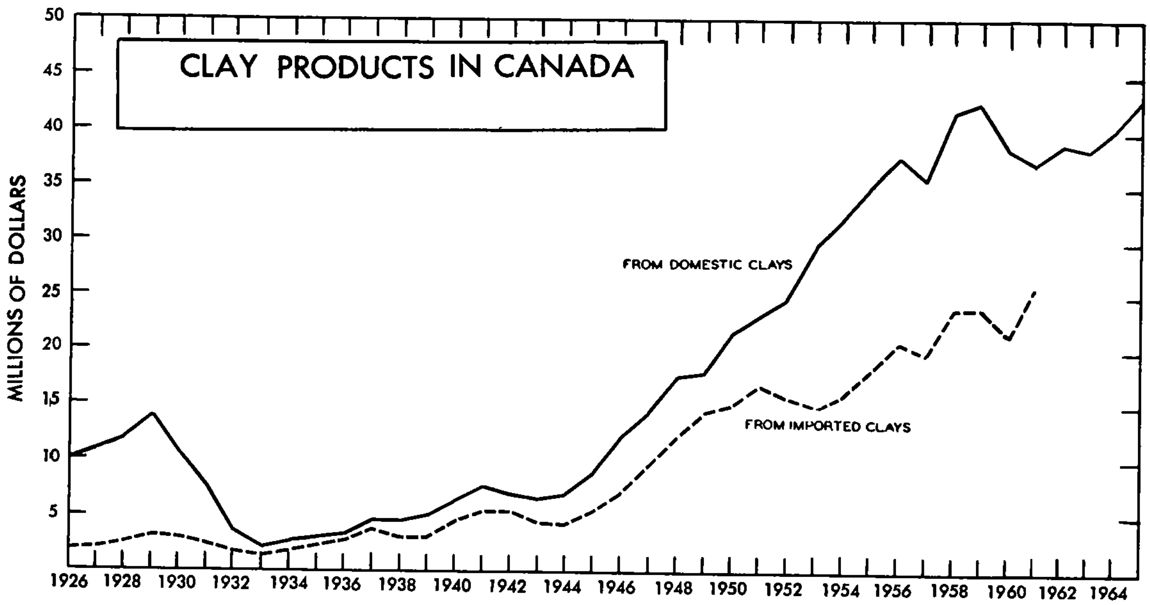


TABLE 1

Production of Clays and Clay Products from Domestic Sources, 1964-65

		1964		1965p	
		Quantity	$	Quantity	$
Production, shipments from domestic sources					
By main classes					
Clays, including bentonite			1,190,969		1,268,167
Clay products from					
Common clay			31,358,374		31,589,218
Stoneware clay			5,793,788		6,765,220
Fire clay			672,571		782,468
Other			1,814,883		2,800,756
Total			40,830,585		43,205,829
By products					
Clay					
Fireclay	s.t.	4,679	70,018	..	65,667
Other clay, including bentonite	"	..	1,120,951	..	1,202,500e
Fireclay blocks and shapes		..	73,674	..	60,151
Firebrick	no.	3,807,178	598,897	..	722,317
Brick					
Soft mud process					
Face	no.	59,754,501	2,963,534		
Common	"	7,129,108	120,882		
Stiff mud process					
Face	"	315,341,370	16,211,360	511,806,000	26,001,853
Common	"	46,439,993	1,292,895		
Dry process					
Face	no.	57,205,803	2,613,790		
Common	"	3,976,814	121,380		

Table 1 (cont.)

		1964		1965p	
		Quantity	$	Quantity	$
Fancy or ornamental	no.	19,797,124	1,412,737		
Sewer brick	"	1,721,510	62,804		
Paving brick	"	1,079,810	116,020		
Structural tile					
Hollow blocks	s.t.	92,789	1,882,860	90,310	1,926,570
Floor tile	sq. ft.	268,666	120,947	..	121,000e
Drain tile	no.	68,508,966	4,439,165	51,649,000	3,539,795
Sewer pipe	ft.	6,265,634	3,465,905	8,640,327	4,674,741
Flue linings	"	1,637,560	1,059,482	1,321,698	819,073
Pottery		..	1,268,401	..	1,271,406
Other products		..	1,814,883	..	2,800,756
Total			40,830,585		43,205,829

pPreliminary; eEstimated; .. Not available;

TABLE 2

Imports and Exports of Clay, Clay Products and Refractories

		1964		1965p	
		Quantity	$	Quantity	$
Imports					
Clay, clay products and refractories					
Bentonite	s.t.	114,446	1,055,405	182,162	1,587,108
Drilling mud	"	12,075	1,095,322	8,054	720,530
China clay, ground or unground	"	169,744	3,572,757	193,966	4,163,758
Fire clay, ground or unground	"	73,171	555,150	66,769	531,734
Clays ground or unground	"	91,371	1,115,393	86,668	1,068,779
Clays and earth, activated	"	2,853	418,643	3,148	525,837
Brick, building					
Glazed	M	3,290	299,939	6,346	506,666
N.e.s.	"	21,543	1,244,378	21,764	1,289,068
Building blocks	"	..	770,478	..	623,615
Earthenware tiles					
Under 2½x2½"	sq.ft.	9,123,212	2,111,408	11,103,491	2,457,179
Over 2½x2½"	sq.ft.	9,437,432	1,783,269	11,797,871	2,286,113
Clay bricks, blocks, tiles, n.e.s.		..	208,134	..	161,116
Firebrick					
Alumina	M	3,239	2,533,090	2,922	2,622,632
Chrome	"	351	474,734	245	325,093
Magnesite	"	733	834,073	578	1,084,807
Silica	"	3,193	1,564,216	2,086	1,539,890
N.e.s.	"	36,074	9,561,803	37,585	10,332,047
Refractory cements and mortars		..	1,203,083	..	1,752,186
Pottery settings and firing supplies		..	244,351	..	230,613
Crude refractory materials	s.t.	3,080	256,439	4,544	331,178
Grog (refractory scrap)	"	19,180	619,146	20,457	670,370
Refractories, n.e.s.	"	..	2,134,286	..	2,196,674
Acid-proof brick		..	166,223	..	379,516
Tableware, china or porcelain		..	8,163,388	..	8,471,788
Porcelain insulating fittings		..	3,020,123	..	3,325,492
Total clay, clay products and refractories			45,005,231		49,183,789

Table 2 (cont.)

		1964		1965p	
		Quantity	$	Quantity	$
By main countries					
United States			30,009,179		31,120,436
Britain			9,495,500		10,421,906
Japan			3,794,108		4,892,754
France			500,823		1,020,958
West Germany			731,164		615,543
Ireland			44,205		366,927
Denmark			87,524		165,588
Other countries			342,728		579,677
Total			45,005,231		49,183,789
Exports					
Clays, clay products and refractories					
Clays, ground and unground	s.t.	1,058	34,198	1,319	50,696
Crude refractory materials	"	1,150,072	2,240,324	905,416	1,878,030
Building brick, clay	M	8,106	470,773	11,713	729,283
Clay bricks, blocks, tiles, n.e.s.		..	351,917		260,661
Firebrick and similar shapes		..	4,700,323		5,438,033
Refractories, n.e.s.		..	337,237		391,745
High tension insulators and fittings		..	312,993		817,680
Tableware, n.e.s.		..	448,517		702,343
Stone, clay and concrete end products			9,590		8,717
Total clays, clay products and refractories			8,905,872		10,277,188
By main countries					
United States			6,659,110		7,069,902
Chile			278,999		351,581
Puerto Rico			171,613		232,539
New Zealand			49,890		185,605
Pakistan			46,210		157,684
Greece			66,648		149,025
Britain			153,114		135,558
Other countries			1,480,288		1,995,294
Total			8,905,872		10,277,188

Source: Dominion Bureau of Statistics.
pPreliminary; ..Not available; n.e.s. Not elsewhere specified.

In 1963 the value of refractories manufactured in Canada (Table 4) includes basic and oxide refractories as well as refractories and refractory specialties that include fire clay as a principal ingredient. The value of imported refractories in 1963 is not available from DBS but according to the Clay Refractories Association it was about $13.7 million.

Seventy-six plants were producing such clay products as facing brick (glazed and unglazed), common brick, structural tile, drain tile and quarry tile, primarily from local common clays and shales.

Five plants manufactured such products as clay sewer pipe, flue liners, conduits and wall coping. Their raw materials were mainly domestic low-grade fire clay, stoneware clay, common clay and plastic shale. Two plants in Ontario imported low-grade fire clay from the United States for production of these products; one of them mixed local clay with the imported fire clays to form a suitable production mix.

Eighteen plants manufacturing refractories used clay as the principal ingredient in many of the products produced. Only four, all in western Canada, used domestic clays.

TABLE 3

Shipments of Clay Products Manufactured in Canada from Imported Clays*

		1961		1962		1963	
		Quantity	$	Quantity	$	Quantity	$
Glazed floor and wall tile	sq.ft.	8,117,000	3,634,000	12,613,000	4,859,000	14,857,000	5,100,000
Electrical porcelains		..	5,357,000	..	5,703,000	..	6,279,000
Pottery, art and decorative ware		..	788,760	..	802,000	..	806,000
Pottery, tableware		..	1,167,852	..	1,377,000	..	1,563,000
All other products (sanitary ware, etc.)		..	9,040,595	..	10,378,000	..	12,016,000

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

TABLE 4

Shipments of Refractories Manufactured in Canada

		1961		1962		1963	
		Quantity	$	Quantity	$	Quantity	$
Fireclay blocks and shapes	s.t.	..	301,945	..	56,742	..	47,621
Firebrick	M	3,873	476,327	4,013	514,260	4,775	636,112
Other firebrick and shapes*	s.t.	..	11,629,868	..	11,964,000r	..	11,257,000r
Refractory cements, mortar castables	s.t.	38,248r	4,427,000r	50,743r	5,628,000r	55,582r	6,257,000r
Other refractories	s.t.	16,084	2,186,918	9,838	1,261,000r	16,142r	2,093,000r

Source: Dominion Bureau of Statistics.
*Includes rigid firebrick, stove linings and other shapes made from imported clays, chrome ore, magnesite, etc.
.. Not available; rRevised.

TABLE 5

Clays and Clay Products Production and Trade, 1956-65
($ millions)

	Production				
	Domestic Clays[1]	Imported Clays[2]	Total	Imports	Exports
1956	37.8	20.9	58.7	52.4	3.5
1957	35.9	19.9	55.8	47.4	4.3
1958	41.7	23.7	65.4	44.8	4.2
1959	42.5	23.9	66.4	48.1	5.1
1960	38.2	21.5	59.7	46.7	5.3
1961	37.0	19.4[3]	56.4	47.1	5.8
1962	37.8	22.5[3]	60.3	48.3	5.4
1963	38.2	25.2[3]	63.4	43.9	7.6[4]
1964	40.8	..		45.0	8.9[4]
1965p	43.2	..		49.2	10.3[4]

Source: Dominion Bureau of Statistics.
[1]Production (shipments) of clay and clay products from domestic material.
[2]Production (shipments) of clay products from imported clay. [3]Does not include refractories.
[4]Includes additional categories of refractories.
pPreliminary. .. Not available.

Five sanitary ware plants, eight electrical porcelain plants, three wall tile plants, two dinnerware plants and numerous souvenir and art potteries were the principal users of ceramic-grade china clay and ball clay, which is imported mainly from the United States and the United Kingdom.

The use of kaolin in Canada has increased slightly in the past few years (Table 6). No statistics on consumption of fire clay and ball clays are available. About 2 million tons of domestic clay are consumed in the products included in Table 1.

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 properties needed in the paper industry are intense whiteness, freedom from abrasive grit and high coating retention. In the ceramic industry it 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, sanitary ware, dinnerware, pottery and electrical porcelain. China clay is used as a source of alumina and silica in the whiteware industries.

TABLE 6

Consumption of China Clay by Industries, 1963-64 (short tons)

	1963	1964p
Ceramic products	12,515	12,715
Paint and varnish	2,131	1,980
Paper and paper products	92,625	103,379
Rubber and linoleum	11,805	12,305
Other products*	10,939	11,502
Total	130,015	141,881

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

pPreliminary.

It also imparts a degree of plasticity to the unfired body and helps to maintain a white fired colour.

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

Extensive deposits of sandy kaolin occur near Wood Mountain, Fir Mountain, Knollys, Flintoft and other localities in southern Saskatchewan. Considerable work had been carried out by the Government of Canada, the University of Saskatchewan and the Government of Saskatchewan, but so far beneficiation has not been successful.

A deposit of refractory clay similar to a secondary china clay occurs along the Fraser River near Prince George, B.C. The material varies from very plastic to very sandy. The upper beds are considerably iron-stained. This material has been investigated as a source of kaolin, as a fire clay and as a raw material for facing brick.

A clay deposit at Arborg, Manitoba, contains colloidal iron, a considerable quantity of quartz and some other impurities in addition to kaolinite. Kaolin-bearing rock occurs in Quebec at St. Remi d'Amherst, Papineau County; Brebeuf, Terrebonne County; Point Comfort, on Thirtyone Mile Lake, Gatineau County; and Chateau 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 Chateau 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.

Kaolinized deposits occur extensively in northern Ontario. To date certain difficulties with quality and exploration have not been overcome. Work on these deposits continued during the year in several laboratories.

BALL CLAY

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

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

In Canada ball clays are known to occur only in the Whitemud formation of southern Saskatchewan. Good-quality deposits are known to exist at Willows, Readlyn, Bid Muddy Valley, Blue Hills, Willow Bunch and Flintoft and in other areas. Clay from the Willows area has been used for many years in the potteries at Medicine Hat and in Vancouver. It has been tested in the United States. The lack of proper quality control, the distance from large markets and lack of reserves have been the principal disadvantages affecting the use of this material. Some ball clay from the Flintoft area is being used for white-to-buff facing brick and for household pottery and crocks.

FIRE CLAY

Canadian fire clays are used principally for the manufacture of medium- and high-duty 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 fire clays are sufficiently refractory for the manufacture of superduty refractories without the addition of some very refractory material such as alumina.

Various grades of good-quality fire clays occur in the Whitemud formation in Saskatchewan. At a large plant at Claybank, fire clays from nearby pits are used for the manufacture of medium- and high-duty refractories and refractory specialties. Good-quality fire clays occur on Sumas Mountain in B.C. At a large plant here the better grades are used in the manufacture of products similar to those produced at the Saskatchewan plant. Some fire clay from the Sumas Mountain deposit is exported to the United States and a small quantity is used at plants in Vancouver.

Fire clay and kaolin occur in the James Bay watershed of northern Ontario along the Missinaibi, Abitibi, Moose and Mattagami rivers. Adverse terrain and climate have made exploration difficult. One of the various interested companies did some sampling in the area in 1962 and another took samples in 1963. Some seams of clay in the deposit at Shubenacadie, N.S., are sufficiently refractory for medium-duty refractories. Preliminary work has been done on their use for the production of ladle brick. Clay from Musquodoboit, N.S., has been used by a few foundries in the Atlantic Provinces.

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

STONEWARE CLAY

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

The principal source of stoneware clay in Canada is the Whitemud formation of southern Saskatchewan and southeastern Alberta. The Eastend, Sask., 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, Sask.

Stoneware or low-grade fire clays occur on Sumas Mountain, near Abbotsford, B.C. 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, 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 in Canada 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 to a salmon or red colour. Their fusion points are low – usually well below cone 15 (approximately 1,430°C), which is considered to be the lower limit of the softening point for fire clays. Ordinarily, they are a heterogeneous mixture including clay minerals and various other minerals such as quartz, feldspar, mica, goethite, siderite, pyrite, carbonaceous material, gypsum, calcite, dolomite, hornblende and many others. The clay minerals are chiefly illitic, chloritic or illitic-chloritic, although frequently a member of the montmorillonite or kaolinite group and various mixed layer clay minerals are found in them.

Clays and shales suitable for the manufacture of clay products usually contain 15 to 35 per cent small-particle quartz. If the quartz exceeds this proportion and there are other nonplastic 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 to a buff colour and adversely affect the fired strength and density. Common clays and shales are usually higher in alkalis, alkaline materials and iron-bearing minerals and much lower in alumina than the high-quality stoneware clays, fire clays and ball clays. 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.

BENTONITE

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

PRICES

Prices are not available for all types of clays. China clay generally commands the highest prices because of the cost of its beneficiation and the special processes necessary to produce it for various industries. For example, the paper industry's specifications and requirements for china clay are different from those of the ceramic industry. The prices of ball clays and high-quality fire clays are about the same as those of most china clays. Low-grade fire clays and stoneware clays generally sell for less than ball clays but are priced higher than common clays and shales. Ball clays and kaolins are sold in bags or in bulk; low-grade fire clays, stoneware clays and common clays and shales are usually sold in bulk.

According to *Oil, Paint and Drug Reporter*, December 27, 1965, prices in the United States were as follows, per short ton:

Ball clay	
Domestic, air-floated, bags, car lots, f.o.b. Tennessee	$18.00–$22.00
Domestic, crushed, moisture repellent, bulk, car lots, f.o.b. Tennessee	8.00– 11.25
China clay	
Domestic, dry-ground, calcined, air-floated, bags, car lots, f.o.b. works	45.00– 68.00
Domestic, dry-ground, uncalcined, air-floated, 99% 325 mesh, f.o.b. Georgia, bags, car lots, f.o.b. works	17.50
Domestic, water-ground, bags, car lots, f.o.b. works	22.50–51.00

Coal and Coke

Coal

T.E. TIBBETTS*

During the year 1965 increases in production, imports and consumption of coal in Canada were realized while exports of coal showed a slight decrease.

Increases in production of lignite and subbituminous coals were recorded but bituminous coal production decreased. Consumption of coal in Canada increased during the year with a large increase in coal used by thermal electric generating stations. Exports of high-grade coking coals from western Canadian mines to Japan were again higher, to continue a trend started in 1958. Exports of coal to the United States dropped sharply.

Mechanization of production, underground and surface coal preparation, particularly of slack and fine sizes, and efforts to control quality through coal sampling and analysis have all been increased to enable the industry to supply higher-quality products.

Subvention assistance and research in the interest of the coal industry were continued and expanded by the federal and provincial governments.

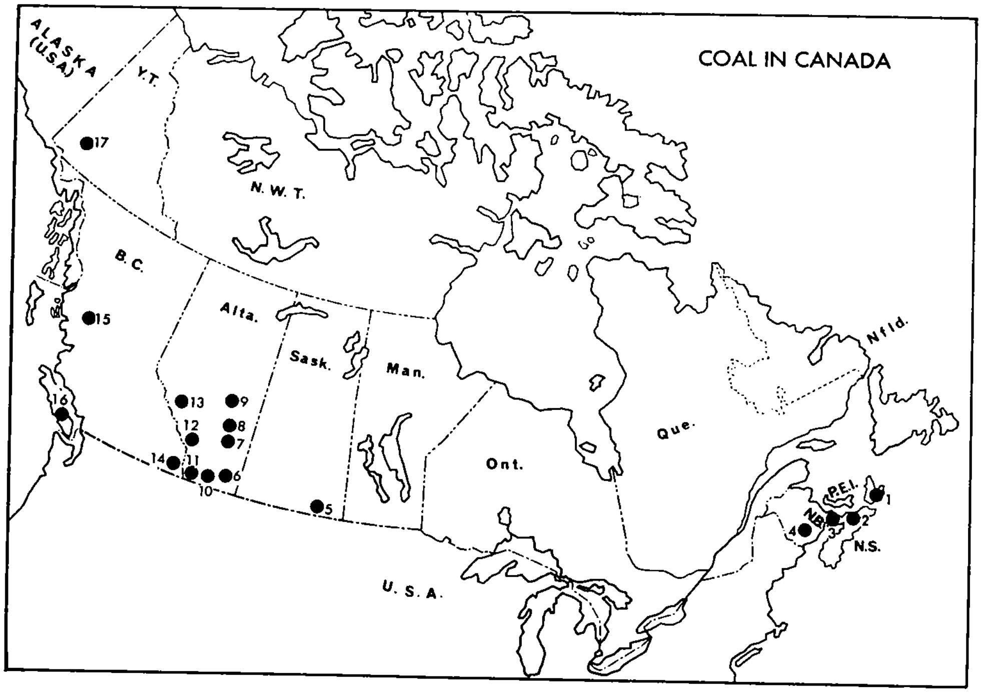
*Fuels and Mining Practice Division, Mines Branch

COAL AREAS AND PRINCIPAL PRODUCERS

(with approximate production in thousands of short tons)

(numbers refer to numbers on map)

Nova Scotia	
1. *Sydney and Inverness areas (high-volatile bituminous)*	
Bras d'Or Coal Co. Ltd. (Four Star mine)	110
Chestico Mining Corporation Limited	37
Dominion Coal Company, Limited	2,803
Dominion Steel and Coal Corporation, Limited, Old Sydney Collieries Division	664
Evans Coal Mines Limited	49
2. *Pictou area (medium- and high-volatile bituminous)*	
Dominion Steel and Coal Corporation, Limited Acadia Coal Company Division	241
Drummond Coal Company Limited	62
Greenwood Coal Company, Limited	19
3. *Springhill and Joggins areas (high-volatile bituminous)*	
River Hebert Coal Company Limited	63
Springhill Coal Mines Limited	83
Joggins Mining Company Limited	3
New Brunswick	
4. *Minto Area (high-volatile bituminous)*	
A.W. Wasson, Limited	3
Avon Coal Company, Limited	243
D.W. & R.A. Mills Limited	289
Dufferin Mining Limited	30
Knox, Harold	8
Michiels Limited	13
Miramichi Lumber Company (Limited)	231
Rogers, L.T.	
Hawkes, R.	10
C.H. Nichols Co. Ltd.	57
Norman I. Swift, Ltd.	10
V.C. McMann, Ltd.	42
C.J. Hoyt Co. Ltd.	22
Saskatchewan	
5. *Souris Valley area (lignite)*	
Great West Coal Company, Limited	730
Manitoba and Saskatchewan Coal Company Limited	346
North West Coal Co. Ltd.	16
Utility Coals Ltd.	972
Alberta	
6. *Brooks and Taber areas (subbituminous)*	
Alberta Coal Sales Limited	104
The Kleenbirn Collieries, Limited	7
7. *Drumheller, Sheerness and Carbon areas (subbituminous)*	
Amalgamated Coals Ltd.	230
Fox, Alfred	1
Fox Coulee Coals Ltd.	37
Great West Coal Company, Limited	211
Halbert Coal mine	1
Nottal Brothers	10
Subway Coal Limited	18
8. *Castor, Ardley and Camrose areas (subbituminous)*	
Battle River Coal Company Limited	267
Burnstad Coal Ltd.	15
Camrose Collieries Ltd.	12
Forestburg Collieries Limited	493
Lynass, John	8
Sissons, R.C.	24
Stettler Coal Company Limited	8
9. *Edmonton, Tofield and Pembina areas (subbituminous)*	
Alberta Coal Ltd. (mines Nos. 419 and 1757)	944
Black Gem Coal Company Ltd.	4
Black Nugget Coal Ltd.	–
Egg Lake Coal Company Limited	16
Jet Construction Ltd.	17
Ostertag, Charles	12
Slide Hill Coal Co. Ltd.	1
Star-Key Mines Ltd.	55
Warburg Coal Co. Ltd.	12
Whitemud Creek Coal Co. Ltd.	15
10. *Lethbridge area (high-volatile bituminous)*	
Lethbridge Collieries, Limited	6
11. *Crowsnest area (medium-volatile bituminous)*	
Coleman Collieries Limited	605
12. *Cascade area (low-volatile bituminous and semianthracite)*	
The Canmore Mines, Limited	243
13. *Coalspur area (high-volatile bituminous) (less than 500 tons produced in this area in 1965)*	
British Columbia	
14. *East Kootenay (Crowsnest) area (medium-volatile bituminous)*	
Crows Nest Industries Limited	923
15. *Northern area (medium- and high-volatile bituminous)*	
Bulkley Valley Collieries, Limited	6
16. *Vancouver Island area (high-volatile bituminous)*	
Comox Mining Company Limited	41
Yukon Territory	
17. *Carmacks area (high-volatile bituminous)*	
Yukon Coal Company Limited	9

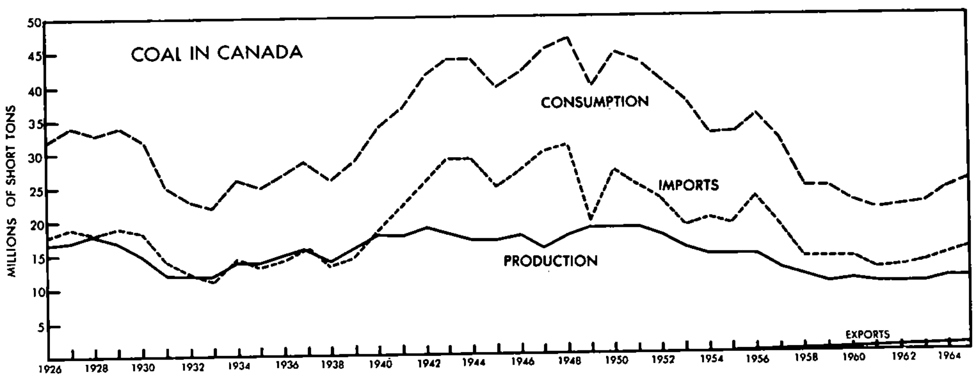


PRODUCTION

Production of coal increased 2.4 per cent to 11.6 million tons valued at $75.9 million in 1965. Production of bituminous coal decreased 3.5 per cent, whereas production of subbituminous coal and lignite increased 21.4 per cent and 3.5 per cent, respectively.

Nova Scotia's coal production decreased 3.7 per cent and amounted to 35.7 per cent of the total coal production in Canada. High-volatile bituminous coking coal is produced in the Sydney, Cumberland and Pictou areas and noncoking high-volatile bituminous coal is produced in the Inverness area, all from underground mines. New Brunswick, where production was down slightly, produced 8.6 per cent of Canada's total coal production. This was high-volatile bituminous coking coal mainly from underground and strip mines in the Minto area but also from strip mines in the Chipman and Coal Creek areas. More than 85 per cent of New Brunswick's coal is from strip mines.

All of Saskatchewan's production is lignite from strip mines located in the Bienfait and Estevan areas of the Souris Valley. The production in 1965 was 17.8 per cent of the national output. Alberta produced 29.5 per cent of the nation's coal output, from semianthracite to subbituminous. The largest output was from the subbituminous mines, which increased production more than 21 per cent. Thirty-seven such mines operating in 1965 produced almost 75 per cent of Alberta's coal. Six mines in the Pembina, Castor, Drumheller, Sheerness and Taber areas produced more than 88 per cent of the subbituminous coal. Total production of coal in Alberta increased 14.9 per cent in 1965 although there was a small decrease in the production of bituminous coal. More than 71 per cent of Alberta's production was from strip mines.



In British Columbia, coal production in 1965 decreased about 7.3 per cent and represented about 8.5 per cent of the nation's coal output. All of British Columbia's coal production is bituminous and the Crowsnest area (East Kootenay district on the mainland) accounted for about 94 per cent of the production. Underground mines produced 79.5 per cent of the total output in the province. The Yukon Territory produced about 8,800 tons of coal from a single underground mine.

The weighted average output per man-day for all coal mines in Canada increased 0.469 ton to 16.364 tons. For strip mines, which accounted for 47.9 per cent of the coal production, the output per man-day decreased by 1.673 tons, and the output from underground mines decreased by 0.284 ton per man-day.

Coal produced in Canada in 1965 had an average value of $6.55 a ton, or 28.98 cents per million BTU. Bituminous coal, which accounted for 86.7 per cent of the total value, averaged $9.44 a ton; this is an increase of about 66 cents a ton from the previous year, resulting largely from an increase of $1.02 a ton for Nova Scotia coals. Lignite decreased in value 16 cents a ton and sub-bituminous coals decreased 6 cents a ton. Nova Scotia coal is still the most expensive at 41.04 cents per million BTU, and Saskatchewan lignite at 12.16 cents per million BTU, is the cheapest source of coal-derived energy in Canada.

TRADE

Nova Scotia shipped about 55.7 per cent of its output to other parts of the country; 86.8 per cent of this went to central Canada. A small amount of Nova Scotia coal was exported to the island of St. Pierre. New Brunswick shipped about 5.3 per cent of its output to central Canada and about 3.1 per cent to the United States.

More than 39 per cent of Saskatchewan's coal production was shipped to Manitoba and Ontario. Alberta shipped 24 per cent of its coal production to other provinces, Saskatchewan and British Columbia taking, respectively, 11.4 and 8.1 per cent. About 3.8 per cent went to Manitoba and 0.9 per cent to Ontario. A large part of the bituminous coking coals produced in the Crowsnest area was exported to Japan where it was used to upgrade the Japanese coal blends for metallurgical use.

About 12.5 per cent of the coal output of British Columbia was shipped to Manitoba and 3 per cent went to markets in Ontario. About 41 per cent of the production from this province was exported, mainly to Japan.

There was an increase of 10.7 per cent in coal imports. Imports of bituminous coal from the United States increased 11.3 per cent whereas imports of anthracite, mainly from the United States with some from Britain, decreased 3.4 per cent. About one third of the bituminous coal imported was high-grade coking coal used in the metallurgical industry in Ontario and Nova Scotia.

CONSUMPTION

Consumption of coal in Canada increased 5.3 per cent in 1965 to 26.4 million tons. More than 60 per cent of the coal consumed was imported.

Much of the output of Nova Scotia and New Brunswick coal mines is used locally for industrial steam raising (including that in thermal electric plants) and household and commercial heating. The greatest single use of Nova Scotia coal is in the generation of thermal electric power. This is followed by its use in the manufacture of metallurgical coke for the steel industry at Sydney. Increasing quantities of Alberta's subbituminous coals are being employed industrially, particularly for thermal electric power generation. A large part of the bituminous coals produced in the Crowsnest areas of Alberta and British Columbia are exported for metallurgical purposes. Lignite from Saskatchewan was used for fuel for thermal electric generating stations and for commercial and household heating and industrial purposes.

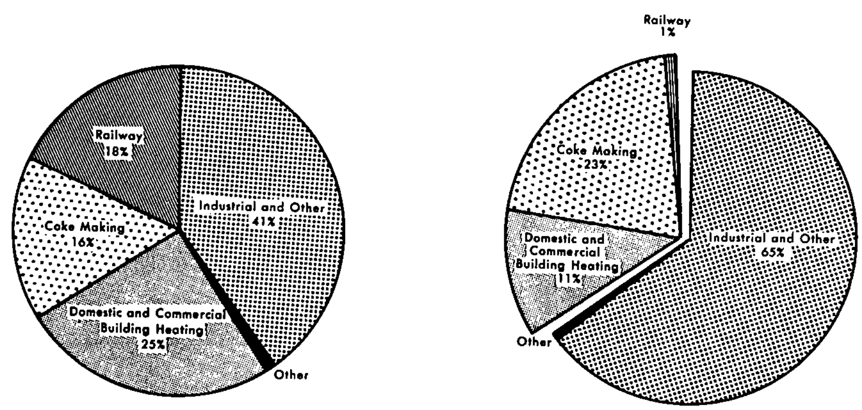
In 1965, coal used in the household and commercial building heating market amounted to about 2.1 million tons. Industrial consumption of coal, including that used by thermal electric generating stations, increased 15.5 per cent. The proportion of Canadian coal used industrially was about 46.4 per cent, the remainder being mainly bituminous coal from the United States. Use of coal in thermal electric generating stations in 1965 is estimated at 7.7 million tons, or about 29 per cent of the total coal consumed in Canada.

There was a small increase to slightly more than 5.9 million tons in the use of coal to manufacture coke, the increased consumption being imported coal. Use of Canadian coal for this purpose decreased by about 20 per cent mainly as a result of substitution of Canadian coal for imported coal at the Sydney steel works.

BRIQUETTES

There was a 45.6 per cent increase in the production of lignite briquettes and a 3.6 per cent decrease in the production of bituminous coal briquettes in 1965. Apparent consumption of briquettes was about 11.4 per cent more than in the previous year.

CONSUMPTION OF COAL IN CANADA BY USES
1956 AND 1965



Other uses include coals for bunkers, colliery and waste

Source: Dominion Coal Board

SUBVENTION ASSISTANCE

Payments by the Federal Government through the Dominion Coal Board to assist the movement of coal to markets increased by $9.5 million in 1965. Subvention assistance amounting to about $3 million was applied to the export of more than a million tons of coal from the Crowsnest area of Alberta and British Columbia. Payments under the Atlantic Province Power Development Act, 1958, totalled almost $2.5 million in 1965.

TABLE 1

Coal – Production, Trade and Consumption, 1964–65

(short tons)

	1964		1965p	
	Short tons	$	Short tons	$
Production				
All Classes				
Nova Scotia	4,293,130	42,827,600	4,134,161	45,486,833
New Brunswick	1,003,362	8,454,868	996,328	8,637,619
Saskatchewan	1,994,039	3,905,202	2,063,933	3,715,385
Alberta	2,971,133	11,182,833	3,413,928	12,173,846
British Columbia and Yukon	1,057,659	6,364,592	980,266	5,887,443
Total	11,319,323	72,735,095	11,588,616	75,901,126
Exports				
Bituminous				
Japan	984,846	9,326,401	1,023,134	10,613,890
St. Pierre	3,790	47,326	4,825	63,011
United States	303,028	2,598,130	163,700	1,994,464
Total	1,291,664	11,971,857	1,191,659	12,671,365
Briquettes				
United States	5,494	92,641	7,420	111,063
Imports (for consumption)				
Anthracite				
United States	648,260	7,895,069	626,536	7,473,746
United Kingdom	5,578	112,674	5,048	101,727
Total	653,838	8,007,743	631,584	7,575,473
Bituminous				
United States	14,335,276	78,232,973	15,955,135	118,248,568
Briquettes				
United States	7,140	231,610	7,934	253,692
Consumption				
Domestic	10,080,243		10,181,171	
Imported	14,987,656		16,593,547	
Total	25,067,899		26,774,718	

pPreliminary.

TABLE 2

Coal — Production, Imports, Exports and Consumption, 1955–65
(short tons)

	Production	Imports[1]	Exports	Consumption		
				Domestic[2]	Imported[3]	Total
1955	14,818,880	19,742,531	592,782	14,060,039	19,322,134	33,382,173
1956	14,915,610	22,613,374	594,166	14,115,095	22,198,049	36,313,144
1957	13,189,155	19,476,249	396,311	12,478,626	19,041,030	31,519,656
1958	11,687,110	14,491,315	338,544	11,054,757	14,154,121	25,208,878
1959	10,626,722	14,236,118	473,768	10,589,263	13,958,996	24,548,259
1960	11,011,138	13,564,836	852,921	9,973,308	13,276,599	23,249,907
1961	10,397,704	12,306,498	939,336	9,572,805	12,057,086	21,629,891
1962	10,284,769	12,614,189	893,919	9,510,293	12,377,965	21,888,258
1963	10,575,694	13,370,406	1,054,367	9,504,903	13,105,686	22,610,589
1964	11,319,323	14,989,114	1,291,664	10,080,243	14,987,656	25,067,899
1965p	11,588,616	16,044,009	1,225,994	10,181,171	16,593,547	26,774,718

Source: Dominion Bureau of Statistics.

[1]Imported coal referred to by DBS as 'Entered for Consumption' represents amounts cleared from customs ports, duty paid. Before 1962, 'Landed Imports' were shown; these were the amounts which actually entered the country, recorded before customs clearance. [2]Sum of sales at Canadian coal mines, colliery consumption, coal supplied to employees and coal used in making coke and briquettes, less coal exported. [3]Deductions have been made to account for foreign coal re-exported from Canada and bituminous coal removed from warehouse for ships' stores. Imports of briquettes not included.
pPreliminary.

TABLE 3

Coal Production, by Types, Provinces and Territories, 1964–65

	1964		1965p	
	Short tons	$	Short tons	$
Bituminous*				
Nova Scotia	4,293,130	42,827,589	4,134,161	45,486,833
New Brunswick	1,003,362	8,454,869	996,328	8,637,619
Alberta	866,221	5,751,602	859,176	5,771,661
British Columbia and Yukon Territory	1,057,659	6,364,592	980,266	5,887,443
Total	7,220,372	63,398,652	6,969,931	65,783,556
Subbituminous*				
Alberta	2,104,912	5,431,231	2,554,752	6,402,185
Lignite*				
Saskatchewan	1,994,039	3,905,202	2,063,933	3,715,385
All types				
Canada total	11,319,323	72,735,085	11,588,616	75,901,126

Source: Dominion Bureau of Statistics.

*Coal classification of the American Society for Testing and Materials as in ASTM Standards on Coal and Coke, 'Classification of Coals by Rank' (ASTM Designation: D–388–64T).

pPreliminary.

TABLE 4

Coal Production, by Type of Mining and Average Output per Man-day, 1965
(short tons)

		Production		Average Output per Man-day[p]	
		Underground	Strip	Underground	Strip
Nova Scotia		4,134,161	—	2.640	—
New Brunswick		143,240	853,088	1.881	5.625
Saskatchewan		—	2,063,933	—	43.784
Alberta		977,164	2,436,764	4.870	27.482
British Columbia		772,118	199,347	6.284	33.487
Yukon		8,801	—	3.696	—
Canada	1965[p]	6,035,484	5,553,132	3.451*	30.399*
	1964	6,462,313	4,857,100	3.735*	32.072*
Total, all mines	1965[p]	11,588,616		16.364*	
	1964	11,319,323		15.895*	

Source: Dominion Bureau of Statistics.

*Weighted average.

[p]Preliminary.

TABLE 5

Comparison of Average Values of Canadian Coals, 1965[p]

	Average Btu/lb*	Average Value per Short ton** ($)	Average Value per Million Btu (¢)
Nova Scotia, bituminous	13,400	11.00	41.04
New Brunswick, bituminous	12,000	8.67	36.13
Saskatchewan, lignite	7,400	1.80	12.16
Alberta			
Bituminous	13,700	6.72	24.53
Subbituminous	8,900	2.52	14.16
British Columbia, bituminous	13,700	5.97	21.79
Yukon Territory, bituminous	11,900	9.73	40.88
Total			
Bituminous	13,300	9.44	35.49
Subbituminous	8,900	2.52	14.16
Lignite	7,400	1.80	12.16
Average, Canada	11,300	6.55	28.98

*Fuels and Mining Practice Division, Department of Energy, Mines and Resources, commercial coal survey reports of analyses.

**Dominion Bureau of Statistics.

[p]Preliminary.

TABLE 6

Interprovincial Shipments of Coal, 1965
(short tons)

Destination	Originating Province				
	Nova Scotia	New Brunswick	Saskatchewan	Alberta	British Columbia
Newfoundland	67,002	—	—	—	—
Prince Edward Island	26,160	—	—	—	—
Nova Scotia	—	1,017	—	—	—
New Brunswick	210,034	—	—	—	—
Quebec	1,339,833	49,021	—	85	—
Ontario	659,867	3,694	178,830	31,733	29,717
Manitoba	—	—	628,814	130,861	122,415
Saskatchewan	—	—	—	388,796	482
Alberta	—	—	—	—	191
British Columbia and Yukon	—	—	—	276,361	—
Total	2,302,896	53,732	807,644	827,836	152,805

Source: Dominion Bureau of Statistics.
—Nil.

TABLE 7

Exports of Coal, 1965
(short tons)

Destination	Shipments from Mines by Provinces*					
	Nova Scotia	New Brunswick	Saskatchewan	Alberta	British Columbia	All
Norway	—	—	—	—	—	—
St. Pierre	4,751	—	—	—	—	4,751
United States	—	30,456	7,234	14,123	998	52,811
Japan	—	—	—	614,801	402,691	1,017,492
Total	4,751	30,456	7,234	628,924	403,689	1,075,054

Source: Dominion Bureau of Statistics.
*Destined for export.
—Nil.

TABLE 8

Imports of Coal for Consumption, 1964–65
(short tons)

Country of Origin		Anthracite	Bituminous*	Total
United States	1965p	626,536	15,955,135	16,581,671
	1964	648,260	14,335,276	14,983,536
United Kingdom	1965p	5,048	—	5,048
	1964	5,578	—	5,578
Total	1965p	631,584	15,955,135	16,586,719
	1964	653,838	14,335,276	14,989,114
Value	1965p	$7,575,473	$118,248,568	$125,824,041
	1964	8,007,743	78,232,973	86,240,716

Source: Dominion Bureau of Statistics, *Trade of Canada*.
*Includes coal dust and coal not otherwise provided for and coal exwarehoused for ships' stores.
pPreliminary; —Nil.

TABLE 9

Consumption of Canadian and Imported Coal, 1955–65

	Canadian		Imported		Total
	Short Tons*	% of Consumption	Short Tons**	% of Consumption	Short Tons
1955	14,060,039	42.1	19,322,134	57.9	33,382,173
1956	14,115,095	38.9	22,198,049	61.1	36,313,144
1957	12,478,626	39.6	19,041,030	60.4	31,519,656
1958	11,054,757	43.9	14,154,121	56.1	25,208,878
1959	10,589,263	43.1	13,958,996	56.9	24,548,259
1960	9,973,308	42.9	13,276,599	57.1	23,249,907
1961	9,572,805	44.3	12,057,086	55.7	21,629,891
1962	9,510,293	43.4	12,377,965	56.6	21,888,258
1963	9,504,903	42.0	13,105,686	58.0	22,610,589
1964	10,080,243	40.2	14,987,656	59.8	25,067,899
1965[p]	10,181,171	38.0	16,593,547	62.0	26,774,718

Source: Dominion Bureau of Statistics.
*Sum of Canadian coal-mine sales, colliery consumption, coal supplied to employees, and coal used in making coke and briquetted, less tonnage of coal exported. **Deductions have been made to account for foreign coal re-exported from Canada and bituminous coal removed from warehouse for ships' stores. Imports of briquettes not included.
[p]Preliminary.

TABLE 10

Consumption of Coal – Major Uses, 1964–65
(short tons)

	1964	1965[p]
Household and Commercial-Building Heating		
Canadian		
Bituminous	435,063	419,692
Subbituminous	399,077	349,960
Lignite	277,808	159,649
Total	1,111,948	929,301
Imported		
Anthracite	331,797	203,877
Bituminous	1,092,602	893,591
Total	1,424,399	1,097,468
Unspecified	114,491	35,417
Total, all types	2,650,838	2,062,186

	1964	1965[p]
Industrial*		
Canadian		
Bituminous	4,208,791	4,046,202
Subbituminous	1,224,461	1,514,187
Lignite	1,499,177	1,635,685
Total	6,932,429	7,196,074
Imported		
Anthracite	250,115	298,008
Bituminous	6,653,419	8,029,900
Total	6,903,534	8,327,908
Total, all types	13,835,963	15,523,982
Coke Making		
Canadian		
Bituminous	654,085	523,516
Imported		
Bituminous	5,212,743	5,379,343
Total	5,866,828	5,902,859

Source: Dominion Bureau of Statistics.
*Does not include firms using less than 500 tons of coal per annum nor coal used to make coke.
[p]Preliminary.

TABLE 11

Coal Used by Thermal Electric Generating Stations, by Provinces, 1964–65

(thousand short tons)

	1964	1965p
Nova Scotia	589	700
New Brunswick	245	368
Ontario	3,080	3,934
Manitoba	149	192
Saskatchewan	1,109	1,195
Alberta	1,093	1,311
Canada, Total	6,265	7,700

Source: Dominion Coal Board.
pPreliminary.

TABLE 12

Briquettes – Production and Consumption, 1964–65

(short tons)

	1964	1965p
Production		
Saskatchewan	21,683	31,562
Alberta* and British Columbia	38,230	36,854
Total, Canada	59,913	68,416
Consumption (briquettes available for consumption)**	61,559	68,596

Source: Dominion Bureau of Statistics.
*Alberta production excludes 19,971 tons of char in 1964, and 38,804 tons in 1965. (Carbonized briquettes previously known as 'char' are now defined as 'coke').
**Production (excluding char) plus 'landed' imports less exports.
pPreliminary.

TABLE 13

Coal Moved Under Subvention, 1964–65

(short tons)

Origin of Coal	1964	1965
Nova Scotia	2,336,571	3,465,093
New Brunswick	407,120	582,192
Saskatchewan	128,215	176,224
Alberta and British Columbia	1,052,526	1,125,317
Total	3,924,432	5,348,826
Value of subvention assistance	$17,194,381	$26,669,551

Source: Dominion Coal Board.

Coke

J.C.BOTHAM*

Of the 26.8 million tons of coal consumed in Canada in 1965 about 5.9 million tons were carbonized to produce coke. The coke was used mainly in the making of primary iron and, to a lesser extent, in foundry practice, base-metal recovery, chemical processes and domestic heating.

Canadian-produced byproduct coke is manufactured mainly at five plants in batteries of standard slot-type ovens, the plants in operation varying in annual coal capacity from 600,000 to 2 million tons. With the exception of one coke oven plant built primarily for the production of domestic coke, they are owned and operated by the steel companies. Apart from the conventional slot-type byproduct coke ovens, Canada has a Curran-Knowles carbonization plant at the Crows Nest Industries Limited collieries in Michel, British Columbia. About 95 per cent of the coal used in the production of coke is processed at these six plants.

There is interest in North America toward a return of the use of non-recovery ovens. The Mitchell oven and modifications of this design are the ovens of this type that are of principal interest at present. Their growing popularity stems primarily from the loss of markets for coke oven byproducts to the petrochemical industry. Some incentives for their use are lower capital cost and lower labour costs than the early beehive oven through improved coal- and coke-handling facilities. Also these ovens can be shut down if not needed. Three Mitchell ovens have been built in the Crowsnest area of British Columbia on an experimental basis to explore the market for foundry coke in western Canada and western United States.

In the Cascade area of Alberta a carbonizing retort commenced operation on a commercial scale early in 1963. A coke product is made by carbonizing briquettes prepared from low-volatile and semianthracite coals; a form-coke could be produced if desired. The product is used primarily for the electric smelting process used in the manufacture of elemental phosphorus; however, markets other than the chemical industry – mainly for metallurgical applications – are envisaged.

Other nonconventional carbonization processes include the Lurgi carbonization retorts which carbonize and briquette a Saskatchewan lignite coal to produce a high fixed-carbon product for domestic fuel and for use in barbecues. A distinctive stoker-type coking plant is operated by the Shawinigan Chemicals Limited, Shawinigan, Que.

In 1965 Lethbridge Collieries, Limited continued to operate their 26-foot rotary hearth carbonizing oven on a continuous basis, supplying the product for the production of pig iron. Further experimental work on upgrading fine material is in progress.

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*Fuel and Mining Practice Division

TABLE 1

Standard Slot-Type Byproduct Coke Oven Plants in Canada

Coke Plant	Battery No.	Type of Oven	Number of Ovens	Year Built	Byproduct Recovered	Plant Capacity (annual rated capacity in tons of coal)	Coke Distribution (sizes in inches)
The Algoma Steel Corporation, Limited, Sault Ste. Marie, Ont.	6	Koppers—Becker Underjet	57	1953	Tar, sulphate of ammonia, pyridine oil, benzole, toluene, xylene, solvent naphtha, naphthalene, light oil, gas	4 batteries of 253 ovens: 2,100,000	Blast furnace—3½ x ¾; base metal industry—¾ x 3/8 and 3/8 x 3/16; sintering—3/16 x 0
	5	Koppers—Becker Underjet	86	1943			
	2	Wilputte gun flue	53	1938			
	7	Wilputte Underjet	57	1958			
The Steel Company of Canada, Limited, Hamilton, Ont.	5	Wilputte Underjet	47	1953	Tar, sulphate of ammonia, naphthalene, pyridine, benzole, toluene, xylene, solvent naphtha, sodium phenolate, gas	3 batteries of 191 ovens: 1,470,000	Blast furnace—plus 5/8; domestic heating—5/8 x 5/16; sintering — minus 5/16
	3	Wilputte Underjet	61	1947			
	4	Wilputte Underjet	83	1952			
Dominion Foundries and Steel, Limited, Hamilton, Ont.	1	Koppers—Becker Gun Type Comb.	25	1956	Tar, light oil, gas	3 batteries of 105 ovens: 930,000	Blast furnace—plus 3/4; sintering — 1/8 x 0; other uses — 3/4 x 1/8
	2	Koppers—Becker Gun Type Comb.	35	1951			
	3	Koppers—Becker Gun Type Comb.	45	1958			
Dominion Steel and Coal Corporation, Limited, Sydney Works, Sydney, N.S.	5	Koppers—Becker Underjet	53	1949	Tar, crude oil, gas	2 batteries of 114 ovens: 900,000	Blast furnace — 3 1/2 x 1 1/2, 2 1/2 x 1 1/2; domestic heating — 2 1/2 x 1 1/2, 1 1/2 x 7/8, 7/8 x 1/4; sintering—1/4 x 0
	6	Koppers—Becker Underjet	61	1953			
Quebec Natural Gas Corporation, Ville LaSalle, Que.	1	Koppers — Becker	59	1928	Tar, sulphate of ammonia, light oil, gas	2 batteries of 74 ovens: 626,300	Foundry coke, domestic heating, chemical industry, blast furnace use, base metal industry, rock-wool producers
	2	Koppers—Becker	15	1947			

TABLE 2

Other Carbonization Plants in Canada

Coke Plant	Type of Unit	No. of Units	Year Built	Coal Capacity of Each Unit (tons/day)	Byproducts Recovered	Plant Capacity (annual rated capacity in tons of coal)	Product Distribution (sizes in inches)
Husky-Dominion Briquettes*, Bienfait, Sask.	Lurgi carbonizing retort	2	1925	150–175	Creosote, lignite tar, lignite pitch	2 units: 110,000	Domestic heating – 31,500 tons char; other – 1,400 tons
Shawinigan Chemicals Limited, Shawinigan, Que.	Travelling grate coking stoker	8	1939	70	Low-grade producer gas	8 units: 200,000	Manufacture of calcium carbide in electric furnaces
The Canmore Mines, Limited, Canmore, Alta.	Vertical retort	1	1963	100	Crude tar, gas	1 unit: 30,000 (agglomerated)	Chemical industries
Crows Nest Industries Limited,** Fernie, B.C.	Mitchell	3	1963	7	No by-products	The 3 ovens are being used mainly to evaluate the foundry coke market	Foundry market.
	Curran-Knowles	10	1939	5.5	Crude tar, gas	4 batteries of 52 Curran-Knowles ovens: 243,000	Base metal industry – 7 x 3; beet sugar industry – 7 x 3; iron reduction in electric furnaces – 7 x 3 and 3 x 1; sintering – minus 1/4.
		10	1943	5.5			
		16	1949	7.5			
		16	1952	7.5			
Lethbridge Collieries, Limited, Lethbridge, Alta.	Rotary hearth	1	1964	150	No by-products	1 unit: 50,000	Iron reduction in electric furnaces; sintering

*Formerly Dominion Briquettes & Chemicals Ltd. **Formerly The Crow's Nest Pass Coal Company, Limited.

In Canada, petroleum coke is used mainly in the production of electrodes for the aluminum industry; pitch coke is obtained only from surplus coal-tar pitch that is not required for such other industrial uses as the production of electrodes or briquettes.

For many years gas-retort plants operated in Canada producing manufactured gas and domestic coke for space-heating, and other domestic and commercial uses. These plants are now practically nonexistent and the markets are largely supplied by natural gas, liquid petroleum gases and oil.

Recently the uses of metallurgical coke have changed because of alterations in the methods of producing pig iron and steel. An increase in the use of agglomerated ores in the iron blast furnace has resulted in increased demand for small sizes of coke and coke breeze. This has made possible, to a greater extent than was previously considered practical, the preparation of sized coke for iron blast furnaces.

TABLE 3

Coke — Production and Trade

	1964		1965p	
	Short Tons	$	Short Tons	$
Production*				
Coal coke				
Ontario	3,495,554		3,527,224	
Other provinces	847,438		841,561	
Total	4,342,992		4,368,785	
Pitch coke	—		—	
Petroleum coke**	206,815		239,738e	
Total	4,549,807		4,608,523	
Imports (all types)				
United States	756,349	13,193,774	982,952	18,115,167
United Kingdom	21	791	—	—
Total	756,370	13,194,565	982,952	18,115,167
Exports (all types)				
United States	101,243	1,338,158	86,596	1,228,633
United Kingdom	5,918	228,446	2,022	78,165
Other countries	13,579	128,544	14	342
Total	120,740	1,695,148	88,632	1,307,140

Source: Dominion Bureau of Statistics.
*Value of coke production and selling price of coke not available. Practically all coke output is that produced in the primary iron and steel industry as material used in process. **Includes quantities of catalytic carbon.
pPreliminary; eEstimated; —Nil.

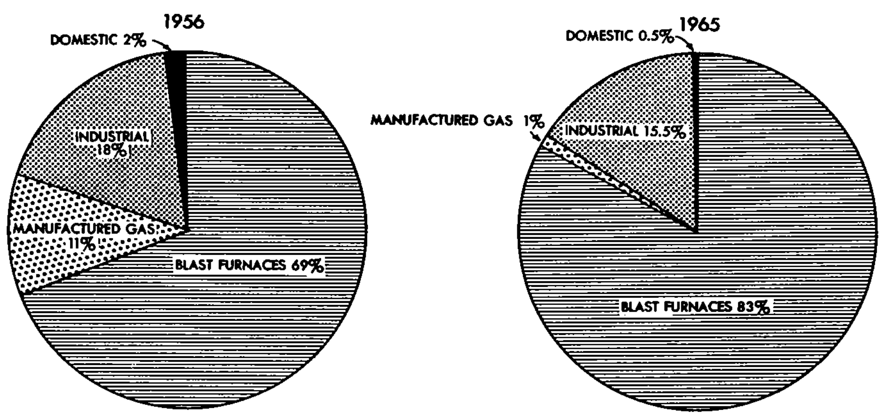
TABLE 4

Coke — Production and Trade, 1955–65
(short tons)

	Production				Imports			Exports
	Coal	Pitch	Petroleum	Total	Coal	Petroleum	Total	Total
1955	4,028,928	3,029	269,899	4,301,856	354,702	405,912	760,614	171,748
1956	4,320,616	8,089	270,905	4,599,610	500,489	442,850	943,339	159,667
1957	4,117,623	5,395	273,296	4,396,314	650,540	426,849	1,077,389	158,298
1958	3,474,985	8,155	462,797	3,945,937	305,330	300,366	605,696	145,202
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
1965p	4,368,791	—	239,738	4,608,529	569,905	413,047	982,952	88,632

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

CONSUMPTION OF COKE IN CANADA BY USES 1956 AND 1965



(1) Industrial uses include iron foundries, non-ferrous smelting and refining, non-metallic mineral products and miscellaneous.

Cobalt

V.B. SCHNEIDER*

Cobalt production in 1965 was 3.8 million pounds, valued at $8.2 million. This was the highest since 1957 when the Canadian record of 3.9 million pounds was set. The increase of 613,757 pounds from 1964 is attributed to greater production of nickel during the recovery of which cobalt is obtained as a byproduct. It is also recovered as a byproduct of silver refining at Cobalt, from silver ores mined in the Cobalt and Gowganda areas of Ontario.

Primary cobalt prices increased on March 1, the first increase in five years. In New York, increases ranged from 15 to 20 cents a pound on granules, fines, and oxides; in Canada the price hikes were 15¢ a pound for cobalt powder, from $1.65 to $1.80, and 22¢ for briquettes, from $1.73 to $1.95. The price for electrolytic cobalt at $2.16 a pound was not affected.

World production and consumption of cobalt is expected to continue increasing in 1966 and 1967. In Canada, the expanding nickel industry will result in the recovery of more byproduct cobalt. Expansion programs have been announced for production in The Democratic Republic of the Congo (Kinshasa) and in Finland. In the Congo, Union Minière du Haut-Katanga announced that production in 1966 will be about 1,100 tons greater than in 1965. In Finland a plant is being built at Kokkola for the recovery of cobalt from the Outokumpu pyrites. The plant is expected to start up in 1967 with an initial capacity of 2.6 million pounds of cobalt a year. This may not represent an absolute increase in world production because pyrites from Outokumpu are already being treated in Germany.

*Mineral Resources Division

TABLE 1

Canadian Cobalt Production, Trade and Consumption, 1964–65

	1964		1965P	
	Pounds	$	Pounds	$
Production[1], all forms	3,184,983	5,990,973	3,798,740	8,205,278
Exports				
Cobalt metal				
United States	556,460	958,576	264,562	486,480
France	6,400	10,511	15,400	27,604
Republic of South Africa	8,443	66,795	5,400	44,216
Other countries	22,304	35,615	6,829	12,267
Total	593,607	1,071,497	292,191	570,567
Cobalt oxides and salts[2]				
Britain	1,600,900	2,127,734	1,364,400	1,897,358
United States	53,800	62,969	49,800	62,355
Jamaica	200	123	—	—
Total	1,654,900	2,190,826	1,414,200	1,959,713
Consumption[3], cobalt metal and cobalt contained in oxides and salts	365,851		366,036	

Source: Dominion Bureau of Statistics.

[1]Production (cobalt content) from domestic ores of cobalt metal and cobalt in alloys, oxides and salts. Excludes cobalt content of nickel-oxide sinter shipped to Britain by INCO but includes cobalt content of Falconbridge shipments of nickel-copper matte to Norway. [2]Gross weight. [3]As reported by consumers.

PPreliminary; —Nil.

TABLE 2

Canadian Cobalt Production, Trade and Consumption, 1955–65

(pounds)

		Exports				Imports		
	Production[1] (all forms)	Cobalt in Ores and Concentrates	Metallic Cobalt	Cobalt Alloys[3]	Cobalt Oxide and Salts[3]	Cobalt Ores	Cobalt Oxides[3]	Consumption[2]
1956	3,516,670	16,000	1,432,884	11,343	1,289,145	1,900	11,353	262,000
1957	3,922,649	15,100	2,155,742	12,400	620,042	800	10,340	153,000
1958	2,710,429	—	1,024,667	9,712	522,144	—	16,230	260,000
1959	3,150,027	—	680,323	3,280	1,100,734	—	24,716	188,000
1960	3,568,811	—	844,293	1,938	1,175,206	—	20,227	182,000
1961	3,182,897	..	603,931	..	1,521,000	—	28,364	307,000
1962	3,481,922	..	542,565	..	1,629,900	—	40,936	299,000
1963	3,024,965	..	739,227	..	1,098,300	2,500	28,291	270,000
1964	3,184,983	..	593,607	..	1,654,900	..	..	276,000
1965P	3,798,740	..	292,191	..	1,414,200	..	..	263,000

Source: Dominion Bureau of Statistics.

[1]Production from domestic ores of cobalt metal and cobalt contained in alloys, oxides and salts. Excludes cobalt content of nickel-oxide sinter shipped to Britain by INCO but includes cobalt content of Falconbridge shipments of nickel-copper matte to Norway. [2]Refined metal only. Producers' domestic shipments 1956–59; as reported by consumers for subsequent years. [3]Gross weight.

PPreliminary; —Nil; ..Not available.

CANADIAN PRODUCTION

ONTARIO

The International Nickel Company of Canada, Limited (INCO), recovers cobalt from its nickel-refining operations at Port Colborne. Cobalt oxide and high-purity electrolytic cobalt are produced at the Port Colborne refinery and cobalt oxide and salts are produced by The International Nickel Company (Mond) Limited, a British subsidiary, at Clydach, Wales, from nickel-oxide sinter shipped to Britain from Ontario. In 1965, INCO reported production of 2.3 million pounds of cobalt from all operations, compared with 2.2 million pounds in 1964.

Falconbridge Nickel Mines, Limited, produced electrolytic cobalt at its refinery at Kristiansand, Norway, from the refining of nickel-copper matte produced at Sudbury. Falconbridge also reported that Cobalt deliveries for 1965 were up over those of 1964.

Cobalt Refinery Limited recovers cobalt as a byproduct of silver from the smelting and refining of silver-cobalt ores of the Cobalt and Gowganda areas. The company sells its cobalt as black cobalt oxide, mostly to Canadian manufacturers of frit for base-coat enamelling. Oxide production in 1965 amounted to 101,210 pounds, down from 136,342 pounds in 1964. Eldorado Mining and Refining Limited had intended to commence cobalt recovery at its Port Hope refinery using a new process developed in 1964 but other commitments caused the postponement of this plan.

MANITOBA AND ALBERTA

Sherritt Gordon Mines, Limited, produced 530,137 pounds of cobalt during 1965, which was 64,112 pounds less than in 1964. Sherritt Gordon recovers cobalt as a byproduct of its nickel-refining operations at Fort Saskatchewan, Alberta; this refinery treats nickel-copper-cobalt ore from the company's Lynn Lake, Manitoba, mine and from purchased cobalt-bearing material. On the basis of available raw material the company is expanding its cobalt-recovery capacity by 100,000 pounds, to 700,000 pounds a year.

WORLD PRODUCTION

World cobalt production in 1965 was 16,757 short tons, up by 1,527 tons from 1964 and surpassed only in 1958 and 1962; all of the leading producer countries registered greater production than in 1964.

The Democratic Republic of the Congo (Kinshasa) is by far the largest producer of cobalt. Its production in 1965 was 9,244 tons, all derived as a byproduct from the copper-refining operations of Union Minière du Haut-Katanga.

Cobalt was produced in Zambia by Rhokana Corporation Limited. Production in 1965, valued at £ 1,702,500, amounted to 1,702 tons, compared with 1,552 tons in 1964.

In French Morocco, cobalt is derived from the cobalt-bearing deposits in the Bou Azzer district by the Société Minière du Bou Azzer et du Graaza. Preliminary reports indicate that production for 1965 was about 2,092 tons. Most of the French Moroccan cobalt concentrates are refined in France, the remainder in Belgium. Like the ores of Cobalt, Ontario, those from Morocco are arsenical and must be treated at smelters that specialize in this raw material.

In the United States, primary cobalt is recovered in small quantities as a byproduct of iron-ore production. As there is only one producer, official production figures are not released but an estimate in *Cobalt*, No. 30, March 1966, placed production for 1965 at about 300 tons, which is 50 tons more than in each of the previous two years. Bethlehem Steel Corporation recovers a pyrite flotation concentrate, containing cobalt and some copper, in its iron-ore concentration plants at Cornwall and Morgantown, Pa. In a plant at Sparrows Point, Md., the company roasts the concentrate and leaches the calcine with sulphuric acid to produce a mixed cobalt-copper sulphate, which is treated by Pyrites Co., Inc., Wilmington, Del., for the recovery of cobalt and copper. In the United States, about 25 refineries and processers produce primary cobalt products from imported ores, concentrates, metal, waste and scrap, all of which are imported duty-free.

In Germany, Duisburger Kupferhutte extracts cobalt from imported pyrites, residues, mostly from Finland, and Gebruder Borchers AG recovers cobalt from scrap and from roasted speiss and matte.

TABLE 3

World Production of Cobalt 1963–65

(short tons)

	1963	1964	1965P
The Democratic Republic of the Congo (Kinshasa)	8,131	8,461	9,244
Morocco	1,764	1,901	2,092
Canada	1,512	1,592	1,899
Zambia	1,599	708	1,702
Germany	1,582	1,527	1,385
United States	250	250	300
Others	562	711	135
Total	15,400	15,150	16,757

Source: Dominion Bureau of Statistics; Cobalt Information Center, Brussels. *Cobalt*, No. 30, March 1966; *1959 Annual Report* of Union Minière du Haut-Katanga; and from Rhodesia, *The Chamber of Mines Journal*, Vol. 8 No. 3, March 1966.

PPreliminary.

USES AND CONSUMPTION

The most important application of cobalt is in high-temperature cobalt-base alloys used for such parts as nozzle guide vanes and turbine rotor blades in jet engines, gas-turbine engines and in guided missiles. The metal is an important constituent of permanent-magnet alloys, cemented carbides, hard-facing rods and high-speed steel. A radioisotope, Cobalt 60, is widely used for radiographic examinations by industry and also in the 'cobalt bomb' treatment of cancer.

Cobalt oxide is used in ground-coat frit for bonding porcelain enamel to a metal base. It is also used as a colouring agent in making glass and ceramics.

Organic salts of cobalt are used as driers in paint, varnish, enamel, ink, etc. Inorganic salts such as cobalt sulphate and cobalt carbonate are used in animal feeds.

The United States is the largest importer and consumer of cobalt and, according to the U.S. Bureau of Mines, Mineral Industry Surveys, *Cobalt Monthly*, May 11, 1966, consumption in 1965 was 13.6 million pounds. This compares with 10.7 million pounds in 1964. Imports for 1965 at 15.4 million pounds were 3.1 million pounds over those of 1964. According to the Cobalt Information Center in Brussels, cobalt consumption in other parts of the non-Communist world increased, reflecting the high level of economic activity that prevailed throughout the year. However, the Center indicated that the U.S. consumption pattern can no longer be considered as representative of the rest of the Free World. It gave two reasons for this: (1) "the increasing share taken by countries other than the U.S.A. in world cobalt consumption", and (2) "the sometimes large differences in the conditions that govern the cobalt market in and outside the United States."* Accordingly, the Center will attempt to gather and publish

TABLE 4

United States Consumption of Cobalt by Uses, 1964-65

(percentage of total consumption)

	1964	1965P
Metallic, steel		
High-speed steel	2.9	2.0
Other tool and alloy steel	6.7	7.0
Permanent-magnet alloys	20.8	21.0
Cutting and wear-resisting materials	3.2	3.2
High-temperature high-strength materials	23.1	24.9
Alloy hard-facing rods and materials	7.5	8.0
Cemented carbides	4.1	3.4
Nonferrous alloys and other metallic uses	7.1	9.1
Total	75.4	78.6
Nonmetallic, exclusive of salts and driers		
Ground-coat frit	5.6	4.1
Pigments	2.0	1.5
Other materials	5.0	4.4
Total	12.6	10.0
Salts and driers: lacquers, varnishes, paints, inks, pigments, enamels, feeds, electroplating, etc.e	12.0	11.4
Grand total	100.0	100.0

Source: U.S. Bureau of Mines Mineral Industry Surveys *Cobalt Monthly*, February 15, 1966.

PPreliminary; eEstimated.

TABLE 5

Cobalt Consumption in Canada, 1964–65

(pounds of contained cobalt)

	1964	1965P
Cobalt metal	276,313	263,130
Cobalt oxide	52,991	86,463
Cobalt salt	36,547	16,443
Total	365,851	366,036

Source: Dominion Bureau of Statistics.

PPreliminary.

*Cobalt Information Center – *Cobalt* No. 30, March 1966.

cobalt consumption statistics on a world-wide basis, comparable to the work of the U.S. Bureau of Mines on United States consumption. Canadian consumption of cobalt in the form of metal, oxide and salts at 366,036 pounds, was up only slightly from that of 1964.

Table 4, which lists the distribution of cobalt consumption by end-use in the United States, shows small increases in the relative amount of cobalt used in the manufacture of most metallics and a slight decrease in the relative amount used in nonmetallics and in salts, driers, lacquers, etc.

PRICES

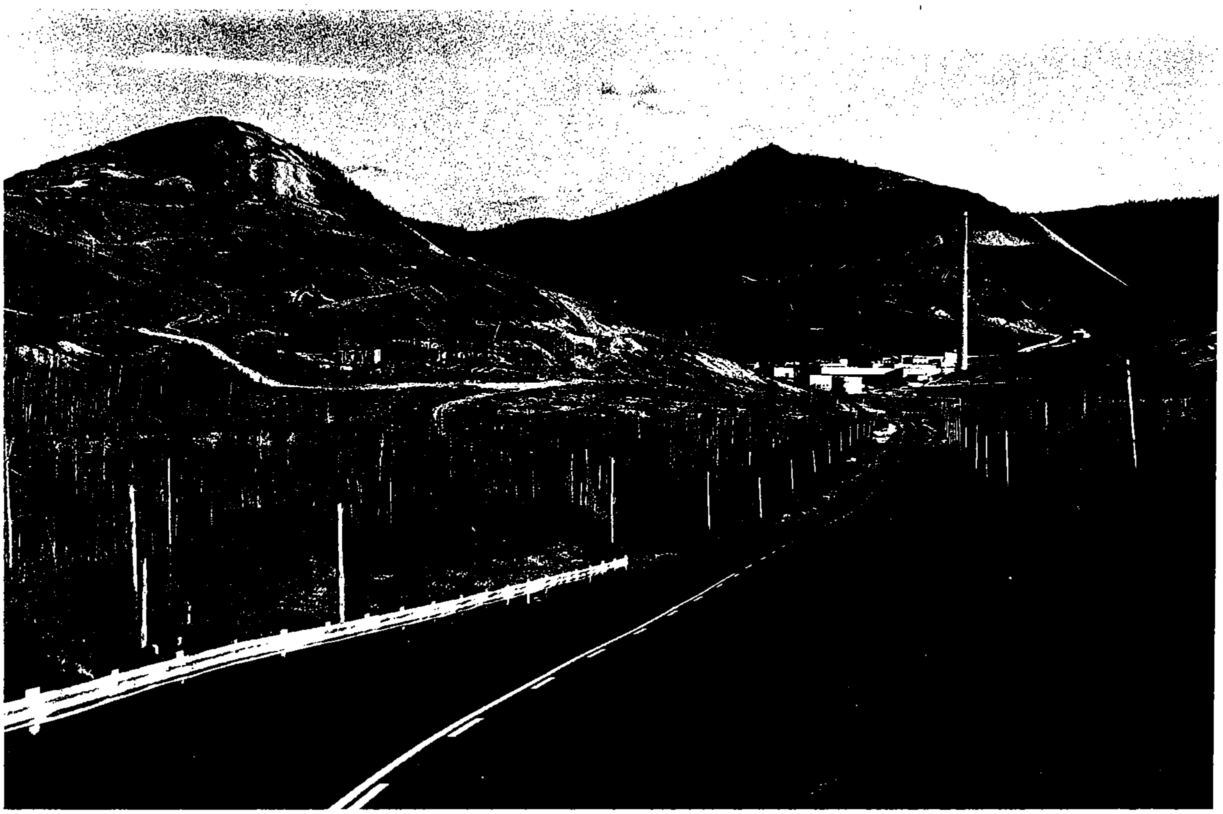
Prices in the United States according to *E & M J Metal and Mineral Markets*, December 27, 1965, were as follows:

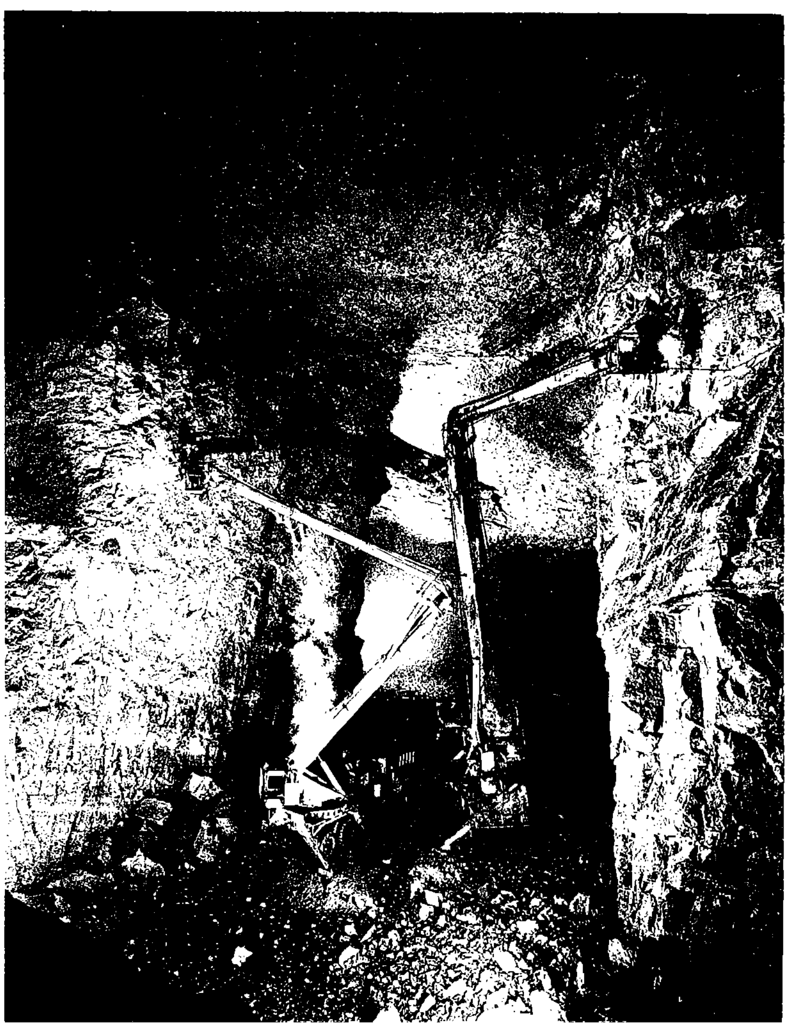
Cobalt Metal, per lb f.o.b. New York	
Shot – 99%+	
less than 100-lb lots	$1.72
100-lb lots	1.67
500-lb lots	1.65
Powder – 99%+	
300 mesh, 100-lb lots	2.01
extra fine, 5 to 50-kilo lots	2.52
S grade, 10-ton lots	1.68
Fines – 95-96%	1.65
300 mesh	1.80
Briquettes, 10-ton lots	1.83
Cobalt oxide, per lb, contained ceramic, delivered, 3¢ more west of Mississippi	
70–71%	1.28
72½ – 73½%	1.32
Metallurgical – 75–76%	1.85

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Ore	free	free	free
Cobalt metal: lumps, powder, ingots, blocks	free	10	25
Cobalt oxide	free	10	10
Cobalt bars	10	10	25

United States	
Cobalt ore	free
Metal	free
Cobalt oxide	1.5¢ per lb
Cobalt sulphate	1.5
Cobalt linoleate	7.25
Other cobalt compounds and salts	12% ad val.





Gaspé Copper Mines, Limited at Murdochville, Quebec, showing the Copper Mountain orebody under development, left centre.

Miners scale and roof-bolt from a pair of 'giraffes' in a room-and-pillar stope. Gaspé Copper Mines, Limited.

Copper

A.F. KILLIN*

Copper remained in short supply in 1965. The high level of industrial activity, war in Viet Nam and an increased demand in the less-developed countries raised consumption to record levels. Strikes and political unrest in many copper-producing countries resulted in production losses. Despite a record production in the Free World the supply shortage is not likely to be eliminated before the last quarter in 1966 and may persist into 1967. Free World consumption increased to about 5,125,000 tons (including secondary material), about 4 per cent higher than in 1964. Mine production in 1965 increased by about 7 per cent to 4,720,000 tons (estimated).

Prices reacted to the shortage and tended to rise throughout the year. Price movements are discussed in a separate section of this review and are illustrated by the graph "Copper Prices 1965".

Escalation of the war in Viet Nam and the threat of interruption of Zambian supplies owing to political developments in Rhodesia brought about the imposition of controls on copper exports in Canada, United States, Great Britain, Australia and Japan. The major effect was felt in the scrap industry. The United States limited exports of scrap to 15,000 tons of contained copper in the first half of 1966; Australia, Great Britain and Japan stopped all exports of scrap. No control restrictions were placed on the movement of copper across the Canada-United States border. Canadian controls were imposed as precautionary measures in case of emergency and in order to prevent offshore exports from Canada of copper of United States origin.

Canadian mine production, refined production and refined consumption increased in 1965; the only decrease in the industry was in the amount of copper exported. Mine production at 517,247 tons valued at $388,005,039 exceeded 500,000 tons for the first time and was 30,347 tons more than in 1964. Production of refined copper at 433,552 tons was 25,043 tons higher than in 1964 and refined consumption was 22,960 tons more than in 1964, totalling 225,185 tons. Decreased production in British Columbia lowered the amount of copper exported in ores and matte to 87,000 tons, 17,550 tons less than in 1964. Exports of refined copper at 199,830 tons were 11 per cent lower than in 1964.

High prices and sustained demand for copper stimulated development and exploration in the copper-bearing areas of Canada.

PRODUCTION AND DEVELOPMENT

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

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*Mineral Resources Division

TABLE 1

Copper — Production, Trade and Consumption, 1964-65

	1964		1965p	
	Short Tons	$	Short Tons	$
Production[1]				
All forms				
Ontario	197,917	131,458,795	219,183	163,860,900
Quebec	158,088	105,602,844	176,074	132,407,661
British Columbia	57,561	38,418,929	44,069	33,139,640
Manitoba	29,777	19,891,109	31,011	23,320,582
Saskatchewan	20,442	13,655,333	19,236	14,465,309
Newfoundland	13,615	9,095,013	17,348	13,045,795
New Brunswick	9,296	6,209,736	9,696	7,291,392
Northwest Territories	—	—	425	319,600
Nova Scotia	204	136,075	205	154,160
Total	486,900	324,467,834	517,247	388,005,039
Refined	408,509		433,552	
Exports				
In ores, concentrates and matte				
Japan	65,211	32,112,839	52,555	32,940,477
Norway	12,359	5,707,620	15,525	8,530,287
United States	13,223	6,533,306	7,217	4,272,924
Sweden	7,168	4,802,712	4,645	4,864,256
Belgium and Luxembourg	1,968	651,489	2,653	1,114,687
West Germany	2,546	1,046,577	1,859	1,055,322
Britain	1,598	864,907	1,664	1,109,493
Other countries	477	150,053	882	359,855
Total	104,550	51,869,503	87,000	54,247,301
In slag, skimmings and sludge				
United States	278	150,199	277	189,124
Belgium and Luxembourg	—	—	234	150,474
Spain	59	33,191	163	125,353
Total	337	183,390	674	464,951
Scrap				
United States	1,243	965,500	4,201	3,823,985
Yugoslavia	464	311,675	3,413	2,931,257
West Germany	2,582	1,795,177	2,942	2,448,124
Spain	1,468	991,622	2,688	2,326,042
Hungary	—	—	1,309	1,037,205
Britain	—	—	1,639	1,623,520
Netherlands	279	218,270	853	767,800
Japan	6,439	4,359,162	818	684,719
Belgium and Luxembourg	42	10,216	855	698,283
Italy	108	63,379	588	467,710
Other countries	522	333,674	578	511,511
Total	13,147	9,048,675	19,884	17,320,156
Brass and bronze scrap				
Japan	5,164	2,674,553	4,250	2,556,356
United States	1,414	614,760	2,099	1,221,015
West Germany	1,152	653,085	1,148	681,641
Netherlands	416	230,893	733	456,279
Italy	167	79,762	500	293,728
Other countries	56	26,208	562	307,775
Total	8,369	4,279,261	9,292	5,516,794
Alloy scrap, n.e.s.				
Japan	167	85,880	277	135,397
United States	202	61,859	162	81,590
West Germany	51	25,818	67	35,706
Other countries	29	18,662	70	29,417
Total	449	192,219	576	282,110

Exports (cont.)	1964 Short Tons	1964 $	1965P Short Tons	1965P $
Refinery shapes				
Britain	110,396	72,208,723	106,098	78,264,114
United States	85,293	58,400,833	71,057	53,375,411
France	15,666	9,677,849	11,525	8,549,419
West Germany	2,907	1,919,921	3,680	2,751,596
Sweden	2,303	1,518,209	2,421	1,777,225
Switzerland	1,373	905,180	1,439	1,060,896
Belgium and Luxembourg	1,835	1,235,573	1,316	921,110
Italy	1,735	1,149,048	968	723,209
Portugal	505	334,949	729	518,428
Other countries	2,260	1,458,607	597	459,345
Total	224,273	148,808,892	199,830	148,400,753
Bars, rods and shapes (sections) n.e.s.				
Norway	6,673	4,487,296	9,257	6,810,420
United States	4,126	3,308,807	7,214	5,924,260
Switzerland	6,205	3,894,528	3,189	2,371,491
Denmark	2,022	1,353,425	2,860	2,094,383
Pakistan	3,758	2,339,697	2,980	2,036,475
Britain	2,746	1,966,677	2,376	1,808,583
Spain	1,822	1,190,903	1,834	1,380,638
Netherlands	...	314	582	465,147
Venezuela	1,413	1,106,126	565	499,460
Colombia	683	523,538	471	413,988
Other countries	1,406	1,028,868	1,270	1,075,749
Total	30,854	21,200,179	32,598	24,880,594
Plates, sheet, strip and flat products				
United States	2,671	2,512,293	1,634	1,737,615
New Zealand	492	487,030	379	434,433
Venezuela	163	156,808	212	226,379
Puerto Rico	228	216,344	80	81,043
Britain	137	149,211	60	68,313
Other countries	422	400,478	279	294,178
Total	4,113	3,922,164	2,644	2,841,961
Pipe and tubing				
United States	2,109	1,861,270	2,950	3,260,624
New Zealand	2,386	2,614,049	2,047	2,596,638
Britain	916	1,011,191	798	866,262
Venezuela	394	400,675	530	570,939
Puerto Rico	514	519,979	242	277,523
Philippines	412	479,252	242	284,847
Other countries	2,202	2,323,120	1,562	1,864,727
Total	8,933	9,209,536	8,371	9,721,560
Wire and cable, not insulated				
United States	119	117,365	852	897,649
Pakistan	11	7,707	857	833,281
Britain	258	226,601	357	306,148
Bolivia	3	2,998	139	129,481
Costa Rica	24	19,082	64	60,973
Other countries	433	353,007	394	389,502
Total	848	726,760	2,663	2,617,034
Alloy refinery shapes, sections and flat products				
United States	1,555	1,383,296	2,312	2,203,566
Denmark	27	28,231	189	153,153
Venezuela	183	160,015	142	140,432
Pakistan	188	122,993	83	64,044
Other countries	1,383	1,258,300	490	509,425
Total	3,336	2,952,835	3,216	3,070,620

Table 1 (cont.)

Exports (cont.)	1964 Short Tons	1964 $	1965p Short Tons	1965p $
Alloy pipe and tubing				
United States	1,275	1,325,326	1,039	1,346,399
Iran	150	163,555	164	183,031
Venezuela	139	153,976	167	263,094
New Zealand	218	243,043	117	150,350
Other countries	727	826,703	341	384,078
Total	2,509	2,712,603	1,828	2,326,952
Alloy wire and cable (not insulated)				
United States	336	496,069	420	572,148
Australia	14	28,788	30	63,833
Britain	30	54,468	27	62,013
Other countries	31	28,862	18	23,599
Total	411	608,187	495	721,593
Copper and copper alloy fabricated materials, n.e.s.				
United States	114	159,112	115	179,033
Other countries	13	62,859	18	90,051
Total	127	221,971	133	269,084
Wire and cable, insulated[2]				
United States	8,659	11,366,533	9,014	12,990,759
Philippines	586	789,605	613	909,755
Nigeria	...	154	588	712,202
Costa Rica	7	8,646	279	290,116
Thailand	8	9,692	258	328,087
Chile	165	180,560	188	265,578
Bahamas	70	73,000	189	211,610
New Zealand	218	265,521	190	266,575
Pakistan	66	64,851	104	118,270
Other countries	1,583	1,563,656	1,090	1,364,518
Total	11,362	14,322,218	12,513	17,457,470
Imports				
Copper in ores, concentrates and scrap	2,215	1,370,558	1,845	1,303,890
Refinery shapes	6,771	4,444,817	5,747	4,542,056
Bars, rods and shapes (sections) n.e.s.	925	816,588	1,272	1,501,885
Plates, sheet, strip and flat products	122	200,648	1,771	2,247,195
Pipe and tubing	431	617,189	1,240	1,937,815
Wire and cable, except insulated	260	312,125	281	425,908
Alloy scrap	218	104,837	515	245,407
Alloy refinery shapes, bars, rods and sections	1,105	1,320,990	3,513	3,931,408
Alloy plates, sheet, strip and flat products	964	1,007,960	3,963	4,993,050
Alloy pipe and tubing	732	1,090,840	1,145	1,984,284
Alloy wire and cable, except insulated	887	1,266,292	1,090	1,696,694
Copper and alloy fabricated materials, n.e.s.		3,089,153		3,660,959
Consumption[3]				
Refined	202,225		225,185	

Source: Dominion Bureau of Statistics.

[1]Blister copper plus recoverable copper in matte and concentrates exported. [2]Includes also small quantities of noncopper wire and cable, insulated. [3]Producers' domestic shipments.

p Preliminary; – Nil; ... Less than one short ton; n.e.s. Not elsewhere specified.

NEWFOUNDLAND AND LABRADOR

Newfoundland's copper production continues to increase with the number of producing mines and with the expansion of existing producers. British Newfoundland Exploration Limited's Whalesback Pond mine started production in 1965 and brought the number of producers to five. Production of copper in 1965 totalled 17,348 tons valued at $13,045,795, an increase of 3,733 tons and $3,950,782 from 1964.

The 2,000-ton-a-day mine and mill at Whalesback Pond, 6 miles southwest of Little Bay, started production in July. The concentrates are trucked to a storage shed at Little Bay, adjacent to that of Atlantic Coast Copper Corporation Limited and are unloaded at Atlantic Coast's dock for shipment to the Murdochville, Quebec, smelter of Gaspé Copper Mines, Limited.

The exploration of the ore zone at Atlantic Coast Copper by diamond drilling below the 1,350-foot level gave encouraging results, and shaft sinking to 2,000 feet below the collar was started. Mining of the ore below the old stopes resulted in higher millheads; the mill will be expanded by the addition of a rod mill, to treat 1,400 tons a day in 1966.

Consolidated Rambler Mines Limited near Baie Verte, was developing its East orebody for production in 1966 and was expanding the mill from 500 to 1,500 tons a day.

The Tilt Cove mine of First Maritime Mining Corporation Limited continued production from low-grade fringes of the mined-out orebodies. The mine, which had been scheduled to close in mid-1965, will continue to operate through 1966. First Maritime continued development of the orebody at its Gullbridge mine at Gull Pond, near Badger. A 1,500-ton-a-day mill is being built at the property.

Exploration parties were active in Newfoundland. Big Nama Creek Mines Limited at York Harbour was driving an adit to explore a copper deposit near this west coast town.

NOVA SCOTIA

The only copper production obtained in Nova Scotia was from the lead-zinc mine of Magnet Cove Barium Corporation near Walton. Mariner Mines Limited continued to explore and diamond drill its copper-molybdenum prospect 6 miles southwest of Sydney on Cape Breton Island.

NEW BRUNSWICK

No new mines were brought into production in 1965 but two zinc-lead-copper orebodies will be producing in 1966. Copper production in 1965 was 9,696 tons valued at $7,291,392.

TABLE 2

Copper – Production, Trade and Consumption, 1956-65

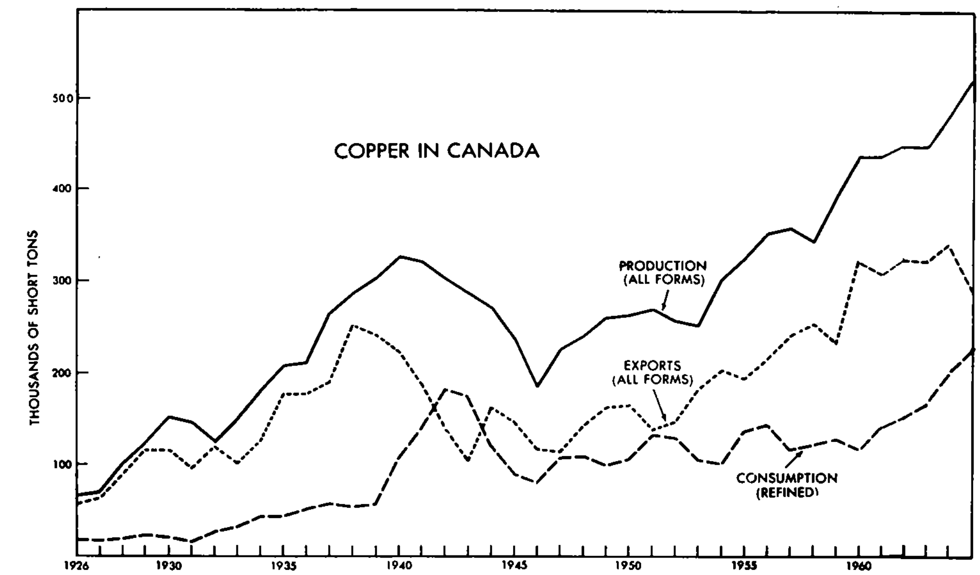
(short tons)

	Production		Exports			Imports	Consumption**
	All forms*	Refined	In Ore and Matte	Refined	Total	Refined	Refined
1956	354,860	328,458	40,993	174,844	215,837	2,541	145,286
1957	359,109	323,540	46,548	198,794	245,342	4,175	118,225
1958	345,114	329,239	30,316	224,638	254,954	1	122,893
1959	395,269	365,366	32,070	222,437	254,507	105	129,973
1960	439,262	417,029	47,633	278,066	325,699	25	117,636
1961	439,088	406,359	42,894	266,247	309,141	3	141,807
1962	457,385	382,868	89,374	223,043	312,417	147	151,525
1963	452,559	378,911	92,930	214,987	307,917	6,549	169,750
1964	486,900	408,509	104,550	224,273	328,823	6,771	202,225
1965p	517,247	433,552	87,000	199,830	286,830	5,747	225,185

Source: Dominion Bureau of Statistics.

*Blister copper plus recoverable copper in matte and concentrate exported. **Producers' domestic shipments, refined copper.

p: Preliminary.



Production in 1964 was 9,296 tons valued at $6,209,736. The Consolidated Mining and Smelting Company of Canada Limited continued production at its Wedge mine and intensified its underground exploration of the ore zone. Heath Steele Mines Limited is shaft sinking at its property and plans to double output to 600,000 tons of ore a year by 1968.

Brunswick Mining and Smelting Corporation Limited was building a 2,250-ton-a-day extension to the present concentrator to treat ore from the No. 6 orebody. Mining will be by open pit and a bulk concentrate will be produced at the mill.

Key Anacon Mines Limited was preparing its No. 2 orebody for production in 1966 and was exploring and developing other known ore zones. Construction of an 800-ton-a-day mill is scheduled for 1966.

The Anaconda Company (Canada) Ltd. was exploring its Caribou orebody by underground drifting and diamond drilling. Many other companies were exploring deposits in the Bathurst-Newcastle area.

QUEBEC

Three new mines were added to the list of Quebec producers in 1965. A total of 176,074 tons of copper valued at $132,407,661 was produced in the province – 17,986 tons and $26,804,817 more than in 1964.

Gaspé Copper Mines, Limited, at Murdochville, announced expansion plans that will increase the concentrator capacity to 11,000 tons of ore a day from the present 7,500 tons and bring into production an open-pit mine at the Copper Mountain orebody by 1967. Terra Nova Explorations Ltd., a subsidiary of Price Brothers & Company, Limited, made an important discovery of copper in the Gaspé Provincial Park west of Murdochville. The discovery started a rush of staking, prospecting and diamond drilling.

Cupra Mines Ltd. was one of the new producers in Quebec. The property is near Stratford Place, about 2½ miles from the Solbec mine. About 800 tons of ore are trucked from Cupra to the Solbec mill each day.

Mining, exploration and development continued at the mines in the Chibougamau district. Campbell Chibougamau Mines Ltd. was preparing to move its mill from the Main mine to the Henderson mine. The greatest part of Campbell Chibougamau's reserves are in the Henderson orebody.

In Poirier township, north of Amos, Mines de Poirier inc., a subsidiary of Rio Algom Mines Limited, started production at its copper-zinc orebody. The 1,500-ton-a-day mill was being expanded to process 700 tons of ore a day from the nearby mine of Joutel Copper Mines Limited. Production from Joutel is expected to start in 1966.

TABLE 3

Producing Companies, 1965

Company and Location	Mill Capacity (tons ore/day)	Ore Produced 1965 (1964) (short tons)	Grade (%) Copper	Zinc	Nickel	Developments
Newfoundland						
American Smelting and Refining Company (Buchans Unit), Buchans	1,250	366,000 (383,000)	1.12	13.37	–	Normal exploration and development.
Atlantic Coast Copper Corporation Limited, Little Bay	1,150	292,023 (317,529)	1.10	–	–	Development of orebody on 1,350 level. Drive will be started to explore North zone on 750-ft. level. Rod mill installed in mill.
British Newfoundland Exploration Limited, Whalesback mine, Springdale	1,500	165,000 (–)	1.32	–	–	Mill completed Sept. 1964, tune-up completed July, 1965 and daily milling rate reached 1,592 tons in Dec. Routine exploration and development.
Consolidated Rambler Mines Limited, Baie Verte	500	128,625 (57,381)	1.48	1.98	–	East zone shaft sunk to 1,125 ft. below collar, surface plant completed. Lateral development scheduled for 1966. Mill expansion to 1,500 tons a day to be completed in 1966.
First Maritime Mining Corporation Limited, Tilt Cove	2,350	713,662 (792,313)	0.82	–	–	Mining of low-grade remnants of orebodies allowed further exploration and development at mine.
Nova Scotia						
Magnet Cove Barium Corporation, Walton	125	.. (48,927)	0.62	1.70	–	Routine development.
New Brunswick						
Brunswick Mining and Smelting Corporation Limited, No. 12 property, Bathurst	4,500	1,657,519 (777,902)	0.30	9.51	–	Routine development at No. 12 mine. A 2,250-ton-a-day annex to No. 12 mill under construction to treat ore from No. 6 mine.
The Consolidated Mining and Smelting Company of Canada Limited, Wedge mine, Bathurst-Newcastle	750 (trucked to heath Steele mill)	271,649 (281,656)	..	..	–	Exploration on lower levels for new orebodies.
Heath Steele Mines Limited, Bathurst-Newcastle	1,500	211,000(e) (290,000)	0.97	6.01	–	Mining of lower B1 orebody continued. Sinking of No. 3 shaft started.
Quebec						
Campbell Chibougamau Mines Ltd. (Main, Kokko Creek, Cedar Bay and Henderson mines), Dore Lake, Chibougamau	3,500	941,198 (896,706)	1.75	–	–	Underground exploration and development continued at Henderson, Cedar Bay and Main mines. Shaft sinking in progress at Cedar Bay.

Table 3 (cont.)

Company and Location	Mill Capacity (tons ore/day)	Ore Produced 1965 (1964) (short tons)	Grade (%)			Developments
			Copper	Zinc	Nickel	
Cupra Mines Ltd., Stratford Place	600 (trucked to Solbec mill)	82,427 (–)	3.35	3.18	–	Production started Sept. 20. Development and exploration at depth continued.
Gaspé Copper Mines, Limited, Murdochville	7,500	2,602,900 (2,725,300)	1.17	–	–	Development of Copper Mountain mine, enlargement of concentrator to 11,000 tons a day.
Lake Dufault Mines, Limited, Noranda	1,300	475,007 (139,956)	5.85	8.51	–	Stope development, underground exploration continued. Surface exploration resumed.
Manitou-Barvue Mines Limited, Val d'Or	1,300	283,875 (244,980)	0.81	–	–	Routine development underground. Induced polarization geophysical survey on surface to be followed by diamond drilling.
		168,895 (142,925)	–	4.48	–	
Mattagami Lake Mines Limited, Matagami	3,850	1,406,154 (1,282,072)	0.69	11.7	–	Routine exploration and development.
Merrill Island Mining Corporation, Ltd, Dore Lake, Chibougamau	650	90,176 (133,552)	2.19	–	–	Routine development and exploration of Merrill orebodies. Crosscut to Chib-Kayrand orebody completed on 300-ft. level, development started. Exploration headings started toward Chib-Kayrand orebody on 600- and 900-ft. levels.
New Hosco Mines Limited, Matagami	900 (trucked to Orchan mill)	324,131 (330,155)	2.42	0.46	–	Routine development of known ore. Exploration of ore zone at depth by drifting, crosscutting, diamond drilling. Preparation for mining zinc ore.
Noranda Mines Limited, Noranda	3,200	771,400 (897,341)	2.08	–	–	Routine development of orebody. Exploration of ore zone on 7,000- and 8,000-ft. levels by drifting and diamond drilling.
Normetal Mining Corporation, Limited, Normetal	1,000	350,693 (348,924)	1.58	8.10	–	No. 5 shaft sunk to 7,952 ft. below collar ventilation raises installed; lateral development of ore zone on 6,565-ft. level completed.
Opemiska Copper Mines (Quebec) Limited, Chapais	2,000	745,976 (748,990)	2.83	–	–	Development of known ore in Springer and Perry zones. Surface and underground exploration in Perry, Springer, Beaver Lake zones.
Orchan Mines Limited, Matagami	1,900 (mills 900 tons of ore a day from New Hosco)	368,877 (369,272)	1.25	13.34	–	Partial changeover to cut-and-fill mining methods. Installation of hydraulic backfill system in mine and mill.

The Patino Mining Corporation, Copper Rand Division (Machin Point, Chibougamau Jaculet, Portage Island and Quebec Chibougamau Goldfields mines), Gouin Peninsula, Chibougamau	1,800 (treated in central mill and Machin Point mine)	663,251 (674,131)	2.25	–	–	Routine development and exploration.
Quemont Mining Corporation, Limited, Noranda	2,300	657,307 (752,691)	1.06	2.29	–	Routine exploration and development.
Rio Algom Mines Limited, Mines de Poirier mine, Poirier township	1,000	– (–)				Mill tune-up started in Dec.
Solbec Copper Mines, Ltd., Stratford Place	1,000	403,869 (424,127)	1.69	4.36	–	Routine exploration and development.
Sullico Mines Limited, East Sullivan Mine, Val d'Or	3,000	993,321 (988,023)	0.53	0.19	–	No new ore discovered. Mine scheduled to close in 1966.
Ontario						
Copperfields Mining Corporation Limited (Temagami mine), Timagami	200	55,922 (56,894)	6.97	–	–	Installed new hoist. Deepened shaft to 1,671 ft. below collar. Lateral work on 3 new levels to explore for more orebodies.
Falconbridge Nickel Mines, Limited (Falconbridge, East, Onaping, Hardy, Fecunis and North mines), Falconbridge	3,000 (Falconbridge) 1,500 (Hardy) 2,400 (Fecunis)	2,246,918 (1,960,000)	0.76	–	1.53	Development at depth in Falconbridge and East mines. North orebody developed for mining from Fecunis shaft. Shaft sinking and development at Strathcona mine; construction of 6,000-ton-a-day mill at Strathcona.
The International Nickel Company of Canada, Limited (Creighton, Frood-Stobie, Garson, Levack, Murray, Crean Hill, Clarabelle and MacLennan mines), Copper Cliff	30,000 (Copper Cliff) 12,000 (Creighton) 6,000 (Levack)	16,704,143 (14,007,969)	..	–	..	Sinking of shaft to 7,150 ft. below collar started at Creighton. MacLennan mine brought into production. Expansion of production at Stobie, preparation of Totten, Copper Cliff North, Kirkwood, Coleman and Little Stobie mines for production.
Kam-Kotia Porcupine Mines, Limited, Timmins	1,500	597,623 (638,000)	1.56	1.37	–	Development of new orebodies discovered by underground exploration. Continuation of underground drifting, diamond drilling to find further ore.
McIntyre–Porcupine Mines, Limited, Schumacher	1,500	549,310 (383,060)	0.93	–	–	Routine exploration and development. Mill will be enlarged in 1966 to treat 1,900 tons of copper ore a day.
Metal Mines Limited, Werner Lake Division, Gordon Lake	700	..	..	–	..	Routine development of main ore zone. Exploration of D zone on 1200- and 1350-ft. levels.
North Coldstream Mines Limited, Kashabowie	1,100	365,082 (366,950)	1.86	–	–	Routine exploration and mining.
Rio Algom Mines Limited, Pronto Division, Spragge	750	248,613 (256,226)	1.83	–	–	Deepening of shaft to 4,000-ft. level, development of orebody below 2,705-ft. level.

Table 3 (cont.)

Company and Location	Mill Capacity (tons ore/day)	Ore Produced 1965 (1964) (short tons)	Grade (%) Copper	Zinc	Nickel	Developments
Sheridan Geophysics Limited, Coppercorp mine, Batchawana	500	29,867 (–)	1.37	–	–	Mill built in 1965, production started Oct. 13.
Willecho Mines Limited, Manitouwadge	1,000 (treated at Willroy mill)		..	..	–	Production started in May. Routine exploration and development.
Willroy Mines Limited, Manitouwadge	1,500	293,989 (530,151)	0.70	5.00	–	Routine exploration and development of known ore on Willroy property. Continued exploration on Willecho and Big Nama Creek properties.
Manitoba						
Hudson Bay Mining and Smelting Co., Limited (Flin Flon, Chisel Lake, Schist Lake and Stall Lake mines), Flin Flon	6,000	1,640,328 (1,585,394)	2.64	4.30	–	Routine exploration and development at producing mines. Preparation of Osborne Lake and Anderson Lake mines for production.
Sherritt Gordon Mines, Limited, Lynn Lake	3,500	1,363,583 (1,362,693)	..	–	..	Continued exploration and development of the O and N zones.
Saskatchewan						
Anglo-Rouyn Mines Limited, Waden Bay	900	tune-up only	..	..	–	Initial development and mill construction completed in 1965. Production scheduled for 1966.
The Hudson Bay Mining and Smelting Co., Limited (Flin Flon and Coronation mines), Flin Flon, Manitoba.	(see Manitoba)					Coronation mine closed in Aug. when ore reserves were exhausted. Company preparing Flexar mine for production in 1966.
British Columbia						
The Anaconda Company (Canada) Ltd., Britannia Beach	4,000 (operating rate 1,600)	226,005 (444,757)	1.24	0.54	–	New copper precipitation plant at 2,200 level. Preparation for mining by open pit in Jane Creek Basin near 4,000-ft. elevation.
Bethlehem Copper Corporation Ltd., Highland Valley	6,000	1,964,042 (1,379,429)	0.73	–	–	Geophysical and geological exploration of own property. Mill capacity increased to 6,000 tons a day; proposed expansion in 1966 to 10,000 tons a day.
The Consolidated Mining and Smelting Company of Canada Limited, Coast Copper mine, Benson Lake, V.I.	750	292,196 (306,132)	..	–	–	Underground exploration on 4,700 level.

Cowichan Copper Co. Ltd., Sunro mine, Jordan River, V.I.	1,500	–	–	–	–	Mill and underground facilities rehabilitated, tune-up started.
Craigmont Mines Limited, Merritt	5,000	1,616,615 (1,874,321)	1.16	–	–	Continued mining in open pit, development of underground facilities. Mine idled by strike Oct. 1, 1965.
Giant Mascot Mines, Limited, Hope	1,250	330,954 (324,635)	0.34	–	0.76	Extensive exploration by drifting and diamond drilling discovered new orebodies in 1,500, 2,000 and 2,200 zones.
The Granby Mining Company Limited, Phoenix Division, Greenwood	2,000	703,420 (686,267)	0.80	–	–	Continued on-property exploration. Dryer installed, concentrate storage building constructed.
Mt. Washington Copper Co. Ltd., Courtenay, V.I.	1,000	..	..	–	–	Continued mining in open pit.

Source: Company reports.

Symbols: e Estimated; – Nil; .. Not available.

Production and development were continuous at the mines in the Matagami, Normetal, Noranda and Val d'Or areas of northwestern Quebec.

Near Belleterre, Lorraine Mining Company Limited started production at 400 tons a day from its nickel-copper orebody. Concentrates are shipped to The International Nickel Company of Canada, Limited at Copper Cliff, Ontario, for smelting.

ONTARIO

Increased production at the nickel-copper mines of the Sudbury district accounted for most of the rise in copper production in this province in 1965. Production of 219,183 tons valued at $163,860,900 was 21,266 tons and $32,402,105 more than in 1964.

In the Sudbury district, The International Nickel Company of Canada, Limited (INCO) brought the McLennan mine into production in 1965 and was preparing the Totten mine for production in 1966, the Coleman, Kirkwood and Copper Cliff North in 1967 and the Little Stobie (6,000 tons a day) by 1968. Production will be expanded at the Stobie mine and a 22,500-ton-a-day concentrator built to mill the ore from the Stobie and Little Stobie orebodies. A 7,150-foot vertical six-compartment shaft will be sunk at the Creighton mine to develop the orebody at depth. Improved roasting and matte cooling facilities at the smelter will allow treatment of the extra production. Falconbridge Nickel Mines, Limited is preparing the Strathcona orebody, on the north rim of the basin, for production in 1967. A 6,000-ton-a-day mill is under construction and the concentrates will be railed to Falconbridge. The company completed a new blast furnace at the smelter in January 1965.

Near Timmins, Kam-Kotia Porcupine Mines, Limited continued to find ore on its property and started deepening the mine shaft from 1,036 feet below the collar to about 2,000 feet. Stripping of the overburden from the orebody of Texas Gulf Sulphur Company in Kidd township was virtually completed and trial shipments of ore were made to the Kam-Kotia mill in the latter part of the year. Planned capacity of the Texas Gulf mill was increased from 6,000 to 9,000 tons of ore a day. Copper production is expected to average 50,000 tons a year. Canadian Jamieson Mines Limited was building a 400-ton-a-day mill and developing its mine in Jamieson township for production in 1966.

Other producing mines in Ontario included Noranda Mines Limited, Geco Division and Willroy Mines Limited at Manitouwadge; Copperfields Mining Corporation Limited at Timagami; North Coldstream Mines Limited at Kashabowie; Rio Algom Mines Limited, Pronto Division at Spragge and Metal Mines Limited's nickel-copper mine at Gordon Lake.

New mines brought into production included Sheridan Geophysics Limited's mine near Batchawana, brought into production at 500 tons a day in November and the Willecho orebody at Manitouwadge, brought into production by Willroy and Lun-Echo Gold Mines Limited in March.

A number of properties were under development including those of Tribag Mining Co., Limited near Batchawana, Munro Copper Mines Limited near Matheson, and Genex Mines Limited near Timmins.

MANITOBA

Production in Manitoba at 31,011 tons was 1,234 tons higher in 1965 than in 1964. Hudson Bay Mining and Smelting Co., Limited operated the Flin Flon mine at Flin Flon and the Chisel Lake, Stall Lake and Schist Lake mines near Snow Lake. The company has a central mill, a copper smelter and a zinc reduction plant at Flin Flon and was developing the Osborne Lake and Anderson Lake mines near Snow Lake for production.

At Lynn Lake, Sherritt Gordon Mines, Limited continued production, development and exploration at its nickel-copper mine and was preparing to sink a shaft at its Fox Lake zinc-copper deposit about 34 miles to the southwest.

SASKATCHEWAN

Most of the 19,236 tons of copper, valued at $14,465,309, produced in Saskatchewan in 1965 was from that portion of Hudson Bay's Flin Flon orebody lying in that province. The ore was milled at Flin Flon. Production in 1965 was 1,206 tons less than in 1964. Hudson Bay also operates the Coronation mine about 18 miles southwest of Flin Flon, and was developing the Flexar mine for production. Production from the Coronation mine ceased in August when the ore reserves were depleted.

Near Lac la Ronge, Rio Algom Mines Limited was developing the orebody at the Anglo-Rouyn mine for production and started the tune-up of the 900-ton-a-day mill. Concentrates will be trucked to Flin Flon for smelting.

BRITISH COLUMBIA

British Columbia and Saskatchewan were the only copper-producing provinces to show production decreases in 1965. A strike at the Craigmont mine near Merritt that started in October and lasted the rest of the year, production loss until April because of a strike at the Britannia mine, and the continued shutdown of the Sunro mine, were contributing factors to lower production in B.C.

The Anaconda Company (Canada) Ltd. started rehabilitation of the Britannia mine, 20 miles north of Vancouver, after settlement in March of the labour dispute. Preparations are under way to mine low-grade ore from the outcrop of the orebody in the Jane Creek basin nearly 4,000 feet above sea level. The ore will be trucked about 6 miles to the mill at sea level.

On Vancouver Island, production on a limited scale was resumed in December at the Sunro mine of Cowichan Copper Co. Ltd. at Jordan River. The mine had been closed by a flood in December 1963. Western Mines Limited at the south end of Buttle Lake was preparing its zinc-copper-lead orebody for production in 1966 and was building a 750-ton-a-day mill. Mt. Washington Copper Co. Ltd. at Courtenay and The Consolidated Mining and Smelting Company of Canada Limited at Benson Lake continued production.

Bethlehem Copper Corporation Ltd. was expanding its mill to treat 10,000 tons of ore a day in 1966. The mine is in the Highland Valley area about 26 miles west of Ashcroft. The Granby Mining Company Limited continued production from the Phoenix mine near Greenwood and was preparing the Granisle copper deposit on an island in Babine Lake for production in 1966 of 5,000 tons a day.

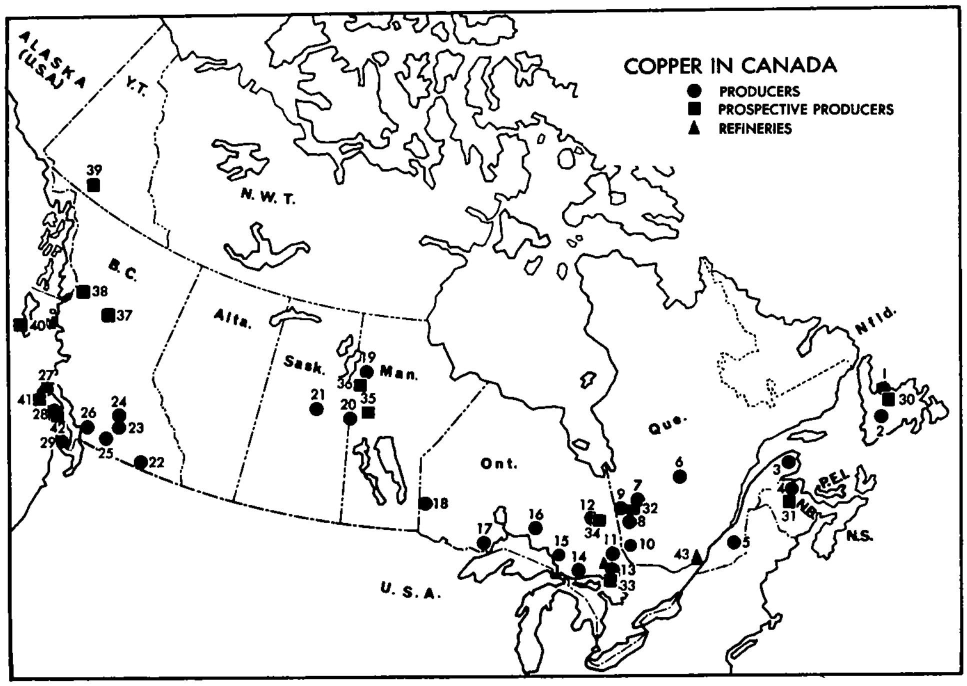
Other mines being developed include Granduc Mines, Limited on the Unuk River north of Stewart, scheduled for 7,000 tons a day in 1969; Falconbridge Nickel Mines, Limited's Wesfrob mine at Tasoo Harbour on Moresby Island, Queen Charlotte Islands, scheduled for

TABLE 4

Prospective Producing Companies*, 1965

Company and Location	Type of Ore	Mill Capacity (tons ore/day)	Production to Start	Destination of Concentrates
Newfoundland				
First Maritime Mining Corporation Limited, Gullbridge mine, Gull Pond	Cu	1,500	1966	..
New Brunswick				
Brunswick Mining and Smelting Corporation Limited, No. 6 mine, Bathurst	Zn,Pb,Cu	2,250 (at No. 12 plant)	1966	Europe and own smelters
Key Anacon Mines Limited, Larder U mine, Bathurst	Zn,Pb,Cu	1,000	1966	
Quebec				
Joutel Copper Mines Limited, Joutel tp.	Zn,Cu	700 (at mill of Mines de Poirier)	1966	..
Gaspé Copper Mines, Limited, Murdochville, Copper Mountain mine.	Cu	3,500 (at expanded mill of Gaspé Copper)	1966	Own smelter
Ontario				
Canadian Jamieson Mines Limited, Jamieson tp.	Cu	700	1966	Europe
Falconbridge Nickel Mines, Limited, Strathcona mine, Sudbury	Ni,Cu	6,000	1966-67	Own smelter
The International Nickel Company of Canada, Limited, Sudbury				
Totten mine	Ni,Cu	Treated at central mill	1966	Own smelter
Kirkwood, Coleman, Copper Cliff North and Frood-Stobie expansion	Ni,Cu	Central mill	1967	Own smelter
Little Stobie mine	Ni,Cu	22,500 (will also treat Frood-Stobie ore)	1968	Own smelter
Texas Gulf Sulphur Company, Ecstall mine, Kidd tp.	Zn,Cu,Ag	9,000	1966	Copper—Domestic smelters. Zinc, lead, silver—U.S.A., Europe.
Manitoba—Saskatchewan				
Hudson Bay Mining and Smelting Co., Limited, Flin Flon, Manitoba				
Flexar mine, Saskatchewan	Cu,Zn	Treated at	1966	Own smelter
Osborne Lake mine, Manitoba	Cu,Zn	Flin Flon mill	1966	
Anderson Lake			1968	
British Columbia				
Falconbridge Nickel Mines, Limited, Wesfrob mine, Tasoo Harbour, Q.C.I.	Fe,Cu	10,000	1966	Japan
The Granby Mining Company Limited, Granisle mine, Babine Lake	Cu	5,000	1966	Japan
Granduc Mines, Limited, Unuk River	Cu	7,000	1969	Tacoma, U.S.A.
Minoca Mines Ltd., Yreka mine, Alice Arm, V.I.	Cu	250	1966	Japan
Western Mines Limited, Buttle Lake, V.I.	Zn,Cu,Pb	750	1966	Export
Yukon Territory				
New Imperial Mines Ltd., Whitehorse Copperbelt	Cu,Fe	2,000	1967	Japan

Source: Company reports. *Includes only companies with announced production plans. .. Not known.



PRODUCERS

(numbers refer to numbers on map)

1. Atlantic Coast Copper Corporation Limited
   British Newfoundland Exploration Limited (Whalesback Pond)
   Consolidated Rambler Mines Limited
   First Maritime Mining Corporation Limited
2. American Smelting and Refining Company (Buchans unit)
3. Gaspé Copper Mines, Limited
4. Brunswick Mining and Smelting Corporation Limited
   The Consolidated Mining and Smelting Company of Canada Limited (Wedge mine)
   Heath Steele Mines Limited
5. Solbec Copper Mines, Ltd.
   Cupra Mines Ltd.
6. Campbell Chibougamau Mines Ltd. (4 mines)
   Merrill Island Mining Corporation, Ltd.
   Opemiska Copper Mines (Quebec) Limited
   The Patino Mining Corporation (Copper Rand Mines Division) (4 mines)
7. Mattagami Lake Mines Limited
   New Hosco Mines Limited
   Orchan Mines Limited
   Mines de Poirier inc.
8. Lake Dufault Mines, Limited
   Manitou-Barvue Mines Limited
   Noranda Mines Limited
   Quemont Mining Corporation, Limited
   Sullico Mines Limited (East Sullivan mine)
   Marbridge Mines Limited
9. Normetal Mining Corporation, Limited
10. Lorraine Mining Company Limited
11. Copperfields Mining Corporation Limited (Temagami mine)
12. Kam-Kotia Porcupine Mines, Limited
    McIntyre-Porcupine Mines, Limited
13. Falconbridge Nickel Mines, Limited (5 mines, 1 smelter)
    The International Nickel Company of Canada, Limited (8 mines, 2 smelters, 1 refinery)
14. Rio Algom Mines Limited (Pronto Division)
15. Sheridan Geophysics Ltd. (Coppercorp mine)
16. Noranda Mines Limited, Geco Division
    Willecho Mines Limited
    Willroy Mines Limited
17. North Coldstream Mines Limited
18. Metal Mines Limited
19. Sherritt Gordon Mines, Limited
20. Hudson Bay Mining and Smelting Co., Limited (5 mines, 1 smelter)
21. Anglo-Rouyn Mines Limited
22. The Granby Mining Company Limited (Phoenix Division)
23. Craigmont Mines Limited
24. Bethlehem Copper Corporation Ltd.
25. Giant Mascot Mines, Limited
26. The Anaconda Company (Canada) Ltd. (Britannia Division)
27. The Consolidated Mining and Smelting Company of Canada Limited (Coast Copper mine)
28. Mt. Washington Copper Co. Ltd.
29. Cowichan Copper Co. Ltd. (Sunro mine)

PROSPECTIVE PRODUCERS

30. First Maritime Mining Corporation Limited (Gullbridge mine)
31. Brunswick Mining and Smelting Corporation Limited (No. 6 mine)
    Key Anacon Mines Limited
32. Joutel Copper Mines Limited
33. Falconbridge Nickel Mines, Limited (Strathcona mine)
    The International Nickel Company of Canada, Limited (4 mines, 1 mill)
34. Texas Gulf Sulphur Company
    Canadian Jamieson Mines Limited
35. Hudson Bay Mining and Smelting Co., Limited (Osborne and Anderson Lake mine)
36. Sherritt Gordon Mines, Limited (Fox Lake mine)
37. The Granby Mining Company Limited (Granisle Mine)
38. Granduc Mines, Limited
39. New Imperial Mines Ltd.
40. Falconbridge Nickel Mines, Limited (Wesfrob mine)
41. Minoca Mines Ltd.
42. Western Mines Limited

REFINERIES

13. The International Nickel Company of Canada, Limited
43. Canadian Copper Refiners Limited.

10,000 tons a day of iron-copper ore in 1966; and Minoca Mines Ltd.'s Yreka mine on Alice Arm, Vancouver Island, scheduled for production in 1966 of 250 tons a day.

The search for large deposits of copper suitable for open-pit mining accelerated during the year. Exploration, geophysical surveying and diamond drilling were being carried out in northwestern B.C. in the Stikine River area, in the Highland Valley-Kamloops area, and in the vicinity of Peachland in the Okanagan.

YUKON TERRITORY

New Imperial Mines Ltd. continued exploration of its ground in the Whitehorse copperbelt. At the year's end a letter-of-intent was signed by the company with a Japanese firm that would supply funds to put the property into production and build a 2,000-ton-a-day mill.

SMELTERS AND REFINERIES

Salient statistics on Canada's six copper smelters and two refineries are given in Tables 5 and 6. The International Nickel Company of Canada, Limited at Copper Cliff, Ontario, has increased its oxygen manufacturing capacity from 325 to 1,100 tons a day and is changing from multihearth to fluid-bed roasters in the smelter. These changes will enable the plant to treat the increased production from the planned mine expansion.

WORLD MINE PRODUCTION

Mine production in the Free World set a record of 3,934,398* tons in 1965, 151,078 tons more than in 1964. This record was set despite production losses by strikes in Canada and Chile and supply interruptions in Zambia. The Free World's five major producers contributed the major increases in production with 1965 output estimated as follows (1964 output in brackets): United States 1,361,688 tons (1,251,475); Zambia 750,000 tons (704,436); Chile 625,000 tons (684,298); Canada 517,247 tons (486,900) and Congo 316,800 tons (303,700).

Free World mine production should increase by about 300,000 tons in 1966 as follows: Canada 50,000 tons; United States 120,000; South America 30,000; Africa 50,000 and other countries 50,000 tons.

CONSUMPTION AND USES

World copper consumption continued to advance in 1965. A slowing in the rate of increase of consumption in Europe and Japan was more than offset by an increased rate in Canada and the United States. Demand again exceeded supply and inventories continued to decline.

Free World consumption of primary refined copper was estimated at 4,600,000 tons in 1965, about 150,000 tons more than in 1964. Domestic consumption of refined copper in Canada in 1965 was 225,185 tons, 22,960 tons more than in 1964.

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 of Canada Limited, London; in Quebec – Noranda Copper Mills Ltd., Eastern Division, Montreal East, Pirelli Cables Limited, St. Johns, and Northern Electric Company, Limited, Montreal.

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*This total excludes production from Japan, Norway, Sweden, Finland, The Messina mine in Transvaal and the production from several small countries from which reports are not available.

TABLE 5

Canadian Copper and Copper-Nickel Smelters

Operator and Location	Product	Rated Annual Capacity (short tons)	Remarks	Ore and Concentrate Treated, 1965 (short tons)	Blister or Anode Copper Produced, 1965 (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	456,437	..
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.	243,000 (of which 60,400 were custom concentrates)	42,800
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.	386,879 (of which 14,412 were custom concentrates)	40,539
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. Electric-furnace melting of copper sulphide and conversion to blister copper.	..	..
Noranda Mines Limited, Noranda, Que.	Copper anodes	1,900,000 (ores and concentrates and scrap)	Roasting furnaces, 2 hot-charge reverberatory furnaces, 1 green-charge reverberatory furnace, 5 converters. Also smelts custom material.	1,725,200 (of which 722,900 were custom material)	183,350

Source: Company reports.

TABLE 6

Canadian Copper Refineries

Canadian Copper Refiners Limited, Montreal East, Que.	The International Nickel Company of Canada, Limited, Copper Refining Division, Copper Cliff, Ont.
CCR brand electrolytic copper wire bars, ingot bars, ingots, cathodes, cakes and billets	ORC brand electrolytic copper, cathodes, wire bars, cakes, billets, ingots and ingot bars
Rated annual capacity: 284,000 tons	Rated annual capacity: 168,000 tons
Controlled by Noranda Mines Limited. 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.	Refining of blister copper from Copper Cliff smelter. Also custom refining. Precious metals, selenium and tellurium are recovered from anode slimes.

Source: Company reports.

TABLE 7

Consumption of Primary Copper in Manufacture of Semifabricated Products, 1963-64

(short tons)

	1963	1964
Copper mill products – sheet, strip, bars, rolls, pipe, tube, etc.	52,863	63,076
Brass mill products – plate, sheet, strip, rods, bars, rolls, pipe, tube, etc.	6,665	10,350
Wire and rod mill products	110,031	109,474
Miscellaneous	1,150	2,144
Total	170,709	185,044

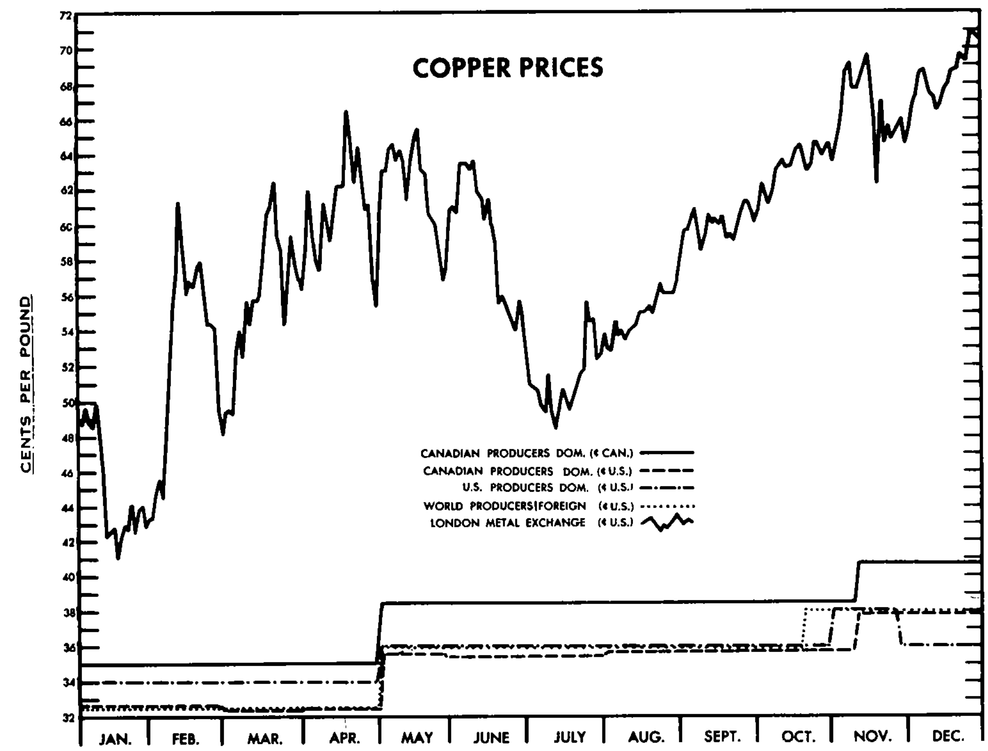
PRICES

The wide discrepancy between the producers' European price and the free market price on the London Metal Exchange continued and became greater in 1965. Despite a determined effort by the producers to hold the price of copper down, the producers' price in offshore markets was raised twice during the year, rising from 32.50 cents (U.S.) a pound in January to 36 cents in May and to 38 cents by mid-October. The United States domestic producers' price, which started the year at 34 cents a pound was raised to 36 cents at the beginning of May. An attempt was made to raise the United States domestic price to 38 cents in November but this level was not maintained when the United States government put export restrictions on copper, announced a release of 200,000 tons of copper from the strategic stockpile and also asked for suspension of the import tariff of 1.7 cents a pound on copper.

The London Metal Exchange price, which opened the year at 49 cents (U.S.) a pound, rose by erratic stages to a high of 70 cents in December.

The Canadian domestic price, which was 35 cents (Can.) a pound at the beginning of the year, followed the price rises in the European market and at the year end was 40.75 cents (Can.) a pound.

Two new developments occurred in world pricing in 1965. The first development occurred in May when the Canadian and foreign producers' prices, which had traditionally reflected the United States price less the 1.7 cents a pound duty, moved to a position equivalent to the United States price; the duty was added to the U.S. buyer's account when importing copper. The second development was the introduction of political influence on copper prices. The price rises in May and October were brought about by Chile when that country announced an increase in the selling price of Chilean copper. The United States government also exerted influence on copper prices by actions that forced a return to 36-cent copper in that country.



SOURCE: AMERICAN METAL MARKET

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, rods, wire, semifabricated forms and fully processed products entering the country. Table 8 summarizes the Canadian tariff rates on copper and its products.

The United States tariff on copper entering the country in ores, concentrates and primary shapes is 1.7 cents a pound on copper content. On fabricated products an ad valorem duty that varies with the type of product is added to the tariff of 1.7 cents a pound on copper content.

TABLE 8
Canadian Tariffs

	British Preferential	Most Favoured Nation	General
Ores, concentrates	free	free	free
Pigs, blocks, ingots, cathodes	3/4¢ lb	3/4¢ lb	3/4¢ lb
Scrap	3/4¢ lb	3/4¢ lb	1.5¢ lb
Anodes	5%	7.5%	10%
Oxides	free	15%	15%
Bars or rods; tubing not less than 6 ft. long, unmanufactured; copper in sheets, strips or plates, not polished, planished or coated	5%	10%	10%
Bars and rods for manufacture of wire and cable	free	10%	10%
Tubing not more than 1/2 in. in dia. and not less than 6 ft. long	5%	10%	10%
Alloys of copper consisting 50% or more by weight of copper in sheets, plates, bars, rods, tubes	7.5%	15%	15%

Feldspar

J. E. REEVES*

Canada's only producer of feldspar, International Minerals & Chemical Corporation (Canada) Limited, shipped an estimated 10,830 short tons in 1965, appreciably more than in 1964. The feldspar was mined in a large, very coarse-grained granitic pegmatite in Derry Township, Quebec, was hand-cobbed at the mine site and fine-ground in the company's mill at Buckingham. The main market was the ceramics industry in southern Ontario and in northern New York State. Exports increased by a little more than 10 per cent. Some feldspar was imported into western Canada, but the amount is not recorded separately.

The Canadian feldspar industry has declined appreciably since 1951, when more than 40,000 tons were shipped. The loss of the glass market and the decrease in the amount of Canadian feldspar used in whitewares, enamels and cleansers have combined to contribute to this decline. There is little reason to anticipate any significant improvement in the near future.

TECHNOLOGY

Feldspar is the general term for a group of related aluminum silicates of potassium, sodium and calcium. Feldspar containing potassium and sodium is of value to the ceramics industry as a source of alumina (Al_2O_3), potash (K_2O) and soda (Na_2O), and for its relatively low firing temperature; it is of some use to manufacturers of cleaning compounds because it is moderately abrasive. High-calcium feldspar, in the form of anorthosite or as pieces of labradorite, is in some demand for building and decorative purposes but is not included in Canadian feldspar statistics.

Potash and soda feldspar occur widely in many types of rock but commercially in only a few with a high feldspar content. Very coarse-grained granitic pegmatites, with the feldspar concentrated in zones, have been the most common commercial sources. The feldspar from such sources is hand-cobbed to remove excess quartz and various other unwanted minerals, and is ground and classified. Nearly all Canadian feldspar has been mined from such pegmatites, which are relatively common in southeastern Ontario and southwestern Quebec.

Elsewhere, the depletion of many of these deposits and the need for mechanized high-tonnage operations, have led to the development of pegmatites or other highly feldspathic rocks in which rich zones of coarse-grained feldspar do not occur, and to bulk handling of mixtures composed of feldspar, quartz and small quantities of other minerals. The feldspar is concentrated mechanically, usually by flotation.

The acceptance of feldspathic substitutes for traditional feldspar has adversely affected the growth of the feldspar industry. Nepheline syenite from Ontario has been substituted by glass manufacturers because of its comparatively higher content of alumina; aplite, a feldspathic byproduct of titanium mineral operations in Virginia, is also used in some types of glass as a relatively cheap source of alumina; and controlled feldspar-silica mixtures have become acceptable in glass and certain clay ware.

*Mineral Processing Division, Mines Branch

TABLE 1

Feldspar — Production, Trade and Consumption, 1964-65

	1964		1965P	
	Short Tons	$	Short Tons	$
Production (shipments)	9,149	212,052	10,830	241,621
Exports				
United States	3,376	79,525	3,746	86,815
Other countries	10	901	—	—
Total	3,386	80,426	3,746	86,815
	1963		1964	
Consumption, available data				
Whiteware	4,800		6,715	
Porcelain enamel	191		189	
Cleaning compounds	411		548	
Other	607		41	
Total	6,009		7,493	

Source: Dominion Bureau of Statistics.
Symbols: P Preliminary; — Nil.

TABLE 2

Feldspar — Production and Trade, 1956-65

(short tons)

	Production	Imports	Exports
1956	18,153	196	1,804
1957	20,450	241	4,047
1958	20,387	1,140	9,956
1959	17,953	1,161	7,552
1960	13,862	1,338	3,183
1961	10,507	1,721	2,626
1962	9,994	1,901	3,698
1963	8,608	2,600	3,282
1964	9,149	..	3,386
1965P	10,830	..	3,746

Source: Dominion Bureau of Statistics.

Symbols: P Preliminary; . .Not available.

USES AND SPECIFICATIONS

Feldspar is sold mainly to the ceramics industries. Where it can compete economically with nepheline syenite it is still used extensively as a source of alumina, soda and potash in the manufacture of glass. The size specification requires a relatively coarse particle, generally with an upper limit of 20 mesh. The iron content should be less than 0.1 per cent ferric oxide (Fe_2O_3).

Feldspar is important as a flux in the manufacture of whiteware bodies and glazes. It must be essentially minus 325 mesh, have a very low quartz and iron-mineral content and, in many cases, contain a high potash-soda ratio. A low iron content (less than 0.1 per cent Fe_2O_3) will generally ensure a white fired product.

In the manufacture of porcelain enamels, feldspar is a source of alumina, potash and silica. It must be at least minus 120 mesh, have a very low iron content and fire white.

Dental spar is a selected high-purity potash feldspar for use in the manufacture of artificial teeth. Freedom from iron-bearing minerals, which would cause specks in the final products, is important.

For cleaning compounds, feldspar should be white and free of quartz.

PRICES AND TARIFFS

According to *E & M J Metal and Mineral Markets* of November 15, 1965, prices in the United States, f.o.b. point of shipment, North Carolina, in bulk, per short ton, were:

mesh	
200	$17.50 to $21
325	18.50 to 23
40, glass	13.50 to 15
20, semigranular	10.00 to 12

Prices and Tariffs (cont.)

Canadian and United States feldspar tariffs in effect at the time of writing were:

	British Preferential	Most Favoured Nation	General
Canada			
Crude only	free	free	free
Ground but not further manufactured	free	15%	30%

United States

Crude	12½ ¢ per long ton
Ground	7½% ad val.

Fluorspar

J.E. REEVES*

In 1965, Canadian production of fluorspar (the common commercial term for the mineral fluorite) increased appreciably. The principal source was St. Lawrence, Newfoundland, where Newfoundland Fluorspar Limited, a subsidiary of Aluminium Limited, operates the Director mine. It ships a partially concentrated product to another subsidiary, Aluminum Company of Canada, Limited, at Arvida, Quebec. As reported in the annual report for 1965 of Aluminium Limited, 112,000 short tons were shipped during the year. Pacific Silica Limited produced a small amount of metallurgical-grade fluorspar as a byproduct of its silica operations in British Columbia.

Exports consisted of a small quantity of optical-grade fluorspar to Britain.

Canada imported 69,848 short tons of fluorspar worth more than $2.1 million, virtually unchanged from the record high in 1964. Mexico is the principal source, although the United States and Britain increased their shipments to Canada in 1965. Imports are mainly of metallurgical grade.

Aluminum Company of Canada, Limited, at Arvida upgrades the fluorspar concentrate from Newfoundland and processes it to make artificial cryolite (sodium aluminum fluoride) for use in the reduction of alumina to aluminum. Allied Chemical Canada, Ltd., imports acid-grade fluorspar and produces hydrofluoric acid at Valleyfield. Some of this acid is consumed in the manufacture of fluorocarbons for use as aerosol propellants and refrigerants. At North Brook, Ontario, Huntingdon Fluorspar Mines Limited produces a 5-pound briquette from imported metallurgical-grade fluorspar, for use in foundries. At Port Maitland, Ontario, Electric Reduction Company of Canada, Ltd., produces fluorosilicic acid as a byproduct of phosphate rock processing, for use in fluoridating water.

Consumption in Canada continued to increase in all markets. The growing demand for fluorocarbon products especially, but also aluminum and steel, indicates a growing need for fluorine-bearing raw materials, at present almost exclusively fluorspar. The probable attendant price increase should make several Canadian deposits of possible commercial value.

*Mineral Processing Division, Mines Branch

TABLE I

Fluorspar — Production, Trade and Consumption

	1964		1965P	
	Short Tons	$	Short Tons	$
Production (shipments)				
Newfoundland	..	2,254,060	..	2,544,000
British Columbia	..	4,736	..	2,419
Total		2,258,796		2,546,419
Exports				
Britain	..	5,625*		9,575*
Imports				
Mexico	58,515	1,653,323	54,785	1,587,655
United States	9,882	344,028	11,776	390,873
Britain	1,589	63,326	3,287	121,907
Total	69,986	2,060,677	69,848	2,100,435
	1963		1964	
Consumption (available data)				
Metallurgical flux	43,663		45,600	
Glass	1,999		2,851	
Other, including aluminum production	97,178		107,377	
Total	142,840		155,828	

Source: Dominion Bureau of Statistics.
*Shipments of clear crystal for optical use.
P — Preliminary; .. Not available.

TABLE 2

Fluorspar — Production, Trade and Consumption, 1956–65

(short tons)

	Production[1]	Exports	Imports	Consumption
1956	140,071	78,380	28,148	96,126
1957	66,245	23,630	14,547	70,761
1958	62,000[2]	7	30,408	89,933
1959	74,000[2]	3,774	26,588	96,016
1960	77,000[2]	10,312	59,690	111,835
1961	78,600[3]	2,048	32,769	111,542
1962	77,700[3]	4	67,847	123,694
1963	85,000[3]	4	66,798	142,840
1964	96,000[3]	..	69,986	155,828
1965P	112,000[3]	..	69,848	

Source: Dominion Bureau of Statistics except where otherwise indicated.

[1] Producers' shipments. Tonnage statistics after 1957 not available for publication. [2] Estimates reported by U.S. Bureau of Mines. [3] Shipments reported in annual reports of Aluminium Limited.

P Preliminary; .. Not available.

TABLE 3

World Production of Fluorspar

(short tons)

	1963	1964	1965[e]
Mexico	530,893	687,917	700,000
U.S.S.R.	330,000	330,000	..
France	160,307	242,508	..
China	220,000	220,000	..
United States	199,948	217,137	225,000
Britain	84,878	171,960	..
Spain	169,094	161,135	..
Italy	137,232	136,723	140,000
Canada	85,000	95,000	100,000
West Germany	95,843	86,098	90,000
Other countries	326,805	421,522	..
Total	2,340,000	2,770,000	2,855,000

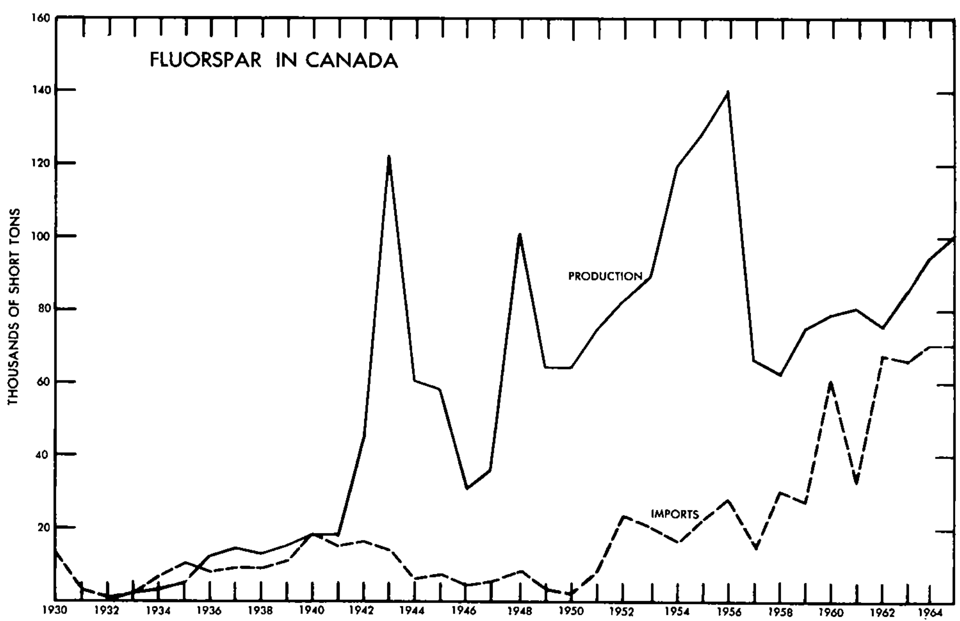
Source: U.S. Bureau of Mines *Minerals Yearbook, 1964* and U.S. Bureau of Mines *Commodity Data Summaries*, January, 1966.

[e] Estimate; .. Not available

CANADIAN RESOURCES

Fluorspar has been produced from deposits in Newfoundland, Nova Scotia, Ontario and British Columbia, but the only significant source at present is in Newfoundland. The deposits, consisting of veins and zones of stringers in a granitic rock, are located near the village of St. Lawrence in the Burin Peninsula. They have been the source of about 1.9 million tons of fluorspar. Newfoundland Fluorspar Limited has continuously shipped a heavy media concentrate to Arvida since 1940. St. Lawrence Corporation of Newfoundland Limited produced metallurgical and acid grades from 1933 to 1957, but found difficulty in competing for markets. Reserves are believed to be substantial. Newfoundland Fluorspar recently obtained control of the deposits and surface plant of St. Lawrence Corporation in this area.

Veins near the village of Madoc in southeastern Ontario yielded metallurgical-grade fluorspar almost consistently from 1910 to



1961. Yearly production varied fron nil in 1926 to 1928 to more than 11,000 tons in 1948. Total production is estimated at 120,000 tons. The several small mines were operated sporadically on a small scale and to shallow depths onlv because of water and financial problems. Considerable amounts of potential ore probably exist at greater depths in the area.

From 1940 to 1949, about 1,400 tons of fluorspar were produced from veins near Lake Ainslie on Cape Breton Island, for metallurgical use. Recent drilling on two deposits has reportedly indicated more than 2 million tons containing an average of 48.5 per cent barite and 14.5 per cent fluorite.

Fluorspar was produced at the Rock Candy mine in British Columbia from 1918 to 1925, in 1929 and in 1942. Substantial reserves probably remain, but the markets have been inadequate. The property of Rexspar Minerals & Chemicals Limited, beside the Canadian National Railways line at Birch Island, B.C., has been shown by diamond drilling and surface exposure to contain a large medium-grade fluorite deposit that is amenable to low-cost open-pit mining. The fluorite is difficult to concentrate to an acceptable grade because of its fine grain size, but processing tests have been encouraging. An increase in fluorspar prices would greatly assist development. Shallow flat-lying deposits along the Liard River in northern British Columbia appear to contain a large amount of fluorite, but their remote location and the high cost of transportation make them currently uneconomical.

The tin-base metal deposit of Mount Pleasant Mines Limited in New Brunswick contains some fluorite that may be recoverable as a byproduct.

WORLD REVIEW

The continuously increasing use of aluminum, steel, and fluorine chemicals and chemical products has led to a rising world consumption of fluorspar. Consumption in the United States may have reached 950,000 short tons in 1965, compared with 898,414 tons in 1964 and 736,350 tons in 1963. Of particular importance is the growth in its consumption in the fluorine chemical industry, especially for making fluorocarbon aerosols, refrigerants and plastics. The use of fluorocarbon products should continue to grow in volume and diversity of application, in North America and in Europe.

There is no present shortage of fluorspar on a world-wide basis, but the demand is supplied by relatively few large sources, and much long-distance shipping is required. As demand grows, price increases should become inevitable to assure a supply, and lower-grade deposits in many countries may become important. Unless another source of fluorine develops dramatically, as could occur with the emergence of large-scale recovery of byproduct fluorine in the processing of phosphate rock, the future of fluorspar is strongly optimistic.

The growing acceptance by steelmakers of pelletized instead of lump fluorspar may also lead to the development of deposits not currently of commercial value, from which the ore must be fine-ground to concentrate the fluorite adequately. A producer of pelletized fluorspar could also serve the market for acid-grade by further beneficiation of the concentrate used to make metallurgical-grade pellets.

USES AND SPECIFICATIONS

Fluorspar is consumed principally in two ways: as a flux in certain metallurgical and ceramics operations, and as a source of fluorine for chemicals and chemical products.

In the steel industry, fluorspar is used as a flux to assist the melting of the furnace charge and to improve the separation of metal and slag. It has proved to be one of the most efficient fluxes. Metallurgical-grade fluorspar for this use is usually sold on the basis of a minimum of 85 per cent fluorite (CaF_2) and a maximum of 5 per cent silica (SiO_2) and 0.3 per cent sulphur, and in lump form essentially between 2 inches and 3/8 inch, with no more than 15 per cent fines. Fluorspar is also used as a flux in foundries and in the making of magnesium.

Ceramic-grade fluorspar, mainly for use in glass and enamels, is purer and used in powdered form. The grade specification requires a minimum of 94 per cent CaF_2, and a maximum of 3.5 per cent calcium carbonate ($CaCO_3$), 3 per cent SiO_2 and 0.1 per cent iron (in terms of ferric oxide, Fe_2O_3).

Fluorspar is the most suitable source material for the flux used in the Hall electrolytic process of producing aluminum. It is converted to hydrofluoric acid, which is used to make artificial cryolite, the principal flux for melting alumina in the Hall cell. A small amount of fluorspar is used directly in the melt.

Fluorspar is the principal raw material for the fluorine chemicals industry, including the manufacture of hydrofluoric acid, fluorine gas, and fluorine chemicals and derivatives. Fluorine chemicals are used for uranium processing, the alkylation of gasoline and the production of high-energy missile fuels. Hydrofluoric acid and fluorine are used for the manufacture of refrigerants, aerosol propellants, chemicals and numerous fluorocarbon plastic intermediate and consumer articles.

Acid grade has the most rigid specifications. It must contain more than 97 per cent CaF_2 and not more than 1 per cent SiO_2. It is used in a fine particle size.

Fluorosilicic acid, sodium fluoride and, to a slight extent calcium fluoride are used to fluoridate public water supplies.

PRICES

Early in 1965 the price in Canada quoted by Aluminum Co. of Canada was $61.50, per net ton, f.o.b. Arvida, Que., ceramic grade, in bulk, coarse. Specifications were CaF_2 94.0% min., with $CaCO_3$ 4.6% max., SiO_2 2.6% max., and Fe_2O_3 2% max.

According to *E & MJ Metal and Mineral Markets* of December 13, 1965, U.S. prices were as follows per short ton, f.o.b. Illinois, Kentucky, bulk:

Metallurgical	
72½% CaF_2	\$37 – \$39
70% CaF_2	35 – 37
60% CaF_2	32 – 34
Pellets, 70% CaF_2	44
Acid, dry basis, 97% CaF_2	
Carload	45
Less than carload	50
Bags, extra \$3	
Wet filter cake, 8–10% moisture, sold dry content, subtract approx. \$2.50	
Pellets, carload lots	
No. 1	55
No. 2	47
No. 3	44
Less than carload lots, add \$5	
Ceramic, calcite and silica variable	
Fe_2O_3 max. 0.14%	
88–90% CaF_2	41
93–94% CaF_2	42
95–96% CaF_2	43
In 100-lb paper bags, extra \$3	

TARIFFS

Canada – free

United States

Fluorspar, by weight of calcium fluoride, per long ton	
containing over 97%	\$2.10
containing not over 97%	8.40

Gold

W.J. BEARD*

Gold production in Canada suffered a sharp decrease in 1965, a continuance of the trend which has prevailed since a postwar high output of 4,628,911 ounces valued at $157,151,527 was attained in 1960. Production in 1965 totalled 3,614,548 ounces valued at $136,376,896 compared with 3,835,454 ounces worth $144,788,388 in 1964. The average Royal Canadian Mint price per fine troy ounce of gold was $37.73 in 1965, slightly below the 1964 average of $37.75.

Production in 1965 was about 5.7 per cent lower in weight than in 1964 and 21.9 per cent down from 1960. Canada's all-time high of 5,345,179 ounces valued at $205,789,392 was recorded in 1941. The auriferous-quartz or lode gold mining industry bore the brunt of the decline as production by this segment dropped 6.2 per cent from that of 1964.

Ontario was the principal producer with 53.8 per cent of the total and Quebec was in second place with 25.3 per cent. The Northwest Territories produced 12.5 per cent and British Columbia 3.3 per cent.

World gold production in 1964 totalled 46,125,000 ounces as estimated by the United States Bureau of Mines. In 1963, production was 44,231,000 ounces. The Republic of South Africa produced 63.2 per cent of the 1964 total or 29,136,542 ounces. Canada with 3,835,454 ounces was in third position behind the U.S.S.R. which produced an estimated 5,600,000 ounces.

Most Canadian lode gold mines continued to receive cost assistance under the Emergency Gold Mining Assistance Act. Ten of the 54 lode mines which operated in 1965 did not apply for assistance for various reasons. The Act, which is designed to assist the marginal gold mines to meet rising costs of operation and thus help to maintain existing gold-mining communities, runs to the end of calendar year 1967.

The gold mines continue to experience economic difficulty, notwithstanding cost assistance, as the costs of gold recovery maintain an upward trend. Eight lode gold mines closed during 1965 mainly due to the exhaustion of ore reserves. Four mines commenced production and two small mines operated on an intermittent scale.

*Mineral Resources Division

TABLE 1

Production of Gold, 1964-65
(troy ounces)

	1964	1965p
Newfoundland		
Base-metal mines	16,717	25,491
Nova Scotia		
Auriferous-quartz mines	63	8
New Brunswick		
Base-metal mines	1,623	1,691
Quebec		
Auriferous-quartz mines		
Bourlamaque-Louvicourt	273,902	247,537
Malartic	222,156	205,354
Chibougamau	9,949	43,887
Noranda	12,456	39,076
Miscellaneous	75	8
Total	518,538	535,862
Base-metal mines	415,952	377,683
Placer operations	279	442
Total	934,769	913,987
Ontario		
Auriferous-quartz mines		
Kirkland Lake	238,966	170,225
Larder Lake	267,976	223,450
Matachewan	–	1,659
Porcupine	981,246	889,691
Red Lake & Patricia	447,375	445,813
Sudbury	32,035	37,421
Thunder Bay	127,280	80,154
Kenora-Rainy River	2,674	79
Miscellaneous	46	892
Total	2,097,598	1,849,384
Base-metal mines	57,772	97,432
Total	2,155,370	1,946,816
Manitoba-Saskatchewan		
Auriferous-quartz mines	24,969	28,773
Base-metal mines	91,105	87,398
Total	116,074	116,171
Alberta		
Placer operations	200	59
British Columbia		
Auriferous-quartz mines	70,719	93,742
Base-metal mines	41,916	44,755
Placer operations	587	1,462
Total	113,222	139,959
Yukon Territory		
Base-metal mines	–	1,132
Placer operations	43,271	56,712
Auriferous-quartz mines	972	–
Total	44,243	57,844
Northwest Territories		
Auriferous-quartz mines	452,816	412,879
Canada		
Auriferous-quartz mines	2,934,730	3,151,593
Base-metal mines	635,318	625,349
Placer operations	44,500	58,512
Total	3,614,548	3,835,454
Total value	$136,376,896	$144,788,388
Average value per ounce	$37.75	$37.73

Source: Dominion Bureau of Statistics.
p Preliminary and partially estimated by author.

OPERATIONS AT PRODUCING MINES

ATLANTIC PROVINCES

Gold production in the Atlantic provinces is derived mainly as a byproduct of base-metal mining although a small amount is obtained intermittently from auriferous-quartz mining in Nova Scotia. In 1965, production increased to about 27,190 ounces from 18,403 ounces in 1964. The base-metal mines of Newfoundland, particularly Consolidated Rambler Mines Limited which commenced production in 1964, accounted for the increase.

QUEBEC

Gold production declined 2.2 per cent from 1964. Fourteen lode gold mines operated, two more than in 1964. Two mines commenced production in 1965 and three closed. Lode gold production was higher while byproduct gold from base-metal mining decreased.

Auriferous-Quartz Mines

Bourlamaque-Louvicourt District – Four gold mines operated during 1965; Bevcon Mines

Limited closed in October. Sigma Mines (Quebec) Limited produced about the same as in 1964 but production at Lamaque Mining Company Limited (Lamaque Division) and Sullivan Consolidated Mines, Limited was noticeably lower.

Malartic District — Production from this area was considerably less due to mine closures early in 1965 of Canadian Malartic Gold Mines Limited and Malartic Gold Fields Limited. A new producer, Camflo Mattagami Mines Limited, was a sizable contributor following its commencement of operations in March. Three of the remaining four mines in the area — Barnat Mines Ltd., East Malartic Mines, Limited and Marban Gold Mines Limited — produced less. Norlartic Mines Limited, which anticipates closure in 1966, produced slightly more.

Chibougamau District — The only lode gold producer in this area, Norbeau Mines (Quebec) Limited, experienced its first full year of production after starting operations in 1964. Production was much higher.

Noranda District — Wasamac Mines Limited began production early in the year and was responsible for a large increase in this area's output. Peel-Elder Limited, the only other producer, saw output decline, and the mine is expected to close in 1966.

Base-Metal Mines

The base-metal mines of the province, principally the copper producers in the Noranda and Chibougamau areas, produced about 41.3 per cent of Quebec's total gold in 1965. Although copper production in 1965 increased substantially, byproduct gold output was lower.

ONTARIO

Thirty-one lode gold mines operated in the province in 1965 but two of the operations were small and intermittent. Four mines closed during the year and two commenced production. Output was about 9.7 per cent lower.

Auriferous-Quartz Mines

Kirkland Lake District — Five lode gold mines operated in 1965 but Wright-Hargreaves Mines, Limited and Lake Shore Mines, Limited closed during the year. Lake Shore will continue to

TABLE 2

World Gold Production, 1963-64

(troy ounces)

	1963	1964
North America		
Canada	4,003,127	3,835,454
United States (including Alaska)	1,468,750	1,469,000
Mexico	237,948	209,976
Nicaragua	204,769	211,900
Other countries	12,406	12,670
Total	5,927,000	5,739,000
South America		
Colombia	324,514	364,991
Brazil	131,979	134,326
Peru	101,019	85,809
Chile	77,290	65,620
Other countries	215,198	111,254
Total	850,000	762,000
Europe		
U.S.S.R.	5,100,000	5,600,000
Sweden	128,600	124,000
Yugoslavia	83,656	93,687
Other countries	487,744	582,313
Total	5,800,000	6,400,000
Asia		
Philippines	376,000	425,770
Japan	262,142	252,094
Korea (including North Korea)	250,095	235,779
India	138,280	147,958
Other countries	113,477	98,399
Total	1,140,000	1,160,000
Africa		
Republic of South Africa	27,431,573	29,136,542
Ghana	921,255	864,917
Southern Rhodesia	566,277	575,386
Republic of the Congo	214,574	125,742
Other countries	236,321	227,413
Total	29,370,000	30,930,000
Oceania		
Australia	1,022,965	963,300
Fiji	107,262	100,493
New Guinea	43,552	38,934
Other countries	14,253	8,991
Total	1,188,032	1,111,718
World total (estimate)	44,275,000	46,103,000

Source: U.S. Bureau of Mines Preprint, *Gold, 1964*. For Canada, Dominion Bureau of Statistics.

GOLD PRODUCERS AND PROSPECTIVE PRODUCERS, 1965

(Numbers refer to numbers on the map)

Newfoundland

1. Atlantic Coast Copper Corporation Limited (a)
   Consolidated Rambler Mines Limited (a)
   First Maritime Mining Corporation Limited (a)
2. American Smelting and Refining Company (Buchans Unit) (a)

New Brunswick

3. The Consolidated Mining and Smelting Company of Canada Limited (Wedge Mine) (a)
   Heath Steele Mines Limited (a)

Quebec

4. Gaspé Copper Mines, Limited (a)
5. Solbec Copper Mines, Ltd. (a)
   Cupra Mines Ltd. (a)
6. New Calumet Mines Limited (a)
7. *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)
8. The Coniagas Mines, Limited (a)
9. *Noranda-Rouyn District*
   Lake Dufault Mines, Limited (a)
   Noranda Mines Limited (a)
   Peel-Elder Limited (b)
   Quemont Mining Corporation, Limited (a)
   Wasamac Mines Limited (b)
   Malartic District
   Barnat Mines Ltd. (b)
   Camflo Mattagami Mines Limited (b)
   East Malartic Mines, Limited (b)
   Marban Gold Mines Limited (b)
   Norlartic Mines Limited (b)
   Bourlamaque-Louvicourt District
   Bevcon Mines Limited (b)
   Chimo Gold Mines Limited (b) (d)
   Lamaque Mining Company Limited (b)
   Manitou-Barvue Mines Limited (a)
   Sigma Mines (Quebec) Limited (b)
   Sullico Mines Limited (a)
   Sullivan Consolidated Mines, Limited (b)
   Duparquet District
   Normetal Mining Corporation, Limited (a)
10. *Matagami District*
    Mattagami Lake Mines Limited (a)
    New Hosco Mines Limited (a)
    Orchan Mines Limited (a)
11. *Belleterre District*
    Lorraine Mining Company Limited (a)

Ontario

12. *Larder Lake District*
    Kerr Addison Mines Limited (b)
    Kirkland Lake District
    Lake Shore Mines, Limited (b)
    Lamaque Mining Company Limited (Teck Mining Division) (b)
    Macassa Gold Mines Limited (b)
    Oakdale Mines Limited
    Upper Beaver Mines Limited (a)
    Upper Canada Mines, Limited (b)
    Wright-Hargreaves Mines, Limited (b)
13. *Porcupine District*
    Aunor Gold Mines Limited (b)
    Broulan Reef Mines Limited (b)
    Dome Mines Limited (b)
    Hallnor Mines, Limited (b)
    Hollinger Consolidated Gold Mines, Limited (Hollinger) (b)
    Hollinger Consolidated Gold Mines, Limited (Ross) (b)
    Hugh-Pam Porcupine Mines Limited (b)
    McIntyre-Porcupine Mines, Limited (a) (b)
    Pamour Porcupine Mines, Limited (b)
    Porcupine Paymaster Limited (b)
    Preston Mines Limited (b)
    Texas Gulf Sulphur Company (a) (d)
    Matachewan District
    Stairs Exploration & Mining Company Limited (b)
14. *Sudbury Mining Division*
    Falconbridge Nickel Mines, Limited (a)
    The International Nickel Company of Canada, Limited (a)
15. Renabie Mines Limited (b)
    Surluga Gold Mines Limited (b) (d)
16. *Port Arthur Mining Division*
    Noranda Mines Limited (Geco Mine) (a)
    Willecho Mines Limited (a)
    Willroy Mines Limited (a)
17. Consolidated Mosher Mines Limited (b)
    Leitch Gold Mines Limited (b)
    MacLeod-Cockshutt Gold Mines Limited (b)
18. North Coldstream Mines Limited (a)
19. *Fort Frances Mining Division*
    Sapawe Gold Mines Limited (b)

20. *Patricia Mining Division*
    Pickle Crow Gold Mines, Limited (b)
21. *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)
    McKenzie Red Lake Gold Mines Limited (b)
    Robin Red Lake Mines Limited (b) (d)
    Wilmar Mines Limited (b) (d)

Manitoba

22. Hudson Bay Mining and Smelting Co., Limited (a)
23. Hudson Bay Mining and Smelting Co., Limited (Snow Lake) (a)
24. San Antonio Gold Mines Limited (b)
25. Sherritt Gordon Mines, Limited (a)

Saskatchewan

22. Hudson Bay Mining and Smelting Co., Limited (a)
26. Anglo-Rouyn Mines Limited (a) (d)

British Columbia

27. The Consolidated Mining and Smelting Company of Canada Limited (a)
28. The Granby Mining Company Limited (Phoenix Copper Division) (a)
29. Bethlehem Copper Corporation Ltd. (a)
30. The Anaconda Company (Canada) Ltd. (Britannia Mine) (a)
    Texada Mines Ltd. (a)
31. Coast Copper Company, Limited (a)
32. Bralorne Pioneer Mines Limited (b)
33. The Cariboo Gold Quartz Mining Company, Limited (b)
34. Small placer operations (c)

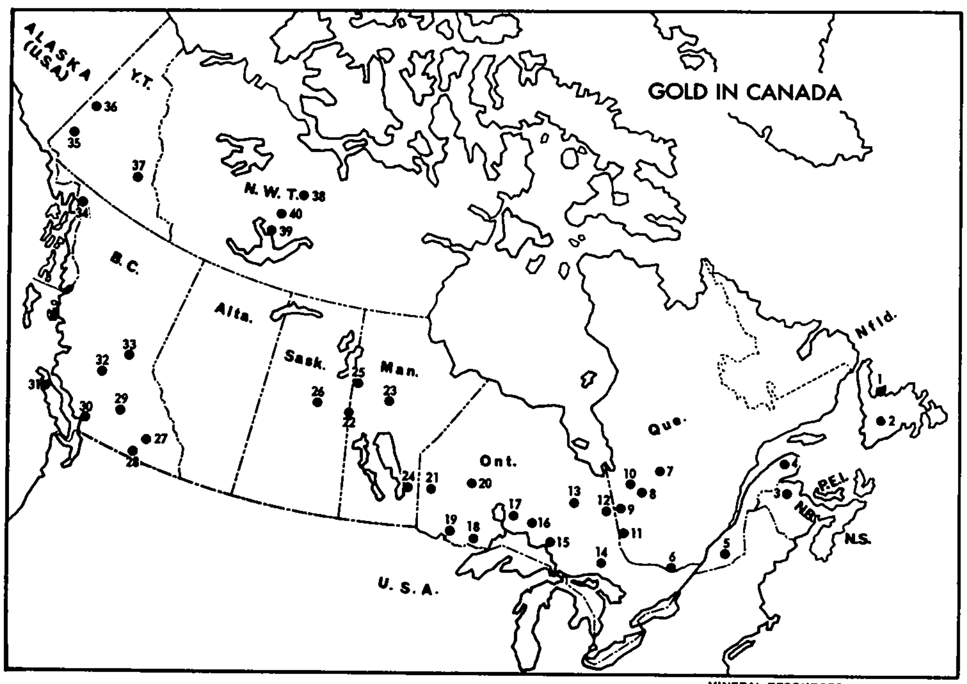
Yukon Territory

35. Small placer operations (c)
36. The Yukon Consolidated Gold Corporation, Limited (c)
37. Discovery Mines Limited (LaForma Mine) (b)

Northwest Territories

38. Tundra Gold Mines Limited (b)
39. The Consolidated Mining and Smelting Company of Canada Limited (Con, Rycon and Vol mines) (b)
    Giant Yellowknife Mines Limited (b)
40. Discovery Mines Limited (b)

(a) Base metal, (b) auriferous quartz, (c) placer, (d) prospective producer.



MINERAL RESOURCES DIVISION

TABLE 3

Canadian Gold Production, 1956-65

Year	Auriferous-Quartz Mines (troy ounces)	%	Placer Operations (troy ounces)	%	From Base-Metal Ores (troy ounces)	%	Total Production (troy ounces)	Total Value ($ Can.)	Average Value per Ounce ($ Can.)	Gold as % of All Mineral Production Value
1956	3,704,870	84.5	74,919	1.7	604,074	13.8	4,383,863	151,024,080	34.45	7.2
1957	3,766,285	85.0	76,303	1.7	591,306	13.3	4,433,894	148,757,143	33.55	6.8
1958	3,928,187	85.9	71,955	1.6	571,205	12.5	4,571,347	155,334,370	33.98	7.4
1959	3,852,074	85.9	72,974	1.6	558,368	12.5	4,483,416	150,508,275	33.57	6.2
1960	3,930,366	84.9	80,804	1.7	617,741	13.4	4,628,911	157,151,527	33.95	6.3
1961	3,774,522	84.4	69,240	1.5	629,937	14.1	4,473,699	158,637,366	35.46	6.1
1962	3,494,821	83.6	57,760	1.4	625,815	15.0	4,178,396	156,313,794	37.41	5.5
1963	3,324,907	83.1	57,905	1.4	620,315	15.5	4,003,127	151,118,045	37.75	5.0
1964	3,151,593	82.2	58,512	1.5	625,349	16.3	3,835,454	144,788,388	37.75	4.3
1965p	2,934,730	81.2	44,500	1.2	635,318	17.6	3,614,548	136,376,896	37.73	3.6

Source: Dominion Bureau of Statistics.

p Preliminary.

operate its mill in a tailings reclamation program. Lamaque Mining Company Limited (Teck Mining Division) increased production slightly in 1965 but closure is scheduled for 1966. Production was down at the mines of Macassa Gold Mines Limited and Upper Canada Mines, Limited. During the year, the Upper Canada mill commenced treatment of gold-copper ores from a nearby mine owned by Upper Beaver Mines Limited.

Porcupine District — Broulan Reef Mines Limited and Hugh-Pam Porcupine Mines Limited, a combined operation, closed during 1965 leaving nine lode gold mines operating in the area. Hollinger Consolidated Gold Mines, Limited operated throughout the year at its Hollinger mine on a salvage basis. McIntyre-Porcupine Mines, Limited recorded lower gold production as a larger tonnage of copper ore was treated in lieu of gold ore. Production at Dome Mines Limited was maintained. Output was higher at Hallnor Mines, Limited, Porcupine Paymaster Limited and Hollinger Consolidated's Ross mine. Porcupine Paymaster, however, is scheduled to close in 1966. Aunor Gold Mines Limited, Pamour Porcupine Mines, Limited and Preston Mines Limited produced less.

Larder Lake District — Kerr Addison Mines Limited continued a planned reduction in its milling rate and production was about 16.3 per cent lower than in 1964.

Port Arthur Mining Division — Leitch Gold Mines Limited at Beardmore closed early in the year. Consolidated Mosher Mines Limited produced considerably less gold and although the adjoining MacLeod-Cockshutt Gold Mines Limited increased output, the gain was quite small.

Red Lake and Patricia Mining Division — Production decreased at Cochenour Willans Gold Mines, Limited and Madsen Red Lake Gold Mines Limited. Annco Mines Limited, which is controlled and managed by Cochenour Willans, began ore shipments to the Cochenour mill. Campbell Red Lake Mines Limited and Dickenson Mines Limited maintained production while higher outputs were recorded by Pickle Crow Gold Mines, Limited and McKenzie Red Lake Gold Mines Limited. McKenzie is expected to close in 1966 while Pickle Crow is having difficulty in maintaining economic operation, principally because of a severe labour shortage.

Fort Frances Mining Division — Sapawe Gold Mines Limited, near Atikokan, ceased production in early 1965 to carry out shaft deepening and mill expansion. Operations were resumed late in the year.

Matachewan District — Stairs Exploration & Mining Company Limited began operations in mid-year with a small mill. Production was small.

Base-Metal Mines

Byproduct gold was recovered from the nickel-copper mines in the Sudbury area and the zinc-copper mines at Manitouwadge. Upper Beaver Mines Limited near Kirkland Lake produced a significant amount of gold from its gold-copper operation while McIntyre-Porcupine Mines, Limited at Timmins recovered appreciable gold from its copper ores.

MANITOBA-SASKATCHEWAN

San Antonio Gold Mines Limited at Bissett, Manitoba had a production decline in 1965. The company, the only lode gold producer in the two provinces, is experiencing difficulty and is expected to close in 1966.

Byproduct gold was recovered from the base-metal mines operated by Hudson Bay Mining and Smelting Co., Limited at Flin Flon and Snow Lake.

ALBERTA

A small amount of byproduct gold is recovered annually from gravel operations on the North Saskatchewan River near Edmonton.

BRITISH COLUMBIA

Production declined at both of the province's lode gold mines, Bralorne Pioneer Mines Limited and The Cariboo Gold Quartz Mining Company, Limited. The reduction at Bralorne Pioneer was mainly due to a planned decrease in the milling rate for about two months while shaft deepening was in progress.

The Phoenix Copper Division of The Granby Mining Company Limited and Coast Copper Company, Limited were the largest base-metal producers of byproduct gold. Small amounts of placer gold were recovered in the Wells and Atlin areas.

NORTHWEST TERRITORIES

Discovery Mines Limited, Tundra Gold Mines Limited and the Con and Rycon mines of The Consolidated Mining and Smelting Company of Canada Limited all recorded higher lode gold production in 1965. Giant Yellowknife Mines Limited, now Canada's largest gold mine, maintained output at close to 1964 levels.

YUKON TERRITORY

Production began in June on a small scale at the LaForma lode gold mine owned by Discovery Mines Limited near Carmacks. This is the only lode gold mine in the territory. Operations are expected to cease in 1966.

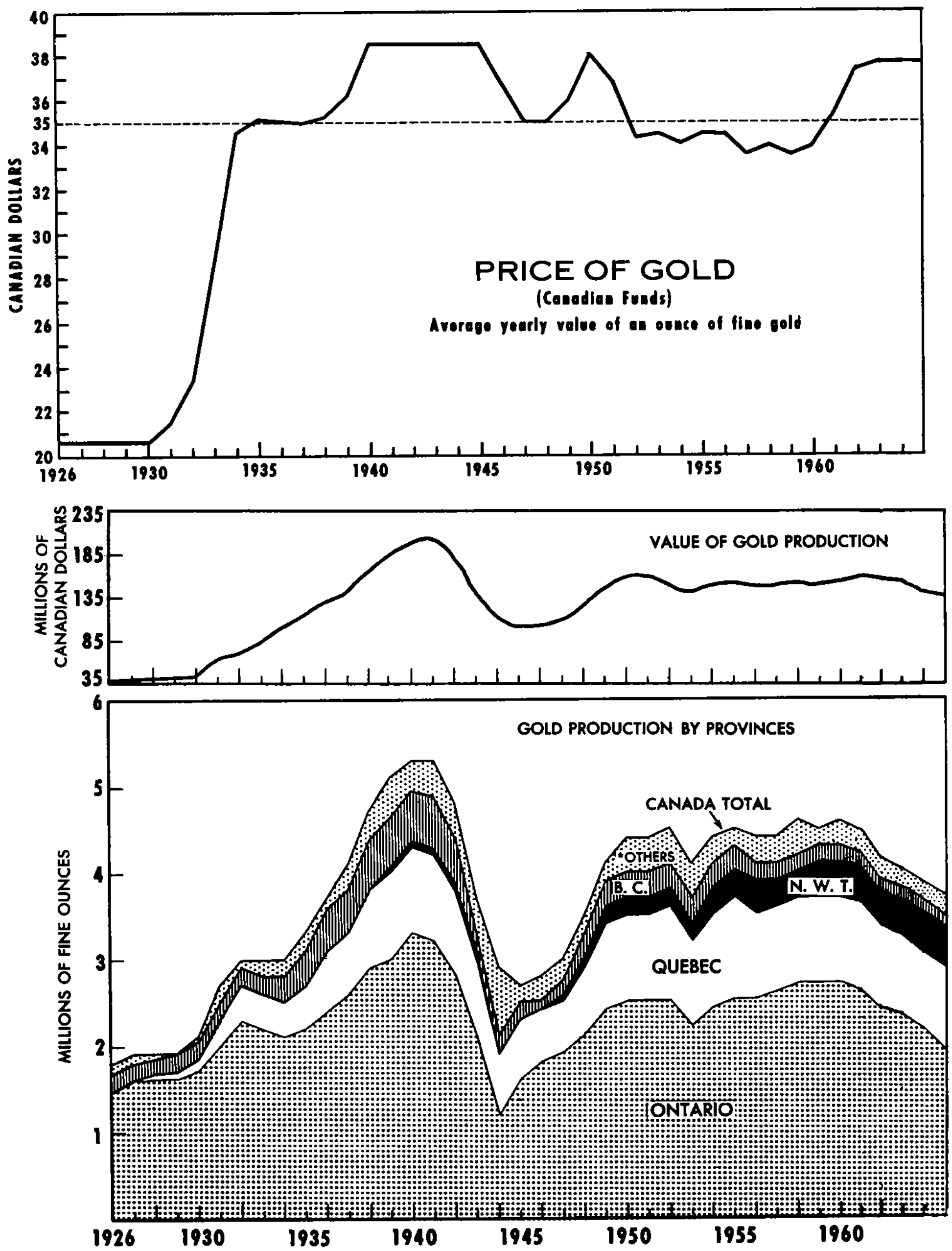
Gold production from placer operations declined sharply during 1965. The largest placer operation in Canada, The Yukon Consolidated Gold Corporation, Limited, operated five dredges in 1965, one less than in the previous year. This factor, together with a dwindling grade of reserves, accounted largely for the drop. The company announced its intention of ceasing operations at the end of the 1966 season.

USES

Gold has always been prized for its rarity, beauty, lustre, its ability to resist corrosion and because it can be easily worked into objects of value. Today, however, it is used principally as a monetary reserve by governments and central banks to give stability to paper currencies and to balance international trade.

The resistance of gold to corrosion led to its early use for jewelry and decoration. This property has made it useful in recent times for electrical contacts and other devices that must operate reliably in corrosive atmospheres. In jewelry, gold is alloyed with silver, copper, nickel, zinc or palladium to improve its hardness and wearing qualities. It is used in many forms such as plating, goldware, foil, leaf, lace, thread, gilding, gold solutions, inserts, inlays and lettering. The colour may vary from natural yellow through various shades of green and even white depending on the alloying elements present.

Gold is extremely ductile, highly conductive, and has a high reflectivity, high density and low specific heat and vapour pressure. It is used in the chemical industry, in dentistry and in glass-making. Gold in solution is applied like lacquer to decorate pottery. Uses in electronics include radio tubes, gold-plated printed circuits, gold-film thermometers, X-ray tubes, bolometers, transparent windows and semiconductors. The electrical industry employs it in electrical-contact alloys, resistance alloys, heating elements, condenser plates and thermal fuses. The textile industry uses it in connection with spinnerets and gold thread. It has provided lining for liquid fuel reactors and, because of its optical qualities, has found increasing use in modern aircraft missiles, earth satellites and space vehicles.



PRICES

The average price paid by the Royal Canadian Mint in 1965 was $37.73, slightly lower than the $37.75-per-ounce average in 1964. During 1965, the price fluctuated between a high of $37.96 and a low of $37.56. The fluctuation is due to the variation of one per cent either way which is permitted from the fixed value of the Canadian dollar of $0.925 in terms of United States funds. As a result of this flexibility the Mint price may range from $37.46 to $38.22 per troy ounce.

Gypsum and Anhydrite

R. K. COLLINGS*

Canada, the world's second largest producer of crude gypsum, is well endowed with large high-purity deposits. Most of these are easily accessible and well located with respect to current markets. Gypsum is produced in Newfoundland, Nova Scotia, New Brunswick, Ontario, Manitoba and British Columbia. Although deposits occur in two of the remaining provinces, Quebec and Alberta, to date no production has been recorded from either. No deposits are known in either Prince Edward Island or Saskatchewan. Nova Scotia, the chief producing province, annually accounts for 75 to 80 per cent of Canada's total production. Most of its output is shipped to gypsum-product plants located along the eastern coast of the United States.

Gypsum production dropped slightly in 1965 to 6.2 million tons valued at $11.4 million as did exports, which were off 6 per cent to 4.7 million tons with a value of $8.3 million. This reduction in output and exports resulted largely from reduced demand by plants in the U.S. supplied by Nova Scotian gypsum. Imports of crude gypsum, mostly from Mexico for consumption in British Columbia, were also lower than those of 1964, by approximately 7 per cent.

In spite of the slight reversal noted in 1965, the general trend towards increased production of gypsum established in Canada during the 20 years following World War II is expected to continue strong, to keep pace with future construction activity. The continuing demand for housing in North America assures a steady market for gypsum products — plaster, lath, wallboard and sheathing — which are an integral part of most private dwellings and apartment buildings as well as many office buildings and factories. Drywall construction utilizing gypsum wallboard has largely replaced the traditional lath-plaster method of wall finishing. This application for gypsum board continues to expand despite increased use of other panel building materials such as masonite and plywood.

Although most deposits are well located and reserves adequate, this is not the case in all areas of Canada, notably Quebec, Alberta and, to a lesser degree, British Columbia. The two gypsum-product plants in Montreal bring in crude from Nova Scotia as there are no known gypsum deposits on mainland Quebec, while the two plants in Calgary obtain crude from British Columbia and Manitoba. Although gypsum deposits are known in Alberta, several of the more interesting deposits occur in national parks. Under present legislation, these deposits are not available for mining; however, negotiations currently under way between Federal and Provincial governments may result in the transfer of certain parklands with, perhaps, an easing of mining restrictions. One of the two gypsum-product plants in Van-

* Mineral Processing Division, Mines Branch

TABLE 1

Gypsum – Production and Trade, 1964-65

	1964		1965[p]	
	Short Tons	$	Short Tons	$
Production (shipments)				
Crude gypsum				
Nova Scotia	5,097,232	8,081,994	4,806,000	7,609,273
Ontario	517,239	1,376,992	515,000	1,383,695
Newfoundland	331,990	893,484	422,000	1,139,400
British Columbia	188,569	581,873	205,160	591,090
Manitoba	121,555	374,138	162,000	504,535
New Brunswick	104,100	215,456	100,800	210,360
Total	6,360,685	11,523,937	6,210,960	11,438,353
Imports				
Crude gypsum				
Mexico	79,500	258,346	74,341	241,677
United States	1,428	29,999	1,066	24,323
Britain	12	530	26	1,348
Total	80,940	288,875	75,433	267,348
Plaster of paris and wall plaster				
United States	3,893	181,334	4,344	180,029
Britain	238	14,213	365	17,796
Other countries	10	588	13	1,065
Total	4,141	196,135	4,722	198,890
Gypsum lath, wallboard and basic products				
United States	3,776	208,604	2,585	174,822
West Germany	7	1,920	–	–
Total	3,783	210,524	2,585	174,822
Total imports		695,534		641,060
Exports				
Crude gypsum				
United States	5,043,469	9,033,140	4,716,202	8,268,167
Bahamas	13,759	26,968	30,436	67,008
Bermuda	25	600	–	–
Total	5,057,253	9,060,708	4,746,638	8,335,175

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

couver obtains gypsum from a company-operated quarry in the southeastern part of the province, while the other imports its requirements from Mexico. The gypsum deposits in southeastern British Columbia are extensive but, although fairly close to the Calgary market, they are somewhat distant from Vancouver. High transportation costs have to date deterred wider development of these deposits. However, a U.S. firm currently is conducting feasibility and market studies directed towards production of gypsum from deposits along the banks of the Lussier River in the Canal Flats area of this province. These are reported to contain more than 100 million tons of good-quality gypsum.

A new underground gypsum mine, the fourth in Canada, was brought into production early in the year near Silver Plains, Manitoba, by Western Gypsum Products Limited. Located 35 miles south of Winnipeg, this mine is now the chief source of crude gypsum for Western's gypsum-product plant at Winnipeg. The 20-foot seam being mined is 140 feet below the surface and is reached by an 11-foot diameter inclined shaft. Operated on a room and pillar system, the mine is designed to produce about 500 tons of ore per day. Reserves have been

TABLE 2

Gypsum Production, Trade and Consumption, 1956–65

(short tons)

	Production[1]	Imports[2]	Exports[2]	Apparent Consumption[3]
1956	4,895,811	70,436	3,840,721	1,125,526
1957	4,577,492	92,139	3,410,684	1,258,947
1958	3,964,129	108,038	2,898,230	1,173,937
1959	5,878,630	117,830	4,848,576	1,147,884
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
1965p	6,210,960	75,433	4,746,638	1,539,755

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.

estimated at 20 million tons. Although no new mining operations were established in eastern Canada during the year, several companies were active in exploration in Nova Scotia and may open new quarries for export of crude gypsum, depending on the results of their exploration programs.

The current expansion of the phosphate fertilizer industry in Canada will result in the accumulation of increasingly large tonnages of synthetic gypsum derived during the manufacture of phosphoric acid by the acidulation of phosphate rock with sulphuric acid. This material is very finely divided and usually somewhat impure. Although essentially a waste product, it would be of interest where natural gypsum deposits are sparse or of poor quality and, in such areas, should be investigated as a possible source material for gypsum products manufacture. This material is now produced in British Columbia, Alberta, Manitoba, Ontario and Quebec and will soon be produced in New Brunswick. Although exact tonnage figures are unknown, when the phosphate fertilizer plant scheduled for production at Belledune, New Brunswick, by Brunswick Fertilizer Corporation Limited is in operation, production of synthetic gypsum in Canada probably will exceed 2 million tons per year.

TABLE 3

World Production of Gypsum, 1964–65

(thousand short tons)

	1964	1965e
United States	10,684	9,945
Canada	6,361	6,211
Britain	5,052	5,400
U.S.S.R.	4,740e	..
France	4,639	4,700
Spain	4,258	..
Italy	2,285	3,000
Other countries	13,501	..
Total	51,520	53,255

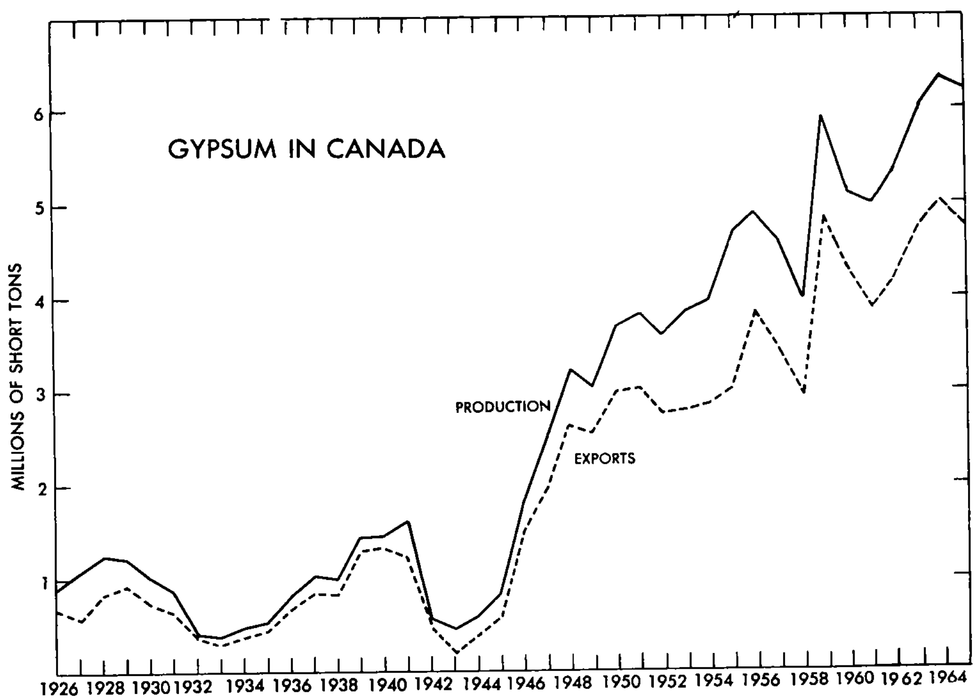
Source: Canada, Dominion Bureau of Statistics; all other countries, U.S. Bureau of Mines *Minerals Yearbook, 1964* and U.S. Bureau of Mines *Commodity Data Summaries*, January 1966.
e Estimate; .. Not available.

OCCURRENCES

Large surface and near-surface gypsum deposits occur in three of the Atlantic Provinces in Nova Scotia, throughout the central and northern parts of the mainland and in Cape Breton Island; in the St. George's Bay area of southwestern Newfoundland; and in southeastern New Brunswick near Hillsborough.

No natural gypsum occurrences are known in mainland Quebec but extensive deposits outcrop over large areas of the Magdalen Islands in the Gulf of St. Lawrence.

In Ontario, gypsum occurs in the Moose River area in the far northeast, and in the



Grand River area, south and west of Hamilton. The Moose River deposits are 15 to 20 feet thick and usually under 10 to 30 feet of cover; the Grand River deposits occur at depths up to 200 feet and are generally thin.

Manitoba and Alberta have large gypsum deposits. The main occurrences in Manitoba are in the southwestern section of the province at Gypsumville, where a 30-foot thickness of gypsum is exposed; at Amaranth, where 40 feet of gypsum occurs at a depth of 100 feet; and at Silver Plains, 30 miles south of Winnipeg, where high-quality gypsum occurs 140 feet below the surface. Gypsum occurs in Alberta in Wood Buffalo Park and is exposed along the banks of the Peace River between Peace Point and Little Rapids. It also occurs along the banks of the Slave and Salt rivers north and west of Fort Fitzgerald and as narrow seams interbedded with anhydrite at a depth of 500 feet at McMurray in the northeastern section of the province. In addition, outcrops of gypsum have been found near Mowitch Creek, within the northern boundary of Jasper Park, and at the headwaters of Fetherstonhaugh Creek, near the Alberta-British Columbia border.

In British Columbia, deposits occur at Windermere, Mayook and Canal Flats, in the southeast; at Falkland near Kamloops; and near Loos in the east-central part.

Gypsum deposits have been found in the southern part of Yukon Territory and, in the Northwest Territories, along the north shore of Great Slave Lake, along the banks of the Mackenzie, Great Bear and Slave rivers, and on several of the Arctic islands.

CURRENT OPERATIONS

NOVA SCOTIA

There are five companies actively producing gypsum in Nova Scotia. Production totalled 4.8 million tons in 1965, 77 per cent of the Canadian total. Approximately 90 per cent of the production of this province was exported to the United States in 1965.

Fundy Gypsum Company Limited, a subsidiary of United States Gypsum Company of Chicago, quarries gypsum for export at Wentworth and Miller Creek near Windsor. National Gypsum (Canada) Ltd., a subsidiary of National Gypsum Company of Buffalo, New York, quarries gypsum near Milford, 30 miles north of Halifax.

Most of the gypsum is for export to company plants in the U.S.; however, small amounts are used in Nova Scotia in cement manufacture and in Quebec in cement and gypsum products. Gypsum for export is also obtained at Walton, Hants County. Little Narrows Gypsum Company Limited, also a subsidiary of United States Gypsum Company, quarries gypsum at Little Narrows on Cape Breton Island, shipping crude rock to the U.S. and to Montreal.

Domtar Construction Materials Ltd., with head offices in Montreal, operates a calcining plant at Windsor, for the production of plaster of paris. Gypsum for this plant is obtained from deposits at McKay Settlement near Windsor. Georgia-Pacific Corporation, Bestwall Gypsum Division, quarries gypsum for export near River Denys. The crushed rock is carried by rail to shipping facilities at Point Tupper, 20 miles from the quarry site.

ONTARIO

Gypsum is mined at Caledonia, near Hamilton, by Domtar Construction Materials Ltd., and at Hagersville, southwest of Caledonia, by Canadian Gypsum Company, Limited. It is used in the manufacture of plaster and wallboard at company plants located near each of the mines.

NEWFOUNDLAND

Atlantic Gypsum Limited produces gypsum plaster and wallboard at Humbermouth, on the west coast of the island. This plant, owned by the Government of Newfoundland, is operated by The Flintkote Company of Canada Limited, Toronto, a subsidiary of The Flintkote Company of New York. Crude gypsum for its operation is obtained from Flintkote's deposits at Flat Bay Station, 62 miles by rail southwest of Humbermouth. Most of the production is transported by aerial conveyor to St. George's, 6 miles distant, where it is loaded on boats for export to company plants along the eastern coast of the United States. Part of the production of crude gypsum is shipped to markets in Ontario.

BRITISH COLUMBIA

Western Gypsum Products Limited quarries gypsum near Windermere in the southeastern part of the province. The gypsum is shipped to company plants in Calgary and Vancouver and to Domtar Construction Materials Ltd. for use in its Calgary plant. Windermere gypsum is also used by cement plants in Alberta and British Columbia.

MANITOBA

Gypsum is quarried at Gypsumville, 150 miles northwest of Winnipeg, by Domtar Construction Materials Ltd. This gypsum is used at Winnipeg and Calgary for plaster and wallboard manufacture at company-owned plants.

Western Gypsum Products Limited obtains gypsum from an underground deposit near Silver Plains, 30 miles south of Winnipeg, for use in company-owned gypsum-product plants in Winnipeg and Calgary. The deposit is 140 feet below the surface.

NEW BRUNSWICK

Gypsum is quarried near Hillsborough by Canadian Gypsum Company, Limited, for plaster and wallboard manufacture at a company-owned plant at Hillsborough. Canada Cement Company, Limited, obtains gypsum from Havelock, west of Moncton, for cement manufacture at Havelock.

OTHER PROCESSING PLANTS

Quebec

Domtar Construction Materials Ltd. and Canadian Gypsum Company, Limited, operate gypsum-products plants in Montreal East. Crude gypsum is obtained from Nova Scotia.

Ontario

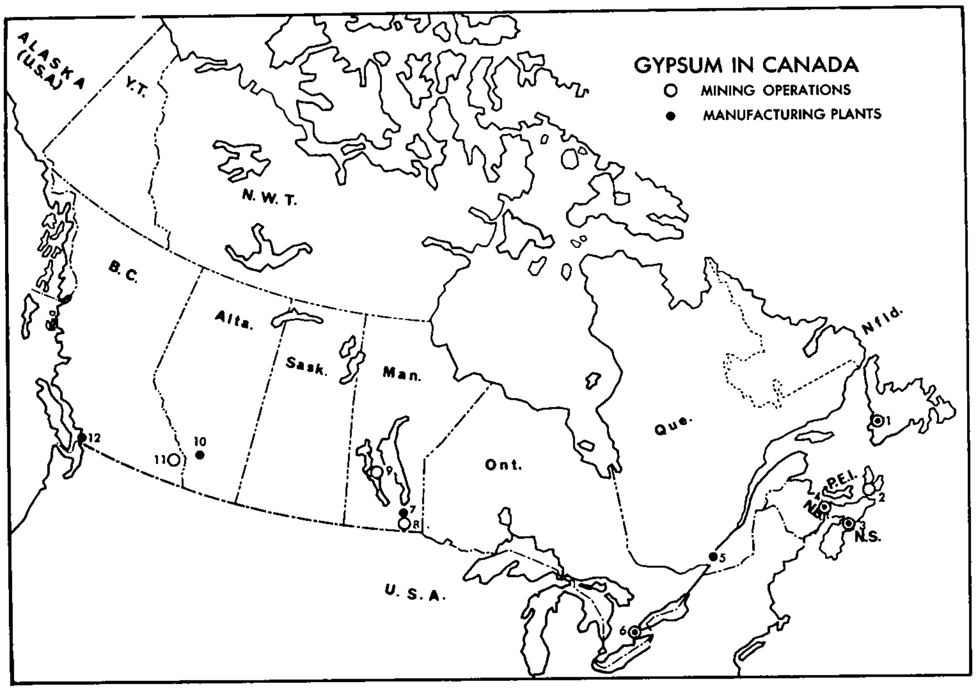
Western Gypsum Products Limited operates a gypsum-products plant at Clarkson, southwest of Toronto. Crude gypsum for this operation is obtained from southern Ontario and from Newfoundland.

Alberta

Domtar Construction Materials Ltd. and Western Gypsum Products Limited produce plaster and wallboard in Calgary. Gypsum for these plants is obtained from British Columbia and Manitoba.

British Columbia

Domtar Construction Materials Ltd. and Western Gypsum Products Limited also have plants in Vancouver for the production of gypsum plaster and wallboard. The former obtains its crude gypsum from Mexico, the latter from its Windermere deposit.



MINING OPERATIONS*
(numbers refer to numbers on map)

1. The Flintkote Company of Canada Limited, Flat Bay Station
2. Little Narrows Gypsum Company Limited, Little Narrows
   Georgia-Pacific Corporation, Bestwall Gypsum Division, River Denys
3. Fundy Gypsum Company Limited, Wentworth and Miller Creek
   National Gypsum (Canada) Ltd., Milford and Walton
   Domtar Construction Materials Ltd., McKay Settlement
4. Canadian Gypsum Company, Limited, Hillsborough
6. Canadian Gypsum Company, Limited, Hagersville (underground)
   Domtar Construction Materials Ltd., Caledonia (underground)
8. Western Gypsum Products Limited, Silver Plains (underground)
9. Domtar Construction Materials Ltd., Gypsumville
11. Western Gypsum Products Limited, Windermere

*Surface operations except where noted otherwise.

MANUFACTURING PLANTS

1. Atlantic Gypsum Limited, Humbermouth
3. Domtar Construction Materials Ltd., Windsor
4. Canadian Gypsum Company, Limited, Hillsborough
5. Canadian Gypsum Company, Limited, Montreal
   Domtar Construction Materials Ltd., Montreal
6. Canadian Gypsum Company, Limited, Hagersville
   Domtar Construction Materials Ltd., Caledonia
   Western Gypsum Products Limited, Clarkson
7. Domtar Construction Materials Ltd., Winnipeg
   Western Gypsum Products Limited, Winnipeg
10. Domtar Construction Materials Ltd., Calgary
    Western Gypsum Products Limited, Calgary
12. Domtar Construction Materials Ltd., Port Mann
    Western Gypsum Products Limited, Vancouver

USES

Calcined gypsum, or plaster of paris, is the main constituent used in manufacturing gypsum board and lath, gypsum tile and roof slabs, and all types of industrial plasters. Plaster of paris is mixed with water and aggregate (sand, vermiculite or expanded perlite) and applied over wood, metal or gypsum lath to form an interior wall finish. Gypsum board, lath and sheathing are formed by introducing a slurry consisting of plaster of paris, water, foam, accelerator, etc., between two sheets of absorbent paper, where it sets, producing a firm, strong wallboard. These products are used in the building-construction industry.

Crude uncalcined gypsum is used in the manufacture of portland cement. The gypsum, acting as a retarder, controls the set of the cement. Crude gypsum, reduced to 100 mesh or finer, is used as a filler in paint and paper. Ground gypsum is used to a small extent as a substitute for salt cake in glass manufacture. Powdered gypsum, as a soil conditioner, offsets the effect of black alkali; aids in restoring impervious, dispersed soil; and is a fertilizer for peanuts and other legumes.

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Gypsum, crude	free	free	free
Gypsum, ground, not calcined	10	12½	15
Gypsum wallboard and lath	15	20	35
Plaster of paris and prepared wall plaster, per 100 lb	free	11¢	12½¢

United States

Gypsum, crude	free
Gypsum, ground or calcined, per long ton	$1.19
Gypsum wallboard and lath	12½%

ANHYDRITE*

Anhydrite, an anhydrous calcium sulphate, is commonly associated with gypsum. It is produced in Nova Scotia by Fundy Gypsum Company Limited at Wentworth; by Little Narrows Gypsum Company Limited at Little Narrows; and for National Gypsum (Canada) Ltd. by B.A. Parsons at Walton. Production in 1965 was about 243,000 tons**. Most of this was shipped to the United States for use in portland cement manufacture and as a fertilizer for peanut crops. Anhydrite also has a small application as a soil conditioner.

Gypsum and anhydrite are potential sources of sulphur compounds but are not utilized as such in Canada. In Europe, gypsum or anhydrite is calcined at a high temperature with coke, silica and clay to produce sulphur dioxide, sulphur trioxide and byproduct cement. The gases are then converted into sulphuric acid.

*Production and trade statistics for anhydrite are not reported separately by the Dominion Bureau of Statistics but are included with gypsum in the gypsum section of this review. **Nova Scotia Department of Mines, Halifax.

Indium

D.B. FRASER*

Indium is found in minute quantities in certain ores of zinc, lead, tin, tungsten and iron. Commonly associated with sphalerite, the most abundant zinc mineral, indium becomes concentrated in zinc residues and smelter slags derived from zinc- and lead-smelting operations. The metal is produced commercially at only a few of the world's zinc and lead smelters.

Statistics on production of indium are not available. There is one producer in Canada and one in the United States. The metal is reported to have been recovered also in West Germany, Belgium, Japan, Peru and Russia. Cominco Ltd., which has plants at Trail, B.C. for the reduction of lead and zinc, is one of the world's largest suppliers of indium.

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, B.C. 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) of 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.

* Mineral Resources Division

PROPERTIES AND USES

Indium is silvery white, very much like tin or platinum in appearance; chemically and physically, it resembles tin more than it does any other metal. Its chief characteristics are its extreme softness, its low melting point and the high melting range. 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 of 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 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 for the last 25 years only, indium and its compounds are relatively new materials whose potential applications are still being explored. Uses have been found in intermetallic semiconductors, electrical contacts, resistors, thermistors and photoconductors. Indium can be used as an indicator in atomic reactors since artificial radioactivity is easily induced in indium by neutrons of low energy. Indium compounds added to lubricants have been found to have a beneficial anticorrosive effect. Indium is used in certain very small lightweight batteries.

TRADE AND CONSUMPTION

No statistics are available on export, import or domestic consumption of indium. Much of Canada's output is exported to the U.S. and Britain, and smaller amounts go to a number of countries in Europe.

PRICES

Prices of indium, 99.97 per cent, quoted per troy ounce in *E & MJ Metal and Mineral Markets* were as follows:

Effective October 1, 1964	
Sticks, 30–90 oz	$2.40
Ingot	
100 oz	1.95
10,000+ oz	1.65
Effective May 3, 1965	
Sticks, 30–90 oz	2.55
Ingot	
100 oz	2.10
10,000+ oz	1.80
Effective October 5, 1965	
Sticks, 30–90 oz	2.75
Ingot	
100 oz ..	2.30 ..
10,000+ oz	2.00

Iron Ore

C.J. GAUVIN*

Iron ore shipments in 1965 totalled 35.5 million tons** valued at $419 million, an increase of 3.8 per cent from 1964 when shipments were 34.2 million tons valued at $405 million.

Three pellet plants were completed in 1965 – Arnaud Pellets in Quebec and those of Caland Ore Company Limited and Jones & Laughlin Steel Corporation in Ontario. Their combined annual capacity of nearly 7 million tons brought total Canadian pelletizing capacity to over 15 million tons a year. A large concentrate producer in Labrador, Wabush Mines, also began production. Most of its rated capacity of 5.3 million annual tons output is to be pelletized by Arnaud Pellets.

Two small mines in British Columbia, Orecan Mines Ltd. and Empire Development Company, Limited, neared production at the end of the year and construction continued at Wesfrob Mines Limited's Moresby Island property.

In Ontario, development of Dominion Foundries and Steel, Limited's (DOFASCO) $40 million Sherman mine project at Timagami, was begun. Completion is scheduled for 1968. Its capacity will be 1.2 million tons of pellets a year.

In addition, several new projects were being considered for early development. The Steel Company of Canada, Limited (STELCO) was considering development of a $50 million pellet operation (the Griffith mine) on the optioned property of Iron Bay Mines Limited near Red Lake. Production would be 1.5 million tons a year. It was expected that Iron Ore Company of Canada would soon announce an increase in its pellet capacity at the Carol project from 5.5 million tons a year to 10 million tons. The expansion program, if undertaken, would be completed by the end of 1967 at which time all ore mined at Labrador City would be pelletized. Also, it was expected that a joint-venture agreement between Steep Rock Iron Mines Limited and The Algoma Steel Corporation, Limited would be announced for the production of over 1 million tons of pellets a year by Steep Rock for Algoma. Steep Rock would also supply pellets to other North American steel producers.

Annual iron ore productive capacity in Canada at the end of 1965 was 45.4 million tons, an increase of 16.7 per cent from 1964. This includes 15.6 million tons of pellets, 12.4 million tons of high-grade concentrates in addition to that used to make pellets, and 17.4 million tons of medium-grade ores and concentrates containing less than 58 per cent natural iron. Upon completion of planned iron-ore pellet plants, productive capacity will be 21.4 million tons a year in 1967 and 24.1 million in 1968.

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* Mineral Resources Division

** The long or gross ton (2,240 pounds) is used throughout unless otherwise noted.

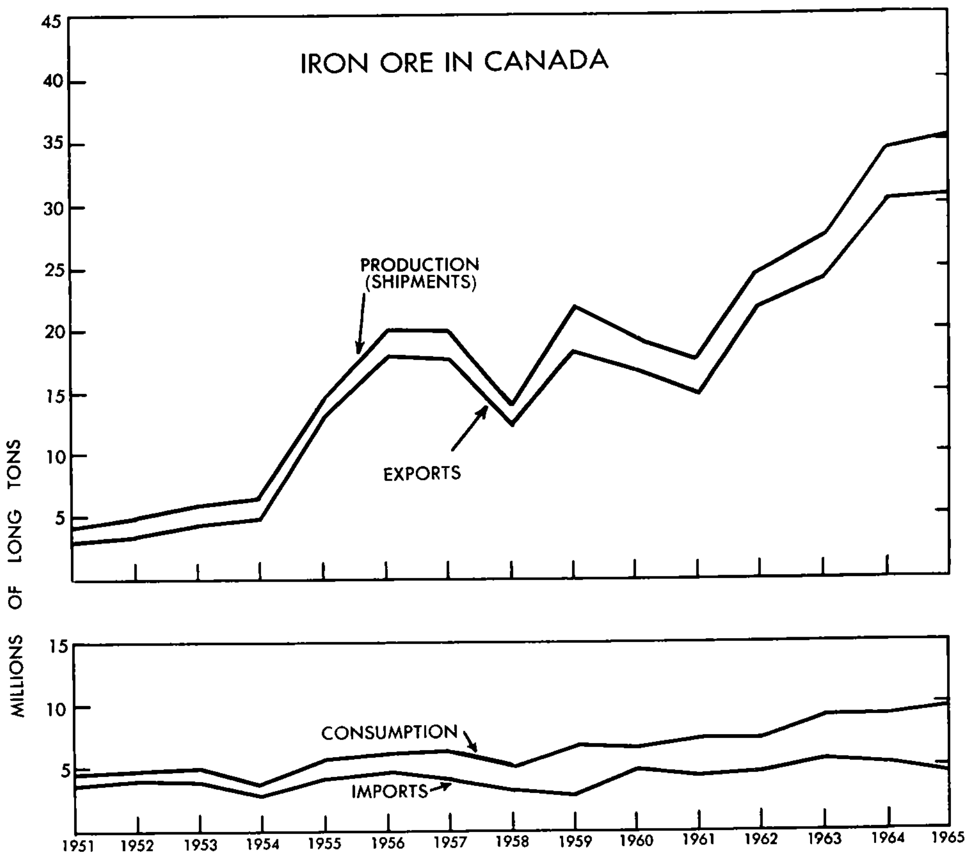


TABLE 1

Canadian Iron Ore – Production and Trade, 1964–65

	1964		1965P	
	Long Tons	$	Long Tons	$
Production (shipments)				
Quebec	13,850,818	161,880,175	13,197,884	141,584,305
Newfoundland	11,396,049	137,038,680	13,041,889	168,498,171
Ontario	7,184,615	85,613,354	7,407,115	90,558,867
British Columbia	1,788,002	20,419,487	1,878,635	18,711,715
Total	34,219,484	404,951,696	35,525,523	419,353,058
Byproduct iron ore*	876,656	..	1,136,546	..
Imports				
United States	4,837,330	63,488,221	4,503,804	58,130,495
Brazil	372,254	3,708,212	259,225	2,419,220
Chile	23,850	90,916	–	–
Total	5,233,434	67,287,349	4,763,029	60,549,715

Table 1(cont.)

	1964		1965p	
	Long Tons	$	Long Tons	$
Exports				
Iron ore, direct shipping				
United States	8,308,132	85,109,981	7,181,726	73,669,321
Britain	227,983	1,972,451	278,134	2,684,844
Italy	–	–	45,243	436,142
Netherlands	–	–	44,234	441,454
West Germany	58,886	392,759	27,913	278,571
Belgium and Luxembourg	59,100	514,420	–	–
Japan	41,734	491,643	–	–
Total	8,695,835	88,481,254	7,577,250	77,510,332
Iron ore concentrates				
United States	10,744,738	120,471,680	8,741,972	96,953,234
Britain	1,976,471	18,730,120	1,940,608	18,814,649
Japan	1,635,598	17,778,204	1,773,012	19,734,258
West Germany	198,205	1,387,569	636,244	5,170,618
Belgium and Luxembourg	213,505	1,866,628	531,046	4,594,497
Italy	30,900	193,125	342,831	3,630,156
Netherlands	112,263	1,266,337	242,499	2,392,004
France	25,000	286,771	–	–
Other countries	5,000	54,658	–	–
Total	14,941,680	162,035,092	14,208,212	151,289,416
Iron ore, agglomerated				
United States	5,212,898	79,447,054	7,223,323	105,922,538
Britain	957,513	15,011,226	695,898	10,303,260
Italy	–	–	180,205	2,730,319
Netherlands	76,292	1,176,196	163,660	2,432,225
West Germany	60,489	973,889	111,394	1,655,681
Belgium and Luxembourg	–	–	1,500	21,990
France	–	–	29,710	435,548
Total	6,307,192	96,608,365	8,405,690	123,501,561
Iron ore, not elsewhere specified including byproduct iron ore				
United States	527,494	8,870,978	608,082	8,516,980
Netherlands	–	–	18	216
Other countries	1,500	11,625	–	–
Total	528,994	8,882,603	608,100	8,517,196
Total exports, all classes				
United States	24,793,262	293,899,693	23,755,103	285,062,073
Britain	3,161,967	35,713,797	2,914,640	31,802,753
Japan	1,677,332	18,269,847	1,773,012	19,734,258
West Germany	317,580	2,754,217	775,551	7,104,870
Italy	30,900	193,125	568,279	6,796,617
Belgium and Luxembourg	272,605	2,381,048	532,546	4,616,487
Netherlands	188,555	2,442,533	450,411	5,265,899
France	25,000	286,771	29,710	435,548
Other countries	6,500	66,283	–	–
Total	30,473,701	356,007,314	30,799,252	360,818,505

Source: Dominion Bureau of Statistics.
*Total shipments of byproduct iron ore compiled by Mineral Resources Division from data supplied by individual companies. Total iron ore shipments include shipments of byproduct iron ore.
p Preliminary; – Nil; .. Not available.

TABLE 2

Iron Ore – Production, Trade and Consumption, 1956–65

(long tons)

	Production (shipments)	Imports	Exports	Consumption* (indicated)
1956	19,953,820	4,525,768	18,094,080	6,385,508
1957	19,885,870	4,052,704	17,972,769	5,965,805
1958	14,041,360	3,047,301	12,391,314	4,697,347
1959	21,864,576	2,500,894	18,552,488	5,812,982
1960	19,241,813	4,514,596	16,942,140	6,814,269
1961	18,177,681	4,132,280	14,868,166	7,441,795
1962	24,428,282	4,604,819	21,645,758	7,387,343
1963	26,913,972	5,325,713	23,854,973	8,384,712
1964	34,219,484	5,233,434	30,473,701	8,979,217
1965P	35,525,523	4,763,029	30,799,252	9,489,300

Source: Dominion Bureau of Statistics.
*Shipments plus imports less exports with no account taken of changes in stocks at consuming plants.
P Preliminary.

MARKETS AND TRADE

Canadian iron ore is consumed by steel industries in five main market areas – Canada, the United States, Britain, Japan and western Europe. Shipments to domestic steel plants, to Japan and to western Europe were higher than in 1964 while shipments to the U.S. and Britain were slightly lower. The United States is the world's largest iron ore importer and is Canada's largest market. It accounts for 67 per cent of total shipments in 1965 even though U.S. imports from Canada were a million tons lower than in 1964. Western European imports from Canada rose to about 2.3 million tons, an increase of approximately 1.5 million tons from 1964, and reflected greater consumption of high-grade concentrates and pellets, mainly in West Germany, Italy, Belgium and Luxembourg. Shipments to Britain declined from 3.2 million tons to 2.9 million tons in 1965, mainly as the result of intensive competition from West African ores. Canadian exports in 1965 rose to 30.8 million tons from 30.5 million tons in 1964. Consumption of iron ore in Canada was up slightly from 1964. Imports, mainly from the United States, decreased to 4.8 million tons from 5.2 million tons in 1964 while shipments of domestic ore to the Canadian steel industry increased slightly to about 4.2 million tons from 4.0 million tons in 1964.

WORLD PRODUCTION

World production of iron ore increased 4 per cent in 1965 to meet the requirements of higher steel production in nearly all major industrial countries. Iron ore markets in Britain, western Europe, and Japan, all of which have highly advanced economies and are large importers of iron ore, continued to be very competitive. They will probably become even more competitive as production from large sources of iron ore begins or is increased in many areas of the world, particularly in West Africa, South America and Australia.

Probably of most long-range significance to world iron ore trade in 1965 was the continuing development of large, high-grade iron ore deposits in northwestern Australia. Long-range delivery contracts, amounting to more than 13 million tons a year, have been made with Japan. An initial contract was also signed for delivery of Australian iron ore to Britain. Also of significance in 1965 were the export of concentrate by the U.S.S.R. to Britain; the buildup of iron ore productive capacity in countries of West Africa to over 31 million tons a year; the plans to increase iron ore production and shipping facilities in Brazil, with participation of foreign interests, to about 20 million tons a year from today's 13 or 14 million tons;

TABLE 3

Production of Iron Ore* by country, 1962–65

(thousand long tons)

	1962	1963	1964	1965P
U.S.S.R.	126,079	135,304	143,695	151,272
United States	71,829	73,599	84,836	87,430
France	62,254	56,978	59,971	59,166
Canada	24,428	26,914	34,522	34,152
China	29,500	34,400	36,400	30,510
Sweden	21,675	23,259	26,116	29,019
India	13,151	14,690	14,646	20,963
Venezuela	13,057	11,562	15,403	17,863
Liberia	3,550	6,453	10,291	17,420
Britain	15,277	14,912	16,068	15,413
Brazil	10,567	11,042	14,763	14,369
Chile	7,964	8,373	9,697	11,791
West Germany	16,380	12,694	11,430	10,676
Total	415,711	430,180	477,838	500,044
Other countries	83,399	83,481	88,878	89,187
World total	499,110	513,661	566,716	589,231

Source: American Iron and Steel Institute *Annual Statistical Report 1965.*
* Direct-shipping, concentrates and agglomerates.
P Preliminary.

and plans for increased production from many other countries, particularly Sweden, Peru and India.

The steel industry in Canada and the United States obtains about 90 per cent of its iron ore requirements from 'captive' iron mines in that the steel companies receive iron ore nearly entirely from mines in which they participate. There is relatively little 'merchant' ore used by the North American steel industry. On the other hand, nearly all iron ore consumed by the steel industries of the other industrial nations of the non-Communist world is obtained under contract from merchant iron ore companies – little captive iron ore is available, as steel companies in those countries have not been major participants in the financing of iron ore projects in foreign lands. This pattern is changing slowly, but only slowly.

The trend toward beneficiation of iron ore to as high a degree as practicable for blast furnace feed continued and is becoming more pronounced each year. Pelletizing is the preferred method for agglomeration of iron ore concentrates from low-grade ores, particularly in North America. The trend is due to economic, transportation, engineering, and probably metallurgical factors. However, many steel plants maintain high rates of pig-iron production from efficient operations using sized, self-fluxing good-grade sinter. Results are comparable to those obtained by using pellets. However, sinter is not transported long distances. It is usually an in-plant operation at the blast furnace location and is made from screened fines from good-grade direct-shipping ore or from concentrate. Pellet capacity in Canada and the U.S. at the end of 1965 was 48 million tons a year; world capacity was about 56 million tons. Under construction in the U.S. and Canada were nearly 20 million tons a year of pellet capacity and in the rest of the world an estimated 7 million tons a year were being built or immediately planned. Long-range projections of the growth of pellet capacity are hazardous and subject to much questioning and speculation though evidently the trend toward using high-grade, sized feed for blast furnaces remains strong.

DOMESTIC CONSUMPTION

Iron ore is used primarily as a raw material in the making of iron and steel. Small amounts of iron oxides, not properly iron ore, are used in the manufacture of paint and cement, for heavy aggregate in concrete, as heavy media in some beneficiation plants and for agriculture. Most iron ore is made into pig iron, some of which is used by iron foundries. Most pig iron, however, along with steel scrap, fluxes, additive agents, etc., goes into the production of crude steel. Some iron ore is also used in steelmaking furnaces. Table 4 summarizes statistics on the consumption of iron ore in Canadian iron and steel plants.

TABLE 4

Consumption of Iron Ore in Canadian Iron and Steel Plants, 1964–65

(tons)

	1964	1965
In blast furnaces, direct	7,284,486	7,835,208
In steel furnaces, direct	325,366	254,675
In sintering plants before ore is charged to blast or steel furnaces	1,271,686	1,188,084
Miscellaneous	98	148
Total	8,881,636	9,278,115

Source: American Iron Ore Association, compiled from company submissions.

TABLE 5

Consumption and Stocks of Iron Ore at Canadian Iron and Steel Plants, 1964–65

(long tons)

	1964	1965
Receipts imported	5,194,724	
Receipts from domestic sources	3,532,110	
Total receipts at iron and steel plants	8,726,834	9,460,961
Consumption of iron ore	8,881,636	9,278,115
Stocks of ore at iron and steel plants, December 31	3,518,381	3,814,534
Change from previous year	+ 1,820	+ 296,153

Source: American Iron Ore Association, compiled from company submissions.

CANADIAN DEVELOPMENTS

NEWFOUNDLAND AND LABRADOR

Dosco Industries Limited continued research on ore from its Wabana mine to find economic methods of upgrading the fines. Ore shipments were 1,186,732 tons in 1965, down about 4.5 per cent from 1964. Shipments of Wabana ore to the parent company's Sydney, N.S., steel plant fell by about 60 per cent. Exports were 21 per cent higher because of an increase of 87 per cent in shipments to Belgium. There was a drop of 43 per cent in shipments to Britain. The mine operated throughout the year and large tonnages of fines from screening were added to stockpiles. Dosco is experiencing increasing difficulty in marketing its ore from Wabana Mines Division because of its relatively low iron and high phosphorus and silica contents.

TABLE 6

Production and Capacity of Pig Iron and Crude Steel at Canadian Iron and Steel Plants, 1964–65

(short tons)

	1964	1965p
Pig iron		
Production	6,540,679	7,064,880
Capacity at December 31	7,288,200	7,883,000
Steel ingots and castings		
Production	9,130,763	10,028,899
Capacity at December 31	10,908,836	11,797,770

Source: Dominion Bureau of Statistics.
p Preliminary.

Production of pellets and concentrate at the Carol project of Iron Ore Company of Canada (IOC) at Labrador City was at capacity. Shipments reached 6.83 million tons, composed of 5.33 million tons of pellets and 1.50 million tons of concentrates. In 1965, the automated railroad was extended to serve the Carol East orebody 7.5 miles from the concentrator. A $2 million expansion was also carried out at the concentrator to upgrade the product and recover an additional 500,000 tons of magnetite concentrate a year by passing the tailings over magnetic separators. The company was expected to announce expansion of pellet capacity by Carol Pellet Company from 5.5 million tons to 10 million tons a year.

The nearby open pit and concentrator of Wabush Mines were officially opened in June 1965. Production capacity is rated at 5.3 million tons of concentrate a year grading 66 per cent iron. The concentrate is railed to the port at

Pointe Noire, Quebec, where a pelletizing plant operated by Arnaud Pellets, an associated company, has a capacity to produce 4.9 million tons of pellets a year. Arnaud Pellets' plant was officially opened in July 1965. Total project cost of Wabush Mines and Arnaud Pellets was about $300 million. The Steel Company of Canada (STELCO) and Dominion Foundries and Steel (DOFASCO) together own 38.5 per cent of Wabush Mines and a somewhat higher portion of Arnaud Pellets. Shipments of pellets were 2.01 million tons in 1965.

LABRADOR-QUEBEC

Shipments of direct-shipping ore from the Schefferville operations of Iron Ore Company of Canada were 7.02 million tons, slightly lower than in 1964. A railway spur was being built northwards to the Redmond deposit that is to be developed in 1966.

QUEBEC

Quebec Cartier Mining Company shipped 8.23 million tons of concentrate in 1965, down 10 per cent from 1964.

Hilton Mines, Ltd., shipped 893,779 tons of pellets, about the same as the previous year. The company continued to increase its effective annual production capacity through plant and process improvements.

Quebec Iron and Titanium Corporation mines ilmenite, a titanium-iron oxide, at Lac Tio, Quebec, and smelts it in electric furnaces at Sorel, Quebec, to produce titania slag (TiO_2) and pig iron. Consumption of ilmenite at Sorel was 1,177,145 tons from which 487,425 tons of slag and 332,785 tons of pig iron were produced. Comparable figures for 1964 were 1,239,520 tons, 486,258 and 335,762 tons, respectively. Although pig iron is produced from ilmenite, the latter is not classed as iron ore and is not included in iron ore statistics.

ONTARIO

Algoma Ore Properties Division of The Algoma Steel Corporation, Limited shipped a record tonnage of sinter. The parent company's Sault Ste. Marie Steelworks and Port Colborne blast furnace plant took 1,623,518 tons, and exports to the U.S. were 197,837 tons, down about 17 per cent, from 1964. The replacement of three small sintering machines installed in 1939 with one large modern machine was nearly completed at the year's end. The new machine is capable of producing 1 million tons of sinter annually while the three obsolete machines to be replaced were capable of producing less than 700,000 tons a year. Algoma continued to investigate possible new iron ore sources in northwestern Ontario and in July 1965 the company exercised its option with Can-Fer Mines Limited on the latter's low-grade magnetite deposit near Nakina. There are no immediate plans to bring the property into production.

On the Steep Rock Range, Caland Ore Company Limited had slightly lower shipments in 1965 at 1,802,234 tons. Caland Ore's screening plant with a capacity of 2.3 million tons was completed in the spring. Its pelletizing plant with a capacity of 1 million tons a year made trial runs in the fall. The pelletizing plant started regular operations early in January 1966. Shipments by Steep Rock Iron Mines Limited in 1965 were 1.26 million tons, about the same as in 1964. In addition to the proposed supply of 1,100,000 tons of pellets a year for Algoma, Steep Rock Iron Mines Limited plans to supply pellets to other North American steel producers. A 26-year contract for the supply of 250,000 tons of pellets annually was under negotiation. The pelletizing plant planned by Steep Rock will have an initial capacity of 1,350,000 tons a year and is designed for expansion to double this capacity. The Canadian Charleson Mine of Oglebay Norton Company shipped 34,534 tons of concentrate from stockpile. The company began production in 1958 but did not operate the mine in 1961, 1963 and 1965. Total shipments were 704,638 tons. Upon final shipment in July, the mine was permanently closed and all mining machinery was sold.

Lowphos Ore, Limited shipped 648,368 tons of pellets, slightly more than in 1964 and a new record. Shipments of pellets by Marmoraton Mining Company, Ltd., declined to 452,773 tons from 554,799 tons in 1964.

The Adams Mine of Jones & Laughlin Steel Corporation began plant operations near the end of 1964. An initial small shipment of pellets was made in December and regular shipments began in February 1965. The pelletizing plant, near Kirkland Lake, has a capacity of 1 million tons a year. Pellets are shipped the year round by rail to the parent company's steel plants in the U.S., mainly to Pittsburgh, Pa. Shipments in 1965 were 750,220 tons of pellets.

The Ontario byproduct producers – The International Nickel Company of Canada, Limited and Falconbridge Nickel Mines, Limited, – operated their iron ore recovery plants at capacity.

At Timagami preparation for production at the $40 million Sherman mine project began in 1965. The Sherman mine is owned 90 per cent by Dominion Foundries and Steel, Limited of Hamilton, Ontario, and 10 per cent by Tetapaga Mining Company Limited, a wholly-owned subsidiary of The Cleveland-Cliffs Iron Company of Cleveland, Ohio. This project is being developed to produce 1.2 million tons of pellets a year beginning in 1968.

The Steel Company of Canada, Limited was considering a $50 million pelletizing operation on the optioned property of Iron Bay Mines Limited at Bruce Lake near Red Lake. The project will probably have an initial design capacity of 1.5 million tons a year and be scheduled for production in 1968.

Several companies continued exploration of large low-grade magnetite iron formations and others were actively negotiating with steel companies for development of their properties.

PRAIRIE PROVINCES

For several years, Peace River Mining & Smelting Ltd., in association with the Research Council of Alberta, has conducted research on oolitic iron ore from a large deposit in the Peace River area of Alberta, some 400 miles north of Edmonton. In 1965, the Research Council completed construction of a $1.5 million multipurpose pilot plant facility near Edmonton in which Peace River is leasing space to test a hydrometallurgical (HCl acid-leach) process to produce high-purity iron powders. Pilot plant testing is expected to begin in 1966.

BRITISH COLUMBIA

Five west coast iron mines produced and shipped magnetic concentrates to Japan in 1965. In addition, The Consolidated Mining and Smelting Company of Canada Limited tripled its production capacity of byproduct iron from pyrrhotite tailings. Higher shipments were recorded by Zeballos Iron Mines Limited and Coast Copper Company, Limited, both on Vancouver Island, and by Texada Mines Ltd. on Texada Island. Shipments by Brynnor Mines Limited on Vancouver Island and by Jedway Iron Ore Limited in the Queen Charlotte Islands were lower in 1964.

Orecan Mines Ltd. commenced production in September 1965 at its 1,250-ton-a-day concentration plant near Kelsey Bay, about 50 miles northwest of Campbell River on Vancouver Island. The plant, at year's end was producing about 500 tons a day of magnetite concentrate, which was stockpiled at the port.

Two companies are preparing for production in 1966 or 1967. Empire Development Company, Limited, was nearing completion of its underground development program that started in 1964. The company ceased operation late in 1963 when its developed ore reserves were depleted, and will resume mining and milling of further underground reserves that were discovered late in 1963. The other new producer will be Wesfrob Mines Limited, a subsidiary of Falconbridge Nickel Mines, Limited. In 1964, the company began development of several magnetite-copper orebodies on Moresby Island in the Queen Charlotte Islands. Some $38 million will be spent in preparing the property for mining and the construction of a 15,000-ton-a-day magnetic separation and copper flotation concentrator together with loading dock, power plant and townsite. Production is scheduled to begin in early 1967.

YUKON AND NORTHWEST TERRITORIES

Crest Exploration Limited, a subsidiary of Standard Oil Company of California, continued feasibility and metallurgical studies on its large Snake River iron deposits in the Yukon Territory. Latest reserve estimates indicate a total of over 11 billion tons of material grading 43.8 per cent iron using a grade cut-off of 35 per cent iron. Production from these deposits is not envisaged for many years.

Baffinland Iron Mines Limited, in which Anglo American Corporation of South Africa Limited and Hudson Bay Mining and Smelting Co., Limited have interests, continued feasibility studies that were initiated in 1964. Indicated ore reserves in one of the four major high-grade deposits were estimated to be over 127 million tons grading 67.8 per cent iron. Potential reserves are much greater in this and the other three high-grade deposits.

TABLE 7

Canadian Producers of Iron Ore During 1965

Company and Property Location	Participating Companies	Product Mined (average natural grade, % Fe)	Product Shipped (average natural grade, % Fe)	Shipments[1] (thous. long tons)	
				1964	1965
The Algoma Steel Corp. Ltd., Algoma Ore Properties Division; mines, sinter plant near Wawa, Ont.	Wholly owned	Siderite, open-pit and underground mines (32.99)	Ore beneficiated by sink-float, sintered (50.54% Fe, 2.9% Mn)	1,783	1,825
Arnaud Pellets; Pointe Noire, Que.	All participants of Wabush Mines except Mannesmann and Hoesch	Operated by Pickands Mather & Co. to process Wabush Mine's concentrate	Pellets (65)	–	1,883P
Brynnor Mines Ltd.; near Ucluelet, Vancouver Is., B.C.	Noranda Mines Ltd.	Magnetite, open-pit mine (54)	Magnetite concentrate (60.2)	673	595
Caland Ore Co. Ltd.; E. arm of Steep Rock L., N. of Atikokan, Ont.	Inland Steel Co.	Hematite and goethite, open-pit mines (53.28)	Direct-shipping ore (53.28) concentrate (56.04) (pellets in 1966)	2.001	1,802
Canadian Charleson Mine; S. of Steep Rock L.. near Atikokan, Ont.	Oglebay Norton Co.	Hematite-bearing gravels (12-20)	Jig, spiral concentrate (55)	182	35
Carol Pellet Company; adjacent IOC's concentrator, Labrador City, Lab.	U.S. participants of IOC	Company's plant operated by IOC, to process IOC concentrate	Pellets (64.27)	4,942	5,325
Coast Copper Co. Ltd.; Benson L., northern Vancouver Is.. B.C.	COMINCO	Copper ore, underground mine containing 30.5% Fe as magnetite	Magnetite concentrate (59.5)	52	91
Empire Development Co., Ltd.; Benson R., 25 m. SW. of Port McNeill, Vancouver Is., B.C.	Loram Ltd.; Quatsino Copper-Gold Mines, Ltd.	Magnetite, underground mine (35.5)	Magnetite concentrate (54.1)	16[4]	–
Hilton Mines, Ltd.; near Shawville, Que., 40 m. NW. of Ottawa	The Steel Co. of Canada, Ltd.; Jones & Laughlin Steel Corp.; Pickands Mather & Co.	Magnetite. open-pit mine (approx. 18)	Iron oxide pellets (66.3)	898	894P
Iron Ore Company of Canada; Schefferville, Que.	The Hanna Mining Co.; Hollinger Consolidated Gold Mines, Ltd.; Armco Steel Corp.; Bethlehem Steel Corp.; National Steel Corp.; Republic Steel Corp.; Wheeling Steel Corp.; The Youngstown Sheet and Tube Co.	Goethite-limonite, open-pit mines (53.6)	Direct-shipping ore (53.6)	7,670	7,025
Labrador City, Nfld.	Same as above	Specular hematite, open-pit mine (38.4)	Specular hematite concentrate (62.50)	1,550[2]	1,505[2]
Jedway Iron Ore Ltd.; Moresby Is., Queen Charlotte Is., B.C.	The Granby Mining Co. Ltd.	Magnetite, open-pit mine (31)	Magnetite concentrate (58.4)	383	353

Table 7 (cont.)

Company and Property Location	Participating Companies	Product Mined (average natural grade, % Fe)	Product Shipped (average natural grade, % Fe)	Shipments[1] (thous. long tons)	
				1964	1965
Jones & Laughlin Steel Corp. (Adams mine) Boston tp., near Kirkland Lake, Ont.	Wholly owned	Magnetite, open-pit mine (20.9)	Pellets (62.2)	—	750
Lowphos Ore, Ltd.; Sudbury area, 20 m. N. of Capreol, Ont.	National Steel Corp.; The Hanna Mining Co. (managing agents)	Magnetite, open-pit mine (34)	Pellets (62.8)	623	648
Marmoraton Mining Co., Ltd.; near Marmora, in southern Ont.	Bethlehem Steel Corp.	Magnetite, open-pit mine (about 43)	Pellets (64.9)	555	453
Nimpkish Iron Mines Ltd.; 26 m. W. of Beaver Cove, Vancouver Is., B.C.	International Iron Mines Ltd.; Standard Slag Co.	Magnetite, open-pit mine (37.3)	Magnetite concentrate (58.1)	25[4]	—
Orecan Mines Ltd.; Menzies Bay, Vancouver Is., B.C.	Public stock company	Magnetite, open-pit mine (45)	Magnetite concentrate (+62)	—	—
Quebec Cartier Mining Co.; Gagnon, Que.	United States Steel Corp.	Specular hematite-magnetite, open-pit mine (32.7)	Specular hematite-magnetite concentrate (64.9)	9,142	8,229
Steep Rock Iron Mines Ltd.; Steep Rock L., N. of Atikokan, Ont.	Premium Iron Ores Ltd.; The Cleveland-Cliffs Iron Co., and others	Hematite-goethite, open-pit, underground mines (54.1)	Direct-shipping ores, gravity concentrates (55.2)	1,312	1,264
Texada Mines Ltd.; Texada Is., B.C.	Private company	Magnetite, open-pit, underground mines (35.7)	Magnetite concentrate (59.7)	515	531
Dosco Industries Limited, Wabana Mines Division; Bell Is., Conception Bay, E. coast of Nfld.	Wholly owned	Hematite-chamosite, underground mine (47.9)	Heavy-media concentrate (50.6)	1,243	1,187
Wabush Mines; Pickands Mather & Co. managing agent; Wabush, near Labrador City, Lab., 190 m. N. of Sept-Iles	The Steel Co. of Canada, Ltd.; Dom. Foundries and Steel, Ltd.; Mannesmann Canadian Iron Ores Ltd.; Hoesch Iron Ores Ltd.; and Wabush Iron Co, Ltd. The Youngstown Sheet and Tube Co.; Inland Steel Co.; Interlake Steel Corp.; Pittsburgh Steel Co.; Finsider of Italy and Pickands Mather & Co.)	Specular hematite-magnetite, open-pit mine	Concentrate	—	130[5]P
Zeballos Iron Mines Ltd.; near Zeballos, Vancouver Is., B.C.	Falconbridge Nickel Mines, Ltd.	Magnetite, underground mine (52.8)	Magnetite concentrate (63.63)	82	242

Table 7 (cont.)

Company and Property Location	Participating Companies	Product Mined (average natural grade, % Fe)	Product Shipped (average natural grade, % Fe)	Shipments[1] (thous. long tons) 1964	1965
Byproduct Producers					
The Consolidated Mining and Smelting Co. of Canada Ltd.; Kimberley, B.C.	Wholly owned	Pyrrhotite flotation concentrates roasted for acid production. Calcine sintered	Iron oxide sinter (about 65) further processed into pig iron at plant	66[3]	143[3]
Falconbridge Nickel Mines, Ltd.; Falconbridge, Ont.	Wholly owned	Pyrrhotite flotation concentrates treated	Iron oxide calcine (about 67)	71	90
The International Nickel Co. of Canada, Ltd.; Copper Cliff, Ont.	Wholly owned	Pyrrhotite flotation concentrates treated	Iron oxide pellets (68)	734	889
Cutler Acid Limited; Copper Cliff, Ont.	Canadian Industries Limited	Plant formerly treated iron sulphide concentrates	Iron oxide calcine (about 66)	–	14[4]
Quebec Iron and Titanium Corp.; mine at Lac Tio, Que., electric smelter at Sorel, Que.	Kennecott Copper Corp.; The New Jersey Zinc Co.	Ilmenite-hematite, open-pit mine (40% Fe, 35% TiO_2)	TiO_2 slag, various grades of desulphurized pig iron or remelt iron	1,240[3]	1,177[3]

Sources: Company reports, personal communications and other.
[1]Statistics supplied by companies to Mineral Resources Division. [2]Does not include concentrate pelletized by Carol Pellet Company.[3] Iron oxide sinter or ilmenite consumed. Ilmenite not included in iron ore statistics. [4]Shipments from stockpile. [5]Does not include concentrate pelletized by Arnaud Pellets.

– Nil; P Preliminary.

TABLE 8

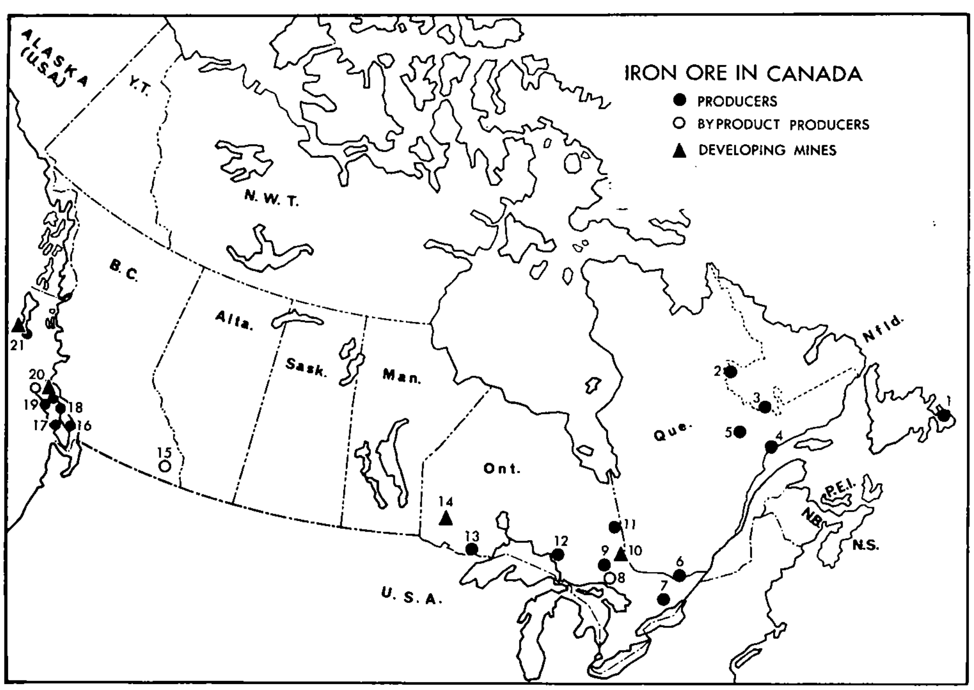
Companies Under Development With Announced Plans for Production

Company and Expected Production Date	Property Location	Participating Companies	Product to be Mined (% Fe)	Product to be Shipped (% Fe)	Designed Annual Capacity (long tons)
Carol Pellet Company (1967)	Labrador City, Nfld.	U.S. participants of Iron Ore Company of Canada	Company's plant operated by IOC to process IOC concentrate. Expansion of 4,500,000 long tons.	Pellets (64.3)	10,000,000
Empire Development Company Limited (1966)	Benson R., Vancouver Is., B.C.	Quatsino Copper-Gold Mines Ltd., and others	Magnetite iron formation, underground mine (35.5)	Magnetite concentrate (about 54)	150,000
Steep Rock Iron Mines Limited (1967)	Steep Rock L., Ont.	Premium Iron Ores Ltd., The Cleveland-Cliffs Iron Company, and others	Hematite-goethite, open-pit, underground mines (54.1)	Pellets (about 64)	1,350,000

Table 8 (cont.)

Company and Expected Production Date	Property Location	Participating Companies	Product to be Mined (% Fe)	Product to be Shipped (% Fe)	Designed Annual Capacity (long tons)
Strathagami Mines, Inc. (Sherman mine) (1968)	Near Timagami, Ont.	Dominion Foundries and Steel, Limited (90%) and The Cleveland-Cliffs Iron Company (10%) through Tetapaga Mining Company, a wholly owned subsidiary	Magnetite iron formation, open-pit mine (22-25)	Pellets (about 65)	1,200,000
The Steel Company of Canada, Limited (Griffith mine) (1968)	Bruce L., near Red L., Ont.	The Steel Company of Canada, Limited, and Pickands Mather & Co. (managing agent)	Magnetite iron formation, open-pit mine (30-33)	Pellets (about 65)	1,500,000
Wesfrob Mines Limited (1967)	Tasu Harbour, Moresby Is., Queen Charlotte Is., B.C.	Falconbridge Nickel Mines, Limited	Magnetite and chalcopyrite, open-pit (37)	Magnetite concentrate for sintering, pelletizing (about 60)	1,100,000

Sources: Company reports and other.



PRODUCERS

(numbers refer to numbers on map)

1. Dosco Industries Limited, Wabana Mines Division
2. Iron Ore Company of Canada
3. Iron Ore Company of Canada Wabush Mines
4. Arnaud Pellets
5. Quebec Cartier Mining Company
6. Hilton Mines, Ltd.
7. Marmoraton Mining Company, Ltd.
9. Lowphos Ore, Limited
11. Jones & Laughlin Steel Corporation (Adams mine)
12. The Algoma Steel Corporation, Limited, Algoma Ore Properties Division
13. Caland Ore Company Limited
    Steep Rock Iron Mines Limited
16. Texada Mines Ltd.
17. Brynnor Mines Limited
18. Orecan Mines Ltd.
19. Zeballos Iron Mines Limited
21. Jedway Iron Ore Limited

BYPRODUCT PRODUCERS

8. Falconbridge Nickel Mines, Limited
   The International Nickel Company of Canada, Limited
15. The Consolidated Mining and Smelting Company of Canada Limited
20. Coast Copper Company, Limited

PROSPECTIVE PRODUCERS

10. Strathagami Mines, Inc. (Sherman mine) (1968)
14. The Steel Company of Canada, Limited (Griffith mine) (1968)
20. Empire Development Company, Limited (1966)
21. Wesfrob Mines Limited (1966)

PRICES AND TARIFFS

Prices received by most iron ore producers in central and eastern Canada for sales to North American consumers are a reflection of the Lake Erie base price that is the price paid per long ton of iron ore delivered to rail of vessel at Lake Erie ports. The Canadian mine price may be approximated by deducting the appropriate handling and transportation charges. The Lake Erie price is based on a natural iron content of 51.5 per cent and various other physical and chemical specifications.

The Lake Erie price rose steadily from the mid-nineteen-forties until April 1962 when the price declined 7 per cent as a result of increasing supplies from Canada and overseas and falling prices in international markets. Downward pressure was exerted on North American ore prices with discounts being granted by ore producers. The price has been relatively stable since July 1963 when Great Lakes freight rates were reduced 10 cents a ton thereby lowering the Lake Erie price. Base prices received by British Columbia mines are individually negotiated but generally range from $8 to $9.70 (U.S.) a metric ton, f.o.b. loading port, for ore grading 57 to 62 per cent iron.

World prices continued to suffer downward pressure during 1965. This trend was particularly apparent to producers and potential producers that supply or would supply Western Europe and Japan. A continuing down-trend seems indicated by announcements in November 1965, of a probable 3-per-cent price reduction of Swedish phosphoric ores to be marketed in West Germany in 1966. Canadian iron ore producers have been compelled to accept steadily lower prices on their European sales in competition with high-grade ores from Sweden and countries in South America and West Africa.

TABLE 9

Lake Erie Base Prices,* 1951-66
(Mesabi non-Bessemer grade)
($ U.S.)

	Long Tons	Units of Iron
1951-52 (to July)	8.30	0.1612
1952	9.05	0.1757
1953 (to July)	9.70	0.1884
1953-54	9.90	0.1922
1955	10.10	0.1961
1956	10.85	0.2107
1957-61	11.45	0.2223
1962-63 (to July)	10.65	0.2068
1963-66	10.55	0.2049

*Basis 51.50% Fe, unscreened, delivered to rail of vessel at Lake Erie ports. Premium for coarse ore 80¢ a ton; penalty for fine ore 45¢ a ton.

The quoted price of Lake Superior pellets grading 63 per cent iron was 25.2 U.S.

cents a long-ton unit*, or approximately $15.88 a long ton, delivered to rail of vessel at Lower Lake ports. This price has not changed for several years.

Downward pressure on world prices of pellets is indicated by prices listed for sales to Japan of future Australian pellets grading about 65 per cent iron. Australia began negotiating contracts for the export of iron ore to Japan where the c.i.f. price, Japan, was 24 to 26.5 U.S. cents a long-ton unit. Late in 1965, the quoted c.i.f. price per unit was, in some cases, down to 19 U.S. cents a unit for direct shipping ore to be delivered in 1966 and down to the same level for pellets to be delivered in 1970. It is estimated that the average c.i.f. price of iron ore in Japan has been reduced by up to 30 per cent since 1961 because of greatly increased competition for Japanese markets.

Neither Canada nor any of its iron ore customers have tariffs on iron ore.

*A long-ton unit is 1 per cent of a long ton (22.4 pounds).

Development of the iron ore property of Wesfrob Mines Limited at Tasu Harbour, Moresby Island, in the Queen Charlotte Islands off the coast of British Columbia.

Iron and Steel

G.E. WITTUR*

Production of iron and steel rose substantially in 1965 for the fifth successive year. Output of crude steel reached 10.03 million net tons compared with 9.13 million tons in 1964 and 8.19 million tons in 1963. Despite near-capacity operation of iron and steel production facilities, domestic steel demand rose faster than steel production and imports rose sharply while exports declined. Consumption, in crude steel equivalent, rose 19.5 per cent to 11.7 million tons. Investment in new steel facilities and modernization of existing facilities continued at a high level although a forecast of expenditures, made at the end of 1964, was not reached. Investment is expected to increase sharply in 1966 to a new record. The medium- and long-term outlook is for steady growth in steel consumption although the growth rate will probably be lower than the average of more than 14 per cent a year from 1961 to 1965. Production is expected to reach 10.6 million tons in 1966.

WORLD PRODUCTION

Canada rose from twelfth to ninth place among world steel producers in 1965, having displaced Poland, Czechoslovakia and Belgium for the first time. World steel production continued to expand and exceeded 500 million tons. Growth was particularly strong in the United States, the U.S.S.R., Japan, Italy and the Netherlands, among the world's more significant producers. Most other countries had higher output but exceptions included East and West Germany, France, Chile, Brazil and Finland, all of which registered slight declines from 1964. A growing concern about world overcapacity developed in 1965; new capacity has been added in recent years exceeding the increase in demand. The trend of developing countries to build their own steel plants has been a limiting factor in the expansion of exports by industrial countries and competition for export markets has become very keen. The construction of new steel plants to be based, even in part, on export markets has become extremely hazardous.

* Mineral Resources Division

TABLE 1

General Statistics of Canada's Primary Iron and Steel Industry 1963–65

	1963	1964	1965
Production			
Index (1949 = 100)			
Total industrial production	215.3	235.3	254.9
Primary iron and steel industry	255.4	291.2	320.0
	($ millions)	($ millions)	($millions)
Value of shipments	953.3	1,087.4	1,189.1
Value of unfilled orders, year-end	112.5	142.3	136.7
Value of inventory owned, year-end	201.5	212.6	255.9
Value of exports*	166.1	210.1	203.7
Value of imports*	207.8	285.3	372.6
Employees			
Administrative	7,054	7,721	8,121
Hourly rated	32,193	35,117	37,433
Total	39,247	42,838	45,554
Average hours per week by hourly rated	40.5	40.7	40.7
Average earnings per hour by hourly rated	$ 2.67	$ 2.71	$ 2.83
Average wages and salaries per week, all employees	$114.42	$ 114.48	$ 118.36
Employment index, all employees (1949 = 100)	131.0	143.2	153.2
Expenditures			
Capital	($ thousands)	($ thousands)	($ thousands)
On construction	28,309	36,600	25,310
On machinery	83,811	169,468	127,099
Total	112,120	206,068	152,409
Repair			
On construction	5,335	5,479	6,482
On machinery	90,288	108,319	122,996
Total	95,623	113,798	129,478
Total capital and repair	207,743	319,866	281,887

Source: Dominion Bureau of Statistics.

*Includes pig iron, steel castings, steel ingots and rolled products but does not include steel in forgings or manufactured products such as machinery and equipment.

TABLE 2

World Production of Steel
(thousand net tons)

	1960	1963	1964r	1965p
North America				
Canada	5,790	8,190	9,131	10,029
United States	99,282	109,261	127,076	131,462
Total North America	105,072	117,451	136,207	141,491
Latin America	5,378	7,731	8,952	8,992

Table 2 (cont.)

	1960	1963	1964r	1965p
Western Europe				
Belgium	7,913	8,295	9,510	9,986
France	19,069	19,350	21,806	21,609
West Germany	37,590	34,830	41,160	40,586
Italy	9,071	11,196	10,795	13,930
Luxembourg	4,503	4,445	5,133	5,167
Netherlands	2,141	2,582	2,930	3,437
Total ECSC countries	80,287	80,698	91,334	94,715
Britain	27,222	25,223	29,378	30,247
Other	12,644	14,463	16,516	17,705
Total Western Europe	120,153	120,384	137,228	142,667
Eastern Europe				
Czechoslovakia	7,460	8,375	9,233	9,480
Poland	7,364	8,823	9,445	10,013
U.S.S.R.	71,971	88,434	93,691	100,305
Other	8,026	10,603	11,317	11,404
Total	94,821	116,235	123,686	131,202
Africa	2,517	3,260	3,633	3,640
Middle East	187	257	292	292
Far East				
China	20,337	9,000	11,000	13,228
India	3,623	6,587	6,653	6,899
Japan	24,403	34,727	43,870	45,383
Other	909	1,388	1,732	1,732
Total	49,272	51,702	63,255	67,242
Oceania				
Australia	4,127	5,119	5,622	5,736
Other	55	100	150	150
Total	4,182	5,219	5,772	5,886
World Total	381,582	422,239	479,025	501,412

Source: American Iron and Steel Institute, *Annual Statistical Report*, and *Metal Bulletin*.
p Preliminary; r Revised.

CANADIAN PRIMARY IRON AND STEEL INDUSTRY

There are six producers of pig iron in Canada, including four integrated iron and steel plants, one producer of pig iron in electric furnaces from pyrrhotite that is calcined and sintered, and one that produces pig iron as a coproduct with titania slag in the electric-furnace smelting of ilmenite.

The four integrated plants – two at Hamilton, Ont., and one each at Sault Ste. Marie, Ont., and Sydney, N.S. – accounted for 87 per cent of 1965 crude steel production. In addition there is one major specialty steel producer with plants at Welland, Ont., and Tracy, Que., and several small but regionally important electric steel plants in Nova Scotia, Quebec, Ontario and the four western provinces.*

PIG IRON

Production, exports and consumption rose in 1965 as did shipments to domestic foundries (Table 3). Capacity rose slightly through improvements to existing furnaces. Two new furnaces, both among the largest in the world,

*A complete listing of the Canadian primary iron and steel industry is contained in the booklet *Operators List 1, Part 1: Primary Iron and Steel*, available from the Mineral Resources Division or the Queen's Printer, Ottawa.

TABLE 3

Pig Iron Production, Shipments, Trade and Consumption, 1963–65
(short tons)

	1963	1964	1965
Furnace capacity, Dec. 31	6,905,000	7,288,000	7,643,000
Production			
Basic iron	5,095,081	5,658,853	6,310,754
Foundry iron	312,651	435,621	479,277
Malleable iron	525,538	446,205	274,849
Total	5,933,270	6,540,679	7,064,880
Shipments			
Basic iron	65,910	76,510	98,816
Foundry iron	332,303	457,110	484,192
Malleable iron	360,300	303,144	322,186
Total	758,513	836,764	905,194
Imports	4,035	15,891	33,474
Exports	481,936	585,841	578,879
Consumption of pig iron			
Steel furnaces	5,182,670	5,655,834	6,145,663
Iron foundries	299,509	333,851	372,450
Consumption of iron and steel scrap			
Steel furnaces	4,065,138	4,629,216	5,236,580
Iron foundries	667,649	760,451	919,607

Sources: Dominion Bureau of Statistics, *Primary Iron and Steel* (monthly).
Note: Value of trade is shown in Table 8.

are now under construction and a third is planned. Annual capacity is expected to exceed 10 million tons by 1970.

CRUDE STEEL

Output of crude steel set a new record for the fifth consecutive year (Table 4). Basic oxygen furnaces produced 32.2 per cent of the total, up from 30.5 per cent in 1964. Electric furnaces produced 12.8 per cent (11.1 per cent in 1964) and open hearth furnaces produced 55 per cent (58.4 in 1964). These trends are expected to continue, especially the relative increase of oxygen steel compared with open hearth output. In terms of actual tonnage, however, open hearth production and capacity will continue to increase until at least 1970. Total steel capacity was 11.8 million tons at the end of 1965 and is expected to rise to 14 million tons by 1970.

TABLE 4

Crude Steel Production, Shipments, Trade and Consumption, 1963–65
(short tons)

	1963	1964	1965
Furnace capacity, Dec. 31			
Steel ingot			
Basic open hearth	5,427,000	5,920,000	6,270,000
Basic oxygen converter	2,550,000	3,100,000	3,550,000
Electric	1,008,500	1,324,900	1,434,650
Total	8,985,500	10,344,900	11,254,650
Steel castings	493,740	563,936	543,120
Total	9,479,240	10,908,836	11,797,770
Production			
Steel ingot			
Basic open hearth	4,983,908[e]	5,333,870[e]	5,514,035[e]
Basic oxygen[1]	2,338,826[e]	2,785,482[e]	3,232,572[e]
Electric	742,138	849,632	1,118,991
Total	8,064,872	8,968,984	9,865,598
Steel castings			
Basic open hearth	6,729	1,628	[2]
Electric	118,678	160,151	163,301
Total	125,407	161,779	163,301
Total steel production	8,190,279	9,130,763	10,028,899
Alloy steel in total	433,195	575,956	740,458
Shipments from plant			
Steel ingots	271,923	193,270	251,493
Steel castings	121,933	151,254	157,935
Rolled steel products	5,916,903	6,710,249	7,101,650
Total	6,310,759	7,054,773	7,511,078
Exports in equivalent steel ingots	1,369,401	1,485,056	1,235,208
Imports in equivalent steel ingots	1,295,276	2,134,990	2,891,970
Indicated consumption[3]	8,116,154	9,780,697	11,685,661

Sources: Dominion Bureau of Statistics; estimates by Department of Mines and Technical Surveys, Ottawa.
[1]Contains some electric steel in 1963. [2]Included with electric. [3]Crude steel production plus imports less exports.
[e]Estimated.

TABLE 5

Shipments of Rolled Steel Products By Type, 1963–65
(short tons)

	1963	1964	1965
Hot-rolled products			
Semis	307,078	378,386	382,909
Rails	339,113	269,044	213,469
Wire rod	391,616	442,561	444,659
Structurals			
Heavy	378,042	462,292	442,482
Light	90,523	105,582	99,675
Bars, concrete reinforcing	426,623	564,332	643,009
Bars, other hot-rolled	544,071	603,020	680,123
Tie plate and track material	78,669	80,868	55,953
Sheet and strip	1,017,892	1,058,783	1,181,385
Plates	730,757	865,975	951,463
Total	4,304,384	4,830,843	5,095,127
Cold-rolled products			
Bars	57,737	68,905	74,207
Sheets, tin mill black plate and tinplate	1,166,767	1,335,384	1,412,556
Galvanized sheets	388,015	475,117	519,760
Total	1,612,519	1,879,406	2,006,523
Total shipments	5,916,903	6,710,249	7,101,650
Alloy steel in total shipments	208,540	274,931	342,904

Source: Dominion Bureau of Statistics, *Primary Iron and Steel* (monthly)

SHIPMENTS OF STEEL PRODUCTS

The value of all shipments by the primary iron and steel industry rose by 9.4 per cent in 1965 to $1,189 million (Table 1). The high level of imports (up 30.6 per cent in value) and of unfilled orders at year's end coupled with the decline in exports (down 3 per cent) indicated the tight domestic supply situation in 1965. The shortfall between demand and domestic supply began to ease toward the end of 1965 and with increasing production from new facilities Canadian plants will be able to supply steadily increasing tonnages of steel.

With the exception of railway track materials and structurals, shipments of all major steel products increased in 1965 with bar products and flat-rolled steel being particularly strong (Table 5). Shipments to all steel-consuming industries also rose, excepting construction, appliance and stamping industries and railway operating (Table 6). The apparent decline in domestic shipments to appliance and stamping plants is probably due to changes in classifications of consuming industries.

TABLE 6

Rolled Steel Products, Shipments to Consuming Industries
1963–65
(short tons)

	1963	1964	1965
Automotive and aircraft	414,493	492,139	586,261
Agricultural equipment manufacturers	164,695	185,751	191,962
Construction	1,147,887	1,143,610	1,373,751
Containers	395,656	413,863	440,646
Machinery and tools	286,917	230,726[a]	272,890
Wire, products, fasteners	473,629	522,548[a]	545,757
Resources and extraction	77,646	155,177[a]	176,745
Appliances, utensils, stampings, pressings	307,860	666,922[a]	600,891
Railway operating	250,764	208,607	207,185
Railway cars and locomotives	35,083	79,785	132,114
Shipbuilding	94,679	108,573	125,136
Pipe and tubes	643,344	751,458	797,868
Wholesalers and warehouses	803,610	947,438	1,025,072
Miscellaneous	22,028	19,920	15,754
Total	5,118,291	5,926,517	6,492,032
Direct exports*	798,615	783,732	609,618
Total	5,916,906	6,710,249	7,101,650

Source: Dominion Bureau of Statistics, *Primary Iron and Steel* (monthly)
*Does not include exports by nonproducers nor ingots and castings exported.
[a]Effective 1964, the classification of consuming industries was adjusted and comparability of the series from 1963 to 1964 is not possible For some, the break in the series is not serious. For others, comparisons are very unreliable, particularly those market with [a].

TRADE

Exports of pig iron fell slightly in 1965 while imports, which are small, more than doubled (Table 3). Pig iron was in short supply at the major integrated plants, partly because four furnaces were relined in 1965. Exports of steel ingots rose substantially while exports of semis fell by more than two thirds (Table 7).

Most exports of these two products are for rolling, with subsequent reimport of the rolled products. Changes in the level of exports of these products, therefore, reflect the availability of rolling capacity in Canada, which has been insufficient in recent years. Imports of ingots and semis are normally small.

Imports of rolled products rose 46.1 per cent to a record 2.14 million tons (Table 7); imports of wire rod, structurals, bars and plates were particularly strong. Exports fell 28.9 per cent, although the decline in exports of semis as a result of increased rolling capacity in Canada accounted for nearly three quarters of the total decline.

Net imports of steel products rose to 1.56 million tons ingot equivalent, the highest since 1957, following a trend towards self-sufficiency, which permitted Canada to reach a small net export position in 1963. The trade position since 1963 has been worsened by a shortage of domestic steel. In this respect, there is little prospect for much improvement in 1966 although new capacity completed recently and in the next few years will relieve the shortage. Another factor towards the end of 1965 was the low level of world export prices for steel. Although there was some tendency for these prices to rise early in 1966, low world prices will continue to be a factor in Canada's trade in 1966.

TABLE 7

Trade in Steel Castings, Ingots and Rolled Products, 1963–65
(thousand short tons)

	Imports			Exports		
	1963	1964	1965	1963	1964	1965
Steel castings	4.0	5.7	5.9	11.6	19.3	18.3
Steel forgings	..	4.8	6.5	..	13.1	16.4
Steel ingots	1.7	2.7	1.2	175.3	103.4	194.7
Hot-rolled products						
Semis	1.3	3.7	28.4	202.0	338.8	109.0
Rails	6.9	5.2	7.4	135.2	126.2	72.6
Wire rod	75.7	117.6	183.5	6.1	7.0	5.8
Structurals	233.0	393.2	528.9	28.9	21.8	18.6
Bars	150.0	254.8	382.1	38.3	27.6	28.1
Track material	3.5	2.7	2.0	15.5	35.2	14.3
Plates	98.0	148.1	396.2	23.5	25.7	25.7
Sheet and strip	111.0	193.9	210.4	205.8	127.9	104.0
Total, hot-rolled	679.4	1,119.2	1,738.9	655.3	710.2	378.1
Cold-rolled products						
Bars	4.8	8.9	12.3	1.4	8.2	9.3
Sheet and strip						
Cold	22.0	19.7	30.1	69.9	115.7	135.0
Galvanized	5.2	6.3	8.0	42.3	66.8	59.9
Other	72.2	88.5	111.7	114.4	131.2	118.6
Pipes	121.5	154.3	158.9	21.0	36.2	55.2
Wire	66.4	69.7	82.1	5.4	5.2	6.7
Total, cold-rolled	292.1	347.4	403.1	254.4	363.3	384.7
Total, rolled products	971.5	1,466.6	2,142.0	909.7	1,073.5	762.8
Total, steel	977.2	1,479.8	2,155.6	1,096.6	1,209.3	992.2

Source: Dominion Bureau of Statistics, *Primary Iron and Steel* (monthly).
.. Not available separately.
Note: Related values are in Table 8.

TABLE 8

Value of Trade in Pig Iron, Steel Castings, Ingots and Rolled Products, 1963–65

(thousand dollars)

	Imports			Exports		
	1963	1964	1965	1963	1964	1965
Steel castings	2,492	3,572	4,881	2,904	5,938	5,586
Steel forgings	..	4,399	6,413	..	7,935	9,259
Steel ingots	563	1,046	336	14,859	12,557	21,891
Rolled products						
Hot	91,363	158,439	218,298	75,130	83,787	55,453
Cold	105,632	117,099	141,228	48,840	70,442	82,020
Total	196,995	275,538	359,526	123,970	154,229	137,473
Total steel	200,050	284,555	371,156	141,733	180,659	174,209
Pig iron	787	727	1,395	24,321	29,391	29,482
Total iron and steel	200,837	285,282	372,551	166,054	210,050	203,691

Source: Dominion Bureau of Statistics, *Primary Iron and Steel* (monthly).

Note: The values in this table relate to the tonnages shown in Tables 3 and 7.

.. Not available.

MANPOWER AND LABOUR

The index of employment (1949=100) rose from 143.2 in 1964 to 153.2 in 1965 and brought total employment in the primary iron and steel industry to 45,554 (Table 1). The obtaining of labour with the necessary skills became increasingly difficult in 1965 and companies are finding it necessary to train their own workers to fill skilled positions. The average weekly hours worked by hourly-rated employees remained stable in 1965 after having risen in 1963 and 1964. Average hourly earnings rose from $2.71 to $2.83.

Negotiations for a new labour contract at the two largest integrated works will begin in May 1966. Existing two-year contracts expire in July. The union is reported to be asking for parity with United States wages and other benefits.

RAW MATERIALS

Despite Canada's position as the world's largest exporter of iron ore, nearly one half the iron ore consumed in Canada is imported, mainly from the United States. In the past few years, large domestic steel companies have placed more emphasis on investment in Canadian iron mines. As a result, iron ore imports fell from the 1963 peak of nearly 6 million net tons to 5.3 million tons in 1965 and are expected to be under 2 million tons by 1970. A large mining-concentrating-pelletizing project in Labrador and Quebec, owned 40 per cent by Canadian steel companies, began production in 1965. Construction began on two other new mining-pelletizing projects in Ontario and a pelletizing plant is being built at an existing mine in Ontario. The output from the three projects under construction is committed mainly to domestic steel plants. The four mines will provide at least 6.5 million annual tons of captive pellets to three Canadian steel plants.

The Canadian steel industry is among the world's leaders in the degree of blast furnace charge preparation. Of all iron ores consumed in blast furnaces, the percentage of agglomerates rose from 81.3 per cent in 1964 to 82.5 per cent in 1965 of which pellets accounted for 48.6 per cent, works sinter 17.2 per cent, and mine sinter 16.7 per cent.

Scrap was in adequate supply at most of the major consuming centres in 1965 although regional shortages existed throughout the year. Several of the smaller steelmakers that use only scrap are concerned about the future availability of scrap and are investigating alternative sources of iron in the form of reduced ore. Two Canadian companies, The Steel Company of Canada, Limited (SL/RN

TABLE 9

Steel, Iron, Coke and Sinter Capacity and Production at Integrated Plants[1], 1965

(short tons)

	ALGOMA Sault Ste. Marie	ALGOMA Port Colborne	COMINCO Kimberley	DOFASCO Hamilton	DOSCO Sydney[2]	Q.I.T. Tracy	STELCO Hamilton[2]	Total for Six Companies	National Total
Crude Steel									
Capacity, Dec. 31									
Open hearth	1,150,000	—	—	—	1,070,000	—	4,000,000	6,220,000	6,280,000
Basic oxygen	1,450,000	—	—	2,100,000	—	—	—	3,550,000	3,550,000
Electric	—	—	—	50,850	30,000	—	—	80,850	1,967,770
Total	2,600,000	—	—	2,150,850	1,100,000	—	4,000,000	9,850,850	11,797,770
Production	2,485,723	—	—	1,785,013	778,118	—	3,741,539	8,790,393	10,028,899
Pig iron									
Capacity, Dec. 31									
Blast furnace	2,125,000	240,000	—	1,550,000	876,000	—	2,350,000	7,141,000	7,141,000
Electric	—	—	110,000	—	—	392,000	—	502,000	502,000
Total	2,125,000	240,000	110,000	1,550,000	876,000	392,000	2,350,000	7,643,000	7,643,000
Production	2,053,400	235,724	102,000	1,577,010	500,592	372,719	2,239,317	7,080,762[3]	7,064,880[3]
Coke									
Capacity (from coal), Dec. 31	1,458,000	—	—	607,750	612,000	—	1,275,000	3,952,750	4,506,750
Production	1,447,421	—	—	675,507	344,942	—	1,263,095	3,730,965	4,368,791
Sinter									
Capacity, Dec. 31	725,000	—	300,000	—	250,000	—	900,000	2,175,000	4,175,000[4]
Production	747,759	—	160,000	—	130,494	—	818,746	1,856,999	3,897,216
Number of furnaces									
Steel									
Open hearth	6	—	—	—	6	—	14	26	30
Basic oxygen	3	—	—	3	—	—	—	6	6
Electric	—	—	—	5	1	—	—	6	..
Pig iron									
Blast furnace	4	1	—	3	2	—	4	14	14
Electric	—	—	2	—	—	8	—	10	10
Coke ovens	249	—	—	105	114	—	191	659	785
Sinter strands	1	—	1	—	1	—	1	4	10

Sources: Company data supplied directly to the Mineral Resources Division, and Dominion Bureau of Statistics.

[1]The seven plants listed account for all pig iron and 87 per cent of crude steel produced in Canada. [2]Dosco and STELCO also have electric furnace plants at Montreal and Edmonton, respectively, each with an annual steel capacity of 110,000 tons. [3]Total of figures reported by companies to the Mineral Resources Division exceeds DBS national total. [4]Includes one mine sinter plant owned by Algoma.

.. Not available; —Nil.

process) and Imperial Oil Limited (FIOR process) have done extensive pilot plant research on reduction processes.

Most coal used for coking and other purposes at Canadian iron and steel plants is imported from the U.S., mainly from mines in Pennsylvania, West Virginia and Kentucky. Three of the four integrated companies own or have a share of coal mining companies in these states and the fourth owns mines in Nova Scotia. Coking capacity at several steel plants was insufficient in 1965 and coke was purchased, mainly from the U.S., to make up the difference.

Details on raw materials consumed at integrated steel plants are listed in Table 10.

TABLE 10

Consumption of Raw Materials at Pig Iron and Integrated Steel Plants*, 1965

(short tons)

	In Sinter Plants	In Iron and Steel Furnaces: Blast Furnaces	Electric Pig Iron	Steel Furnaces	Total
Iron ore					
Crude and concentrate	1,137,967	1,817,670	1,318,402**	108,329	3,244,401
Pellets	128,367	5,061,591	–	181,348	5,242,939
Sinter (from mines)	77,070	1,738,347	–	–	1,738,347
Total	1,343,404	8,617,608	1,318,402	289,677	10,225,687
Sinter (produced at plant)	–	1,790,242	160,000	–	1,950,242
Total iron ore	1,343,404	10,407,850	1,478,402	289,677	12,175,929
Tons contained iron	836,834	6,162,300^e	475,000^e	193,600^e	6,830,900^e
Other iron-bearing materials					
Cinder	165,000	–	–	–	–
Flue dust	129,670	–	–	–	–
Scale, sponge iron, etc.	349,664	152,377	–	97,622	249,999
Total	644,334	152,377	–	97,622	249,999
Tons contained iron	359,110	101,914^e	–	61,550^e	163,464
Other materials					
Ferromanganese	–	–	102	76,273	76,375
Pig iron	–	2,610	–	6,162,039	6,164,649
Coal	–	–	..	–	..
Coke					
Own make	62,231	3,562,603	–	1,202	3,563,805
Purchased	15,457	319,281	43,331	–	362,612
Total	77,668	3,881,884	43,331	1,202	3,926,417
Scrap					
Own make	47,119	63,226	–	2,770,386	2,833,612
Purchased	–	72,396	–	996,446	1,068,842
Total	47,119	135,622	–	3,766,832	3,902,454
Stone					
Limestone	73,858	704,104	6,026	173,317	883,447
Dolomite	84,843	557,834	34,136	103,781	695,751
Total	158,701	1,261,938	40,162	277,098	1,579,198
Burnt stone					
Lime	300	–	–	262,054	262,054
Burnt dolomite	–	–	–	80,679	80,679
Total	300	–	–	342,733	342,733
Production	1,856,999	6,606,043	474,719	8,790,393	

Source: Company data supplied directly to Mineral Resources Division.

*Includes the seven plants in Table 9. **Ilmenite ore used to make titania slag and pig iron.

– Nil; ^{e}Estimated; ..Not available.

Iron ore prices rose slightly in 1965, mainly a reflection of increasing quality. Coke prices were stable but are expected to increase in 1966 because of increased coal costs. Prices of major ferroalloys fluctuated slightly during the year but on the average were stable. Tungsten, molybdenum, columbium and vanadium alloys were in tight supply and their prices rose. The price of zinc was stable after having risen in 1964; that of tin tended to be very erratic but at a high level. Brokers' scrap prices at major consuming centres trended downward during the year, declining at Hamilton, for example, from $30 a ton in January to $22.50 in December. However, prices paid by some regional steel producers tended to rise.

ENERGY AND REDUCTANT MATERIALS

Table 11 lists consumption of energy and reductant materials at the four major steel plants in 1965. Although the list is not complete, the use of these materials in various processes is indicated. The increasing use of fuel oil, natural gas and other fuels in the blast furnace is of particular interest.

INVESTMENTS AND CORPORATE DEVELOPMENTS

Capital expenditures by iron and steel mills were $152.4 million in 1965 compared with $206.1 million in 1964. According to an industry survey of expectations conducted by the Dominion Bureau of Statistics late in 1965, capital expenditures should reach a record $236 million in 1966. Most of the major steel producers are planning large expenditures in each of the next several years and the present high level of expenditures is expected to continue through to 1970.

Among the major items of new equipment completed in 1965 were the 80-inch cold strip mill at Algoma's Sault Ste. Marie plant; continuous casting machines at Atlas Steels' Tracy, Quebec, plant and Dosco Steel's Montreal plant; conversion of a reversing hot strip mill to a continuous unit and repowering of the roughing mill at DOFASCO'S Hamilton plant; and a 148-inch plate mill, an 80-inch pickling line and an 80-inch temper mill at STELCO's Hilton Works in Hamilton and the first rod mill at Contrecoeur.

THE ALGOMA STEEL CORPORATION, LIMITED, SAULT STE. MARIE, ONT.

Capital expenditures in 1965 were $25.2 million compared with $37.5 million in 1964 and $31.5 million in 1963. Expenditures in 1966 are expected to be $50 million.

Projects Completed in 1965

An 80-inch cold strip mill, relining and enlargement of the No. 5 blast furnace, additions to steel and slag transportation equipment and replacement of an oven for drying ingot moulds, all at Sault Ste. Marie.

TABLE 11

Energy and Reductant Consumption at Integrated* Steel Plants, 1965

	Coal (net tons)	Coke (net tons)	Coke Oven Gas (million cu. ft.)	Tar and Pitch (thousand imp. gal.)	Natural Gas (million cu. ft.)	Fuel Oil (thousand imp. gal.)	Oxygen (million cu. ft.)	Electricity (million kwh)
In coke ovens	5,296,218	–	5,977	–	–	–	–	53
In sinter plants	–	62,231	448	–	–	–	–	25
In blast furnaces	–	3,903,062	3,795	..	..	34,689	9	180
In steel furnaces	–	1,202	4,667	..	..	81,413	10,895	137
For other uses	98,620	20,644	35,012	..	..	95,267	634	1,477
Total consumption	5,394,838	3,987,139	49,899	5,611	7,453	211,369	11,538	1,872

Source: Company data supplied directly to the Mineral Resources Division.
*Comprises the integrated plants: Algoma (Sault Ste. Marie and Port Colborne works), STELCO (Hilton Works), DOFASCO (Hamilton works), and Dosco (Sydney works).
–Nil; ..Included in total, publication would disclose confidential company data.

Projects Underway in 1966

Continuous casting plant for blooms and beam blanks (to be completed late in 1966 or early in 1967), a new battery of 60 coke ovens (early 1967), fourth blast furnace turbo blower and a new boiler shop, all at Sault Ste. Marie; a 12-foot sinter strand to replace three small machines and a new maintenance building at Wawa (Algoma Ore Properties Div.), all of which were under construction in 1965. Projects beginning in 1966 include relining and enlargement of the No. 4 blast furnace, relocation of maintenance shops, installation of a second reheating furnace for the rail and structural and wide flange beam mills, new metallurgical and research building, site clearance for a new blast furnace and a new oxygen steel plant, engineering and castings for a 160-inch plate mill and hot strip mill, relocation of certain facilities and miscellaneous improvements.

New Program

In September 1965 the company announced plans for a $175-million expansion program to increase annual steel capacity by 40 per cent to 3.75 million tons. The program, to be completed by 1970, will include a new battery of coke ovens, a large blast furnace, two 200-ton oxygen steel furnaces, a 160-inch plate mill and expanded capacity for sheet, strip and structural steel. Some of these projects will get underway in 1966. In 1965 Algoma made an agreement with Steep Rock Iron Mines Limited for the supply of iron ore pellets beginning in 1967 and leased the low-grade magnetite iron ore property of Can-Fer Mines Limited near Nakina, Ontario. Under the former agreement, Algoma acquired an interest in Steep Rock's Lake St. Joseph (Ontario) iron property. No plans have been announced to develop any of these low-grade properties.

ATLAS STEELS COMPANY, DIVISION OF RIO ALGOM MINES LIMITED, WELLAND, ONT. AND TRACY, QUE.

Atlas expended $15.8 million in 1964, mainly at the Tracy plant. Expenditures in 1965 are not available but were lower than in 1964. The Tracy plant, where construction began in 1961, has an electric furnace to make stainless steel, a continuous casting plant and hot and cold-rolling mills to produce stainless strip to 48 inches wide. Steelmaking, cold-rolling and finishing facilities were completed by the end of 1964. The continuous casting machine was completed early in 1965. The hot-rolling mill began initial production early in 1966 but was not expected to reach full operation until mid-1966. A second cold-rolling mill will be completed in mid-1966 at a cost of $7.5 million.

BAY STEEL CORPORATION

This company was formed early in 1965 by Brunswick Mining and Smelting Corporation Limited to build and operate a planned $60-million steel mill in New Brunswick. Tentative plans were to treat pyrite from Brunswick's base metal mines to produce sulphur, sulphuric acid and pelletized, partially-reduced iron oxide. The pellets would then be smelted in electric furnaces to make 250,000 tons of steel annually. The project would be built in four stages; stage one to produce sulphur, acid and iron ore pellets; stage two to produce reduced pellets; stage three to produce electric furnace steel; and stage four to produce rolled steel products. No specific plans for construction of the iron ore or steel stages have been announced.

BAYCOAT LIMITED, HAMILTON, ONT.

The company was formed by Dominion Foundries and Steel, Limited and The Steel Company of Canada, Limited to build a plant in Hamilton to produce painted and coated steel strip. Production will begin early in 1966.

BURLINGTON STEEL COMPANY, HAMILTON, ONT.

The company completed a second 20-ton electric furnace in 1965 to double its annual ingot capacity to 128,000 tons.

CANADIAN STEEL FOUNDRIES DIVISION, HAWKER SIDDELEY CANADA LTD., MONTREAL, QUE.

A $1-million expansion program to increase plant capacity for large castings by some 40 per cent, was completed in 1965.

THE CONSOLIDATED MINING AND SMELTING COMPANY OF CANADA LIMITED, KIMBERLEY, B.C.

The company continued construction of a $2-million steelmaking plant at Kimberley. The plant, to consist of one 18-ton basic oxygen (L-D) furnace with an annual capacity of 70,000 tons of steel, will be completed in 1966. Ingots will be railed to Vancouver for rolling at Western Canada Steel Limited, a COMINCO subsidiary.

CONTINUOUS COLOUR COAT LIMITED, REXDALE, ONT.

A $1.5-million continuous-coating strip line and a $1-million electro-zinc plating line were under construction in 1965 for completion in 1966.

DOMINION FOUNDRIES AND STEEL, LIMITED, HAMILTON, ONT.

Capital expenditures were $44.8 million in 1965 compared with $37.7 million in 1964 and $18.1 million in 1963. Authorized expenditures at the end of 1965 totalled approximately $101 million, including $42.6 million for mine expenditures. In 1965 the company announced a $120-million expansion program to include a new coke battery, an oxygen plant, increased hot- and cold-rolling capacity, expanded foundry capacity and a new iron mine.

Projects Completed in 1965

Addition of three stands to the hot-strip mill to make a continuous seven-stand mill, repowering of roughing mill to increase capacity, six ingot-soaking pits, third continuous pickle line, and the Wabush Mines-Arnaud Pellets project in Labrador, of which the company owns about 15 per cent.

Projects Underway in 1966

A 53-oven coke battery (to be completed late in 1966), a two-stand 56-inch cold reduction and temper mill with annealing furnaces (early 1966), three additional 66-inch stands to form a five-stand cold-rolling sheet mill, a 400-ton-per-day oxygen plant, a scarfing machine on the hot-strip mill, a third continuous galvanizing line, relining of a blast furnace, a new personnel, safety and medical building, replacement of a 105-ton oxygen furnace with a 150-ton unit, and a new iron mine at Timagami, Ontario (Sherman Mine) to produce 1.2 million long tons of pellets annually.

DOMINION BRIDGE COMPANY, LIMITED, MANITOBA ROLLING MILLS DIVISION, SELKIRK, MAN.

An $8-million expansion program, including replacement of existing electric and open hearth furnaces with two electric furnaces having an annual capacity of 160,000 tons of ingots, and installation of a continuous casting machine, will be completed in mid-1966.

DOSCO STEEL LIMITED, MONTREAL AND CONTRECOEUR, QUE. AND SYDNEY, N.S.

Capital expenditures by Dosco Steel were $17.6 million in 1965 compared with $19.3 million in 1964. Most of these expenditures were on the new rolling mill plant at Contrecoeur, which will eventually have rolling mills and related facilities for rods and bars and hot- and cold-rolled strip up to 48 inches wide. The rod and bar mill was completed in 1964, the cold-strip mill will be completed in the first half of 1966 and the hot-strip mill will be completed later in 1966. Billets will be shipped from Sydney.

Projects Completed in 1965

A continuous casting machine at Montreal and rebuilding and relining of two blast furnaces at Sydney.

Projects Underway in 1966

New raw materials dock and handling facilities at Sydney; miscellaneous modernization and improvement projects at Sydney and Montreal; slabbing and hot-rolling strip mills (late 1966), cold-rolling mill (mid-1966) and cleaning and slitting lines (early 1966) at Contrecoeur.

INTERPROVINCIAL STEEL AND PIPE CORPORATION LTD., REGINA, SASK.

A $2-million expansion program began in 1965 to include increased ingot and slab reheating capacity, increased sheet and sheared coil capacity and a 50-per-cent increase in pipe capacity, all to be completed in 1966.

NEWFOUNDLAND STEEL COMPANY LIMITED, OCTAGON POND, NFLD.

The company plans an electric furnace (25-ton) steel plant for bar and merchant products. The plant, to cost $3.6 million, is scheduled for completion in mid-1966 and will have an annual capacity of 60,000 tons of ingots.

QUEBEC IRON AND TITANIUM CORPORATION, SOREL, QUE.

A $13.5-million expansion program began in 1965 to increase capacity for pig iron and titania slag 20 per cent by 1967. The project includes a ninth electric furnace and increased transformer capacity of two existing furnaces.

SIDBEC

Sidbec, the company formed to build a provincial government-backed steel plant in the Province of Quebec, in 1965 appointed four engineering firms (two from Montreal plus Kaiser Engineering of Canada and Sofresid of France) to plan, engineer and manage construction of the project. The consortium was to present a preliminary plan to Sidbec's board of directors not later than April 1, 1966, outlining recommendations as to size of the plant, processes, product mix and investment.

THE STEEL COMPANY OF CANADA, LIMITED, HAMILTON, ONT.

Expenditures in 1965 were $75.5 million compared with $109.3 million in 1964 and $52.2 million in 1963. Estimated cost of completing authorized projects at the end of 1965 was $190 million. Early in 1966, the company integrated its principal western Canada operations under the name of the parent company.

Projects Completed in 1965

A 148-inch plate mill, a vertical edger on the No. 2 blooming mill, an 80-inch HCl pickling line, an 80-inch temper mill, modifications and improvements to the 110-inch plate mill which is now integrated with the 56-inch hot strip mill, all at Hamilton; first section of the new bar mill at Contrecoeur, Quebec; the Wabush Mines-Arnaud Pellets project in Labrador and Quebec, about one quarter owned by the company; and additional facilities at various plants for fasteners and cold-drawn bars.

Projects Underway in 1966

A fifth new blast furnace (to be completed in 1967), relining of an existing blast furnace, a new battery of 73 coke ovens, a six-strand continuous casting plant, a second rod mill, and a third continuous galvanizing line(1967) at Hamilton; a $6-million plus program at the Edmonton Works to improve quality, reduce costs, double capacity and expand product range by 1969; various projects at most works to raise capacity and improve efficiency; completion of the rod mill at Contrecoeur by mid-1966; a new research centre at Burlington, Ontario; and a new iron mine at Bruce Lake, Ontario (Griffifth Mine) to produce 1.5 million long tons of pellets beginning in 1968.

WESTERN CANADA STEEL LIMITED, VANCOUVER, B.C.

A $2-million expansion program to provide facilities for steel rods and drawn steel was begun in 1965, with completion scheduled for April 1966. New capacity will be 50,000 tons of rod and wire a year.

TABLE 12

Posted Base Prices for Canadian Carbon Steel. 1965–1966 (f.o.b. mill)

	Jan. 1965	Jan. 1966
Semis, for rerolling ($ per ton)	$78	$78
	(cents per pound)	(cents per pound)
Wire rods	5.70	5.70
Bars and small shapes		
(merchant)	5.30	5.65
Bars, reinforcing	5.30	5.30
Structurals	5.50	5.75
Plates, universal	5.10	5.45
Sheets and coils		
Hot-rolled	4.95 – 5.00	5.15 – 5.20
Cold-rolled	6.35	6.60
Galvanized	6.70	6.90
Skelp	4.70	5.00
Rails, heavy	5.55	5.80

Source: *STEEL, the Metalworking Weekly*, January 1965 and 1966.

PRICES AND TARIFFS

Base prices for a wide range of steel products were raised by 3 to 7 per cent in 1965, mainly during February, March and April (Table 12). This was the first increase since 1957 and was attributed to increased costs of raw materials, labour and construction in excess of gains in productivity. Despite the increase, net profits of major steel companies rose at a lower rate than sales. Another reason given for this was the heavy expense incurred during the start-up of large new items of equipment at several plants.

There were no changes in the Canadian tariff schedule for primary steel products in 1965 (Table 13). Meetings in Geneva, Switzerland, of the General Agreement on Tariff and Trade (GATT) continued throughout 1965 with the object of multilaterally reducing tariffs on all products, including steel.

TABLE 13

Canadian Customs Tariff on Selected Iron and Steel Items

	British Preferential	Most Favoured Nation	General	Tariff Item
Iron ore	free	free	free	32900–1
Iron and steel scrap	free	free	free	37301–1, 37302–1, 37302–2
Pig iron ($ per ton)	$1.50	$2.50	$2.50	37400–1
Ingots, n.o.p. ($ per ton)	free	$3.00	$5.00	37700–1
Semis (blooms, billets, slabs)	free	5%	10%	37800–1
Bars or rods, hot-rolled	5%	10%	20%	37900–1
Bars or rods, cold-rolled	5%	15%	25%	37905–1
Rods for wire manufacture	free	$3.00	$5.00	37915–1
Shapes and sections either hot-rolled or cold-rolled	(%)	(%)	(%)	
General, n.o.p.	5	10	20	38001–1
Large sections not made in Canada	free	less	less	38002–1, 38003–1
Plate, hot- or cold-rolled	5	10	20	38100–1
Sheet and strip				
Hot-rolled	5	10	20	38201–1
Cold-rolled	5	15	25	38202–1
Coated with tin or enamel	10	15	25	38203–1
Galvanized	7.5	15	25	38204–1
Skelp (plate and sheet for pipe)	free	7.5	15	38400–1
Rails	5	10	20	38700–1
Castings, n.o.p.	15	17.5	27.5	39000–1
Forgings	17.5	22.5	30	39200–1
Pipe, large diameter	10	15	30	39900–1
Wire, n.o.p.	15	15	20	40107–1

Note: Details for specific variations of which there are many can be found in the Department of National Revenue's *The Customs Tariff and Amendments*.
n.o.p. Not otherwise provided for.

Lead

J.G. GEORGE*

Canada's recoverable production of lead in 1965 rose sharply to 41 per cent over that of 1964. An increase occurred in the Northwest Territories because of the start of regular shipments of ore and concentrates by Pine Point Mines Limited. Output by Brunswick Mining and Smelting Corporation Limited near Bathurst, which in 1965 completed its first full year's operation, accounted for the increase in New Brunswick's production. Also contributing to the increase were smaller amounts from Willecho Mines Limited near Manitouwadge, Ontario, and Cupra Mines Ltd. in Quebec, both of which came into production in 1965. In British Columbia output was less than in 1964. Value of Canadian production rose by over 60 per cent because of higher output and prices.

Mine development was carried out in many areas including Vancouver Island, northern Saskatchewan, Ontario and New Brunswick. Large potential deposits were discovered in the Vangorda Creek area, Yukon Territory, and exploration activity increased substantially in the Pine Point area, Northwest Territories. Mine output of lead should increase again in 1966.

Refined lead output at Canada's only primary lead smelter and electrolytic refinery, operated by The Consolidated Mining and Smelting Company of Canada Limited (COMINCO) at Trail, B.C. was considerably higher than in 1964.

After ranging between 182,557 and 212,229 tons annually from 1960 to 1964, total Canadian production was substantially higher in 1965 and reached an all-time high. This is based on the lead content of ores and concentrates produced, rather than the recoverable content of ores and concentrates exported and the lead content of bullion produced.

Most of the lead ores and concentrates from western Canada were treated by COMINCO at Trail; the remainder were treated at plants in northwestern United States. Lead concentrates produced in eastern Canada were shipped to smelters in Europe and the United States.

Exports of ores and concentrates were about 33 per cent higher than in 1964 with about 80 per cent of them going to the U.S. and Belgium. Metal exports increased in 1965. Britain and the U.S. were the main markets.

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*Mineral Resources Division

TABLE 1

Lead – Production, Trade and Consumption, 1964-65

	1964		1965P	
	Short Tons	$	Short Tons	$
Production, all forms[1]				
British Columbia	134,369	36,118,321	121,222	37,578,680
Northwest Territories	3,063	823,279	78,362	24,292,220
New Brunswick	21,716	5,837,216	46,537	14,426,470
Newfoundland and Labrador	25,415	6,831,452	23,318	7,228,447
Yukon	10,209	2,744,235	8,507	2,637,325
Quebec	3,954	1,062,964	3,977	1,232,987
Ontario	2,027	544,974	1,958	607,080
Nova Scotia	1,669	448,577	1,700	527,000
Manitoba	1,295	348,092	1,230	381,151
Total	203,717	54,759,110	286,811	88,911,360
Mine output[2]	209,673		302,952	
Refined[3]	151,372		186,484	
Exports				
In ores and concentrates				
United States	30,471	4,848,199	46,063	8,925,910
Belgium and Luxembourg	31,106	6,096,935	39,384	7,401,972
Italy	-	-	6,485	1,218,000
Britain	7,434	1,436,754	5,689	1,166,916
West Germany	4,605	685,087	3,895	695,714
Other countries	6,741	1,195,764	5,448	1,075,742
Total	80,357	14,262,739	106,964	20,484,254
In pigs, blocks and shot				
Britain	42,014	9,243,987	60,476	19,818,635
United States	30,487	7,340,417	31,622	9,534,950
Netherlands	3,305	683,747	11,212	3,527,027
India	8,473	1,940,790	10,399	3,257,680
West Germany	1,690	466,228	5,042	1,484,409
Japan	9,808	2,163,378	3,761	1,104,183
Spain	-	-	2,222	707,431
Other countries	90	19,492	4,331	1,231,351
Total	95,867	21,858,039	129,065	40,665,666
Lead and lead-alloy scrap				
United States	2,905	534,481	4,511	827,917
France	-	-	1,149	206,890
Belgium and Luxembourg	573	110,145	1,075	265,406
Yugoslavia	-	-	823	814,736
Italy	54	14,051	561	123,629
Netherlands	753	249,486	352	95,493
West Germany	381	72,791	320	63,213
Other countries	612	97,581	409	92,994
Total	5,278	1,078,535	9,200	2,490,278
Lead-fabricated materials not elsewhere specified				
United States	1,520	510,833	894	418,401
West Germany	-	-	100	34,300
Jamaica	92	31,367	68	29,179
Philippines	174	58,859	63	23,183
Italy	-	-	50	8,267
El Salvador	-	-	46	14,609
Panama	-	-	45	15,309
Other countries	83	36,436	78	34,320
Total	1,869	637,495	1,344	577,568

Table 1 (cont.)

	1964		1965P	
	Short Tons	$	Short Tons	$
Imports				
Lead pigs, blocks and shot	73	26,462	71	35,906
Lead oxide: litharge, red lead, mineral orange	1,528	469,890	1,185	478,082
Lead fabricated materials, not elsewhere specified	347	280,018	258	235,714
Total	1,948	776,370	1,514	749,702

	1964			1965P		
	Primary	Secondary (short tons)	Total	Primary	Secondary (short tons)	Total
Consumption						
Lead used for or in the production of:						
Antimonial lead	867	16,941	17,808	1,132	16,932	18,064
Batteries and battery oxides	17,094	811	17,905	18,967	1,338	20,305
Cable covering	4,559	1,582	6,141	4,500	2,114	6,614
Chemical uses: white lead, red lead, litharge tetraethyl lead, etc.	16,251	1,958	18,209	17,537	2,065	19,602
Copper alloys: brass, bronze, etc.	419	137	556	275	151	426
Lead alloys						
Solders	1,717	2,540	4,257	2,878	2,591	5,469
Other, including babbitts, type metal, etc.	198	2,070	2,268	354	1,699	2,053
Semifinished products: pipe, sheet, traps, bends, blocks for caulking, ammunition, foil, collapsible tubes, etc.	9,485	3,790	13,275	11,256	3,753	15,009
Other	1,051	1,266	2,317	1,097	1,529	2,626
Total	51,641	31,095[4]	82,736	57,996	32,172[4]	90,168

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.

P Preliminary; - Nil.

Reported consumption of primary and secondary lead in Canada was almost 9 per cent higher than in 1964. Greater use of primary lead in the manufacture of batteries and battery oxides, semifinished products, chemicals, and lead alloy solders was mainly responsible for the increase.

Canadian and U.S. lead prices remained unchanged throughout 1965 at 15.5 cents (Can.) a pound and 16 cents (U.S.) a pound.

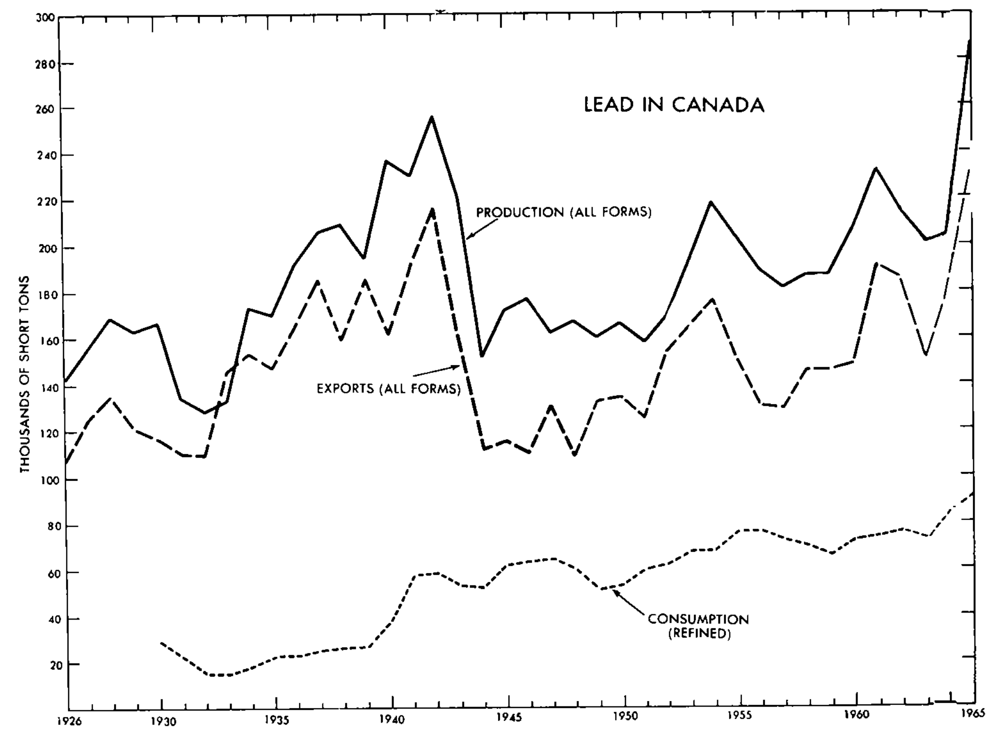


TABLE 2

Summary — Lead Production, Trade and Consumption, 1956-65
(short tons)

	Production		Exports				
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total	Imports, Refined[3]	Consumption[4]
1956	188,854	147,865	49,974	79,633	129,607	105	75,882
1957	181,484	142,935	44,167	84,541	128,708	1,507	71,583
1958	186,680	132,987	54,081	92,351	146,432	1,668	69,769
1959	186,696	135,296	53,726	92,252	145,978	1,810	65,935
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
1965p	286,811	186,484	106,964	129,065	236,029	71	90,168

Source: Dominion Bureau of Statistics.
[1] Lead content of base bullion produced from primary materials (concentrates, slags, residues, etc.) plus recoverable lead in domestic ores and concentrates exported. [2] Primary refined lead from all sources.
[3] Lead in pigs and blocks. [4] Consumption of lead, primary and secondary in origin.
p Preliminary.

UNITED STATES IMPORT QUOTAS AND STOCKPILES

After completing an investigation of the lead-zinc industry begun in March 1964, the United States Tariff Commission in June 1965 advised the President that termination of import quotas on unmanufactured lead and zinc would not likely have a detrimental effect on domestic producers unless world demand for these metals should subside substantially in relation to world supplies. On October 22, 1965, the President by proclamation abolished the quotas effective immediately for lead and zinc ores and concentrates, and 30 days later for lead and zinc metal. No change was made in import duties on unmanufactured lead and zinc. The absolute quotas, which had been in effect since October 1, 1958, were equivalent to 80 per cent of the average annual commercial imports into the United States during the 5-year period from 1953 to 1957. The Canadian quarterly allotments under these quotas were 7,960 tons of lead metal and 6,720 tons of lead contained in ores and concentrates, both of which were fully subscribed in the first three quarters of 1965.

Early in April the U.S. Government authorized the release of 200,000 short tons of lead from the U.S. government stockpile including 50,000 tons for government use only. Of the 150,000 tons authorized for private use, 60,000 tons were offered for sale and 20,000 tons were sold. In October the remaining 40,000 tons were offered on a once-a-month basis, and by year's end 16,900 tons of the 40,000 tons had been sold. Monthly sales of the remaining 23,100 tons continued in 1966. Sales were made to domestic producers and representatives of foreign producers and were for consumption in the United States only. At the end of 1965 the balance of stockpile lead amounted to almost 1.3 million tons, all of which was surplus to conventional war requirements as the stockpile objective remained at zero.

WORLD PRODUCTION AND CONSUMPTION

Free World mine production of lead, at 2.24 million short tons in 1965, was slightly higher than in 1964. Higher Canadian output accounted for most of the increase, while the remainder was mainly attributable to higher production in Zambia, Peru, United States and France. Free World refined lead metal production in 1965 was an estimated 2.89 million tons, about 60,000 tons more than the previous year. Canada, Belgium, and the Republic of South Africa were the countries reporting the largest increases. The United States had the greatest reduction in output, decreasing from 850,000 tons in 1964 to 808,000 tons in 1965.

Free World consumption of lead continued to rise and in 1965 reached a record total of over 3 million short tons. In the United States, which is the world's largest consumer and which took almost one third of Canada's combined exports of lead concentrates and metal in 1965, consumption was 1.09 million tons compared with 1.07 million tons in 1964. Most of the increase was due to larger amounts used in the manufacture of storage batteries, cable covering, and red lead and litharge. Declines were reported in several uses with the largest occurring in the production of caulking lead.

TABLE 3

Free World Mine Production of Lead, 1964-65

(short tons)

	1964	1965*
Australia	413,300	398,000
United States	298,000	305,200
Canada	209,500	303,500
Mexico	183,400	..
Peru	179,700	187,800ᵉ
Yugoslavia	112,000	106,800ᵉ
Republic of South Africa	105,500	98,100
Morocco	79,500	..
Sweden	72,000	73,200
Spain	63,100	61,700
Japan	59,600	60,600
West Germany	57,100	57,300
Italy	36,800	37,700
Zambia	14,700	37,600
Other countries	200,100	..
Total	2,084,300	2,239,300ᵉ

Source : International Lead and Zinc Study Group.

* Total figure includes estimates for those countries for which figures are not available.

.. Not available; ᵉ Estimate.

In reviewing the balance of supply and demand at its November 1965 meeting the International Lead and Zinc Study Group noted that supplies in 1965 had been augmented by imports from Communist-bloc countries and by sales from the U.S. Government surplus stocks. World supply and demand had been approximately in balance. For 1966 the forecast was for a larger increase in consumption than in 1965 and for continuing increases in production. On the basis that there would be no releases from U.S. Government stocks in 1966 and that imports from East-bloc countries would be at the 1965 rate, the statistics showed a continuing balance.

PRODUCING MINES

The Consolidated Mining and Smelting Company of Canada Limited, from its Sullivan, Bluebell, and H.B. mines in B.C., produced 118,791 tons or almost 40 per cent of Canadian mine production of lead in 1965. Although there was no interruption in production at any of its mines in southeastern British Columbia, ore production dropped about 15 per cent at the Sullivan, 13 per cent at the H.B., and slightly at the Bluebell mine.

Major producers other than COMINCO, in declining order of output, were: Pine Point Mines Limited at Pine Point, N.W.T.; Brunswick Mining and Smelting Corporation Limited, which completed its first full year's operations near Bathurst, N.B.; the Buchans unit of American Smelting and Refining Company in Newfoundland; and United Keno Hill Mines Limited at Elsa, Y.T. Ore produced by United Keno Hill Mines Limited in 1965 was less than in the previous year mainly because of the critical shortage of skilled labour. Commencement of regular production of ore early in 1965, and of milling operations about mid-November, at Pine Point, N.W.T., was of great significance as output of lead from there accounted for over one quarter of Canadian production.

Other producers included Canadian Exploration, Limited and Reeves MacDonald Mines Limited in southeastern B.C. and Heath Steele Mines Limited, about 32 miles northwest of Newcastle, N.B. In addition to Pine Point Mines Limited, regular production was initiated at two other new mines in 1965 – Willecho Mines Limited near Manitouwadge, Ont., whose ore was custom-milled at the nearby property of Willroy Mines Limited; and Cupra Mines Ltd. at Stratford Place, Que., whose ore was trucked 2½ miles to the mill of Solbec Copper Mines, Ltd. for custom treatment. No lead producers of consequence closed in 1965.

OTHER DEVELOPMENTS

YUKON TERRITORY

Exploration reached record levels in the four mining districts of the Yukon Territory in 1965. Dynasty Explorations Limited's find of a potentially large lead-zinc deposit in the Vangorda Creek area, Whitehorse mining district, sparked the Territory's greatest staking rush in recent years. From April 1965 to the end of January 1966 over 9,000 mineral claims were recorded, more than all the claims recorded in the preceding three years. Dynasty Explorations Limited and Cyprus Mines Corporation of Los Angeles, California, formed Anvil Mining Corporation Limited to continue property exploration. From diamond drilling results to the end of the year it appeared that substantial reserves of more than 8 per cent combined lead and zinc were available for open-pit operations.

No exploration work was done in 1965 at the property of Vangorda Mines Limited, which is also in the Vangorda Creek area. Estimated reserves of this lead-zinc-copper-silver-gold deposit remain unchanged at 9,400,000 tons. Vangorda is controlled by Kerr Addison Mines Limited. Diamond drilling by Kerr Addison on another group of claims near Swim Lakes, about 6 miles southeast of the Vangorda property, indicated a zone of sulphide mineralization of grade similar to that at the Vangorda property. Many other companies, syndicates and individuals hold claims in the Vangorda area on which exploration will be continued or undertaken in 1966.

TABLE 4

Principal Lead Producers in Canada, 1964-65

Company and Location	Mill Capacity (tons ore/day)	Grade of Ore Milled in 1965 (principal metals)				Ore Produced 1965 (1964) (short tons)	Lead in Concentrates and Direct-Shipping Ores 1965 (1964) (short tons)	Remarks
		Lead (%)	Zinc (%)	Copper (%)	Silver (oz/ton)			
British Columbia								
Aetna Investment Corporation Limited[1], Mineral King mine, Toby Creek	500	..	..	..	..	145,196 (182,958)	1,578 (2,479)	Plans exploration via 3 levels in new shaft.
Canadian Exploration, Limited, Jersey mine, Salmo	1,900	1.06	3.54	—	..	377,124 (407,062)	3,522 (5,700)	Plans continued drilling to outline orebody as far as possible.
The Consolidated Mining and Smelting Company of Canada Limited								
Sullivan mine, Kimberley	10,000	..	..	—	..	2,301,071 (2,711,000)	101,091 (106,124)	High-grade Pine Point ore processed.
Bluebell mine, Riondel	700	..	..	—	..	256,332 (258,000)	12,930 (11,266)	Exploration continued, 5 level north.
H.B. mine, Salmo	1,200	..	..	—	..	415,290 (478,000)	4,770 (4,135)	Extensive exploration program initiated below and to east of known ore.
Johnsby Mines Limited, Silverton	150	3.9	4.9	—	13.5	10,925 (2,988)	421 (94)	Plans to complete mining existing ore shoots. No development planned.
London Pride Silver Mines Ltd. Cork Province mine, Kaslo	100	2.1	7.4	—	1.9	26,019 (6,742)	540 (148)	
Mastodon-Highland Bell Mines Limited, Beaverdell	100	..	..	—	27.92	23,213 (25,090)	316 (303)	Increased underground exploration.
Reeves MacDonald Mines Limited, Remac	1,200	1.21	3.65	—	..	(409,504) 379,269	(4,119) 3,972	Stepped up exploration program; considerable diamond drilling.

Table 4 (cont.)

Company and Location	Mill Capacity (tons ore/day)	Grade of Ore Milled in 1965 (principal metals) Lead (%)	Zinc (%)	Copper (%)	Silver (oz/ton)	Ore Produced 1965 (1964) (short tons)	Lead in Concentrates and Direct-Shipping Ores 1965 (1964) (short tons)	Remarks
Yukon Territory – Northwest Territories								
United Keno Hill Mines Limited, Hector-Calumet, Elsa, Keno, and Silver King mines, Mayo District, Y.T.	500	7.06	6.22	–	33.25	146,850 (181,849)	9,377 (10,876)	Tonnage of ore milled considerably lower because of critical shortage of skilled labour.
Pine Point Mines Limited, Pine Point, N.W.T.	5,000	22.5 4.27	29.1 7.63	– –	.. ..	364,168[2] 75,356[3]	.. ..	Milling operations initiated mid-November when construction of concentrator completed.
Manitoba – Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited Flin Flon mine, Flin Flon	6,000 treated at central mill, Flin Flon	0.2	3.2	2.20	0.90	873,934 (789,918)	1,262 (1,329)	Development continued, Osborne Lake and Anderson Lake mines; surface plant being installed, Anderson Lake mine.
Chisel Lake mine, Snow Lake.		0.7	10.3	0.59	1.27	293,221 (267,630)		
Ontario								
Noranda Mines Limited (Geco Division), Manitouwadge	3,300	..	4.26	1.97	2.17	1,326,400 (1,299,300)	1,060 (1,745)	Sinking of No. 4 shaft completed; conveyor system to mill under construction.
Willroy Mines Limited, Manitouwadge	1,500	0.29	4.25	0.79	1.84	293,989 (530,151)	619 (377)	Treatment of Willecho ore started at Willroy mill.
Willecho Mines Limited, Lun-Echo, Manitouwadge	ore custom-milled	0.19	4.16	0.60	1.73	283,259	382	Began regular production; ore custom-milled at nearby Willroy mill.

Quebec								
The Coniagas Mines, Limited, Bachelor Lake	500	0.52	8.31	–	3.14	123,059 (114,459)	606 (607)	
Cupra Mines Ltd., Cupra Mine, Stratford Place	ore custom-milled	0.44	3.18	3.35	1.342	82,427 (–)	5 (–)	Production begun, end of Sept. Will continue development at depth.
Manitou-Barvue Mines Limited, Val d'Or	1,300	0.43	4.48	–	2.85	168,895[4] (142,925)[4]	586 (682)	Plans induced polarization survey of surface area, drilling if warranted.
New Calumet Mines Limited[5], Calumet Island	800	1.66	6.08	–	3.58	97,586 (94,823)	1,544 (1,581)	Completed No. 5 internal shaft, discovered new ore lens on 2,050-ft. level. Plans development of new lens, other exploration.
Solbec Copper Mines, Ltd., Stratford Place	1,500	0.56	4.36	1.69	1.234	403,869 (424,127)	1,832 (1,277)	Plans to continue underground exploration.
New Brunswick								
Brunswick Mining and Smelting Corporation Limited, No. 12 mine, Bathurst	4,500	3.96	9.51	0.30	2.76	1,657,519 (777,902)[6]	.. (..)	No. 6 mine, concentrator under construction; production rate 2,250 tons of ore per day planned June 1966.
Heath Steele Mines Limited[7], Newcastle	1,500	2.41	6.01	0.97	2.61	.. (290,000)	4,679 (5,570)	Plans to sink No. 3 shaft and mine lower B1 orebody.

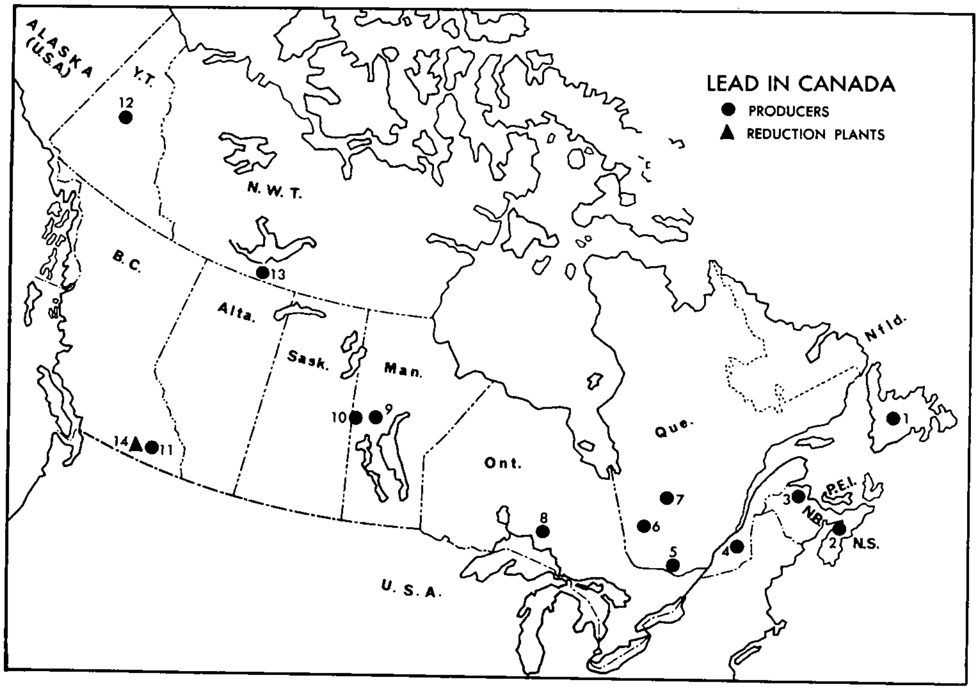
Table 4 (cont.)

Company and Location	Mill Capacity (tons ore/day)	Grade of Ore Milled in 1965 (principal metals)				Ore Produced 1965 (1964) (short tons)	Lead in Concentrates and Direct-Shipping Ores 1965 (1964) (short tons)	Remarks
		Lead (%)	Zinc (%)	Copper (%)	Silver (oz/ton)			
Nova Scotia								
Magnet Cove Barium Corporation, Walton	125	3.98	1.7	0.62	12.5	48,594 (48,927)	1,737 (1,759)	
Newfoundland								
American Smelting and Refining Company, Buchans unit, Buchans	1,250	7.53	13.37	1.12	4.24	366,000 (383,000)	26,177 (26,064)	

Source: Company reports.

[1] In September 1965, name changed from 'Sheep Creek Mines Limited' to 'Aetna Investment Corporation Limited.' [2]High-grade ore shipped directly. [3] Ore milled from commencement of milling operations in mid-November. [4] Manitou-Barvue also mills copper ore. In 1965, 283,875 tons grading 0.81 per cent copper were treated. [5] Production for fiscal years ending September 30. [6] Production during the second half of 1964 when the mill was at normal operating capacity following start-up in March of that year. [7] About one half of Heath Steele's mill capacity used to treat copper ore mined by COMINCO at its Wedge mine.

– Nil; .. Not available.



PRINCIPAL PRODUCERS

1. American Smelting and Refining Company, Buchans unit
2. Magnet Cove Barium Corporation
3. Brunswick Mining and Smelting Corporation Limited
   Heath Steele Mines Limited
4. Cupra Mines Ltd.
   Solbec Copper Mines, Ltd.
5. New Calumet Mines Limited
6. Manitou-Barvue Mines Limited
7. The Coniagas Mines, Limited
8. Noranda Mines Limited (Geco Division)
   Willecho Mines Limited
   Willroy Mines Limited
9. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake mine)
10. Hudson Bay Mining and Smelting Co., Limited (Flin Flon mine)
11. Aetna Investment Corporation Limited
    Canadian Exploration, Limited
    The Consolidated Mining and Smelting Company of Canada Limited (Bluebell mine, H.B. mine, Sullivan mine)
    Johnsby Mines Limited
    London Pride Silver Mines Ltd.
    Mastodon-Highland Bell Mines Limited
    Reeves MacDonald Mines Limited
12. United Keno Hill Mines Limited
13. Pine Point Mines Limited

REDUCTION PLANT

14. The Consolidated Mining and Smelting Company of Canada Limited, Trail (smelter and refinery)

NORTHWEST TERRITORIES

After completion of the Great Slave Lake Railway late in the fall of 1964, test shipments of ore began from Pine Point Mines Limited, a subsidiary of The Consolidated Mining and Smelting Company of Canada Limited and the first lead-zinc producer in the N.W.T. The property is on the south shore of Great Slave Lake at Pine Point. Ore reserves at the end of 1965 were estimated at 21.5 million tons averaging 4 per cent lead and 7.2 per cent zinc. In 1965 a total of 364,000 tons of high-grade ore, assaying 22.5 per cent lead and 29.1 per cent zinc, were shipped to the Trail and Kimberley, B.C. plants of COMINCO and to The Bunker Hill Company at Kellogg, Idaho. Late in November 1965 milling began at Pine Point's 5,000-ton-a-day concentrator, and by the end of the year 75,356 tons of ore averaging 4.27 per cent lead and 7.63 per cent zinc had been processed. Lead concentrates and zinc concentrates were shipped to COMINCO's smelters at Trail. It is planned to continue shipments of high-grade direct-shipping ore and of concentrates in 1966.

Late in October 1965, Pyramid Mining Co. Ltd. announced the discovery of a major ore deposit on its claims that adjoin those of Pine Point Mines Limited. Early diamond drilling on two anomalies indicated ore reserves of substantial tonnage averaging 2.5 per cent lead and 8 per cent zinc. Many other mining companies hold claims in the Pine Point area and most of the ground in the immediate vicinity of Pine Point Mines Limited has been staked. Their properties were in various stages of exploration at the year's end but few had commenced drilling operations. Exploration in the area will be widespread in 1966 and the possibilities of finding additional zinc-lead deposits are good.

Under agreement with Bankeno Mines Limited, COMINCO carried out diamond drilling and exploration work at the former's property on Little Cornwallis Island in the Canadian Arctic. Mineralization was encountered in three zones in one of which COMINCO estimated there are at least 900,000 tons of lead-zinc ore averaging 13 per cent zinc and 2 per cent lead. Exploration work was continuing.

BRITISH COLUMBIA

Western Mines Limited completed plans to bring its Lynx mine into production about mid-1966. A 750-ton-a-day concentrator was under construction at the property at Myra Falls in the Alberni district on Vancouver Island. Proven and probable ore reserves at the Lynx mine at September 30, 1965, were estimated at 1,932,000 tons grading 10.05 per cent zinc, 1.09 per cent lead, 2.24 per cent copper, 2.58 ounces of silver and 0.064 ounce of gold a ton. In November 1965, Giant Mascot Mines, Limited decided to place the old Estella mine near Cranbrook into production at 100 tons a day on a 60-40 basis with Copper Soo Mining Company Limited. Jointly-owned Giant Soo Mines Limited was formed as the operating company.

Ventures Mining Ltd. explored a silver-lead-zinc-copper prospect 20 miles east of Cassiar. Bralorne Pioneer Mines Limited entered into an agreement with Silbak Premier Mines, Limited for extraction of remaining ore in the latter's lead-zinc-silver mine in the Portland Canal district. Milling operations were resumed late in 1965.

SASKATCHEWAN

Late in 1965, agreement was reached between Share Mines & Oils Ltd. and Western Nuclear Inc., Denver, Colorado, whereby the latter would provide the financing required to bring into production Share's base-precious metals property (Par group of claims) in the Hanson Lake area about 45 miles west of Flin Flon, Manitoba. Ore reserves were estimated at 253,000 tons averaging 11.42 per cent zinc, 8.08 per cent lead, 0.61 per cent copper, 4.74 ounces of silver and 0.03 ounce of gold a ton. Production at a rate of 200 to 300 tons of ore a day was planned.

ONTARIO

Development work continued at the silver-gold-lead-zinc prospect of Golsil Mines Limited in the Favourable Lake area, about 100 miles north of Red Lake. Surface diamond drilling outlined about 600,000 tons of ore averaging 7.81 ounces of silver and 0.18 ounce of gold a ton, 2.06 per cent lead, and 2.99 per cent zinc.

The company was considering bringing the property into production and installing a 500-ton-a-day concentrator if warranted by the results of further diamond drilling and underground development work. Preparation of the open-pit mine and construction of the concentrator continued at Texas Gulf Sulphur Company's major zinc-copper-silver property near Timmins. In addition to zinc and copper concentrates, the company will recover, as a byproduct, lead concentrates containing about 10,000 tons of lead annually.

NEW BRUNSWICK

In 1965 Brunswick Mining and Smelting Corporation Limited completed its first full year's operation at its No. 12 mine and 4,500-ton-a-day mill near Bathurst. Construction continued on a new 2,250-ton-a-day concentrator, at the No. 12 minesite, that will treat zinc-lead-copper ore from the nearby No. 6 open-pit mine where approximately 14.8 million tons averaging 5.63 per cent zinc, 2.25 per cent lead, 0.46 per cent copper, and 1.91 ounces of silver a ton are available for open-pit mining. Milling of ore from the No. 6 mine was expected to begin late in June 1966. At Belledune Point, about 20 miles north of Bathurst, Brunswick's wholly-owned subsidiary, East Coast Smelting and Chemical Company Limited, continued construction of an Imperial Smelting Process zinc-lead blast furnace and acid auxiliary plant. It is scheduled for completion in August 1966.

Heath Steele Mines Limited prepared to sink a new shaft on the B orebody at its lead-zinc-copper producing property about 40 miles northwest of Newcastle. It is part of an expansion program to double ore production by 1968.

Exploration and underground development work continued at the New Larder U property of Key Anacon Mines Limited, 10 miles east of Brunswick's No. 12 mine. Metallurgical tests and feasibility studies were undertaken and the company was considering construction of a 1,000-ton-a-day mill. Indicated ore reserves in the No. 2 zone, above the 1,300-foot level, as at August 1, 1965, were 1,500,000 tons averaging 2.95 per cent lead, 7.23 per cent zinc, 0.32 per cent copper and 3.05 ounces of silver a ton, after allowing for dilution. Nigadoo River Mines Limited, a subsidiary of the Sullivan group of companies, continued surface and underground development work at its base metal deposit in Gloucester County in the Bathurst area. Indicated ore reserves are close to 1.5 million tons and the company was planning construction of a 1,000-ton-a-day concentrator. Production is anticipated early in 1967.

The base metal property of Restigouche Mining Corporation, Ltd. about 70 miles west of Bathurst, jointly owned by Teck Corporation Limited and The New Jersey Zinc Company, was actively explored. Approximately 3 million tons of ore, grading 12 per cent combined lead and zinc together with some gold, silver and copper values, were outlined in earlier development work. Tentative plans called for construction of a 1,000-ton-a-day concentrator with construction to begin in the spring of 1966. The Anaconda Company (Canada) Ltd. continued exploration and diamond drilling of its Caribou zinc-lead-copper deposit near Bathurst.

NOVA SCOTIA

In 1965 many mining companies actively explored several areas of the province and issuance of mineral licences was at an all-time high. Nearly two thirds of the area which they cover is on Cape Breton Island. Some 400 square miles of the Cape Breton plateau were staked immediately south of the Cape Breton Highland National Park. Barrington Exploration Corporation Limited, late in 1965, made a lead-zinc-silver discovery in Inverness County about 7 miles from the ocean port of Cheticamp. Surface prospecting was conducted and diamond drilling of the property was expected to get under way in the spring. A staking rush developed following the Barrington discovery and several companies began exploring their claims.

USES

The major uses for lead continued to be in the manufacture of batteries, chemicals, antimonial lead and semifinished products. These principal outlets accounted for more than 80 per cent of the combined primary and secondary lead consumed in Canada in 1965.

An unusual combination of chemical and mechanical properties has given to lead a wide range of industrial applications. Lead is soft, ductile, malleable and easily worked. It has a high specific gravity, high boiling point, low melting point, good corrosion resistance, and alloys readily with many other metals.

The major uses of lead are for storage batteries, gasoline antiknock additives, cable sheathing and pigments. It is also used extensively in the manufacture of corrosive-liquid containers, various types of lead-base babbitts, solders and type metals, caulking materials, ammunition, plumbing equipment such as pipes, drains and bends, and collapsible tubes. Smaller quantities are used in the manufacture of ceramics, insecticides, rubber, and in oil refining.

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 antivibration pads are now being widely used in foundations for office buildings, hotels and apartments exposed to severe vibration from nearby trains, subways, etc. 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 ship ballast, wheel weights, roofing systems, sprayed lead coatings, various alloys and terne steel and as lead-ferrite for permanent magnets in small electric motors. A newer and growing market for lead is the use of organometallic lead compounds in lubricating oils, wood preservatives in marine environment, biocides, fungicides, insecticides, antifouling pigments and curing agents for rubber. Another relatively new application in recent years has been for radiation shielding against gamma rays in nuclear-powered submarines and ships, nuclear power stations and radioactive-fuel shipping containers.

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, common and chemical. 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.

TABLE 5

United States Consumption of Lead by End Use, 1964-65
(short tons)

	1964	1965P
Batteries	429,348	446,672
Gasoline antiknock additives	223,466	225,203
Pigments	103,636	105,433
Solder, type metal, terne metal and bearing metals	120,923	119,233
Ammunition and collapsible tubes	71,397	67,581
Caulking	73,628	63,239
Cable sheathing	56,225	59,605
Sheet and pipe	50,085	44,726
Miscellaneous	73,430	66,365
Estimated undistributed consumption	-	23,200
Total	1,202,138	1,221,257

Source: U.S. Bureau of Mines mineral industry surveys, *United States Lead Industry*, January 1966.
P Preliminary; - Nil.

RESEARCH

Continuing a long-term research program at the Mines Branch, Department of Mines and Technical Surveys, Ottawa, on the fundamental properties of liquid metals, the viscosity, surface tension and density of lead, tin and lead-tin alloys have been measured. In addition, the density of indium and lead-tin alloys has also been determined.

The same apparatus and techniques that were used in the zinc and zinc-alloy program have been employed.

PRICES AND TARIFFS

The Canadian price, f.o.b. Toronto and Montreal, remained unchanged throughout 1965 at 15.5 cents a pound. The U.S. domestic price for common lead, f.o.b. New York, remained unchanged at 16 cents a pound. The London Metal

Exchange settlement and cash sellers' price fluctuated from 16.6 to 21 cents (Can.) a pound early in the year and then began a downward trend to reach a low of 12.8 cents a pound on July 8. It recovered to 15 cents a pound at the end of the year.

Canadian and U.S. tariffs in 1965 were as follows:

	British Preferential	Most Favoured Nation	General
Canada			
Lead in ores and concentrates	free	free	free
Lead, old, scrap, pig and block, per lb	½¢	½¢	1¢
Lead in bars and sheets	10%	10%	25%
Babbitt metal and type metal in blocks, bars, plates and sheets	10%	20%	20%

United States

	(¢ per lb)
Lead in ores and concentrates*	0.75 on lead content
Lead bullion, lead waste and scrap**	1.0625 on 99.6% of lead content
Other forms of unwrought lead**	1.0625 on lead content

* Subject to quarterly import quotas until October 22, 1965.
** Subject to quarterly import quotas until November 21, 1965.

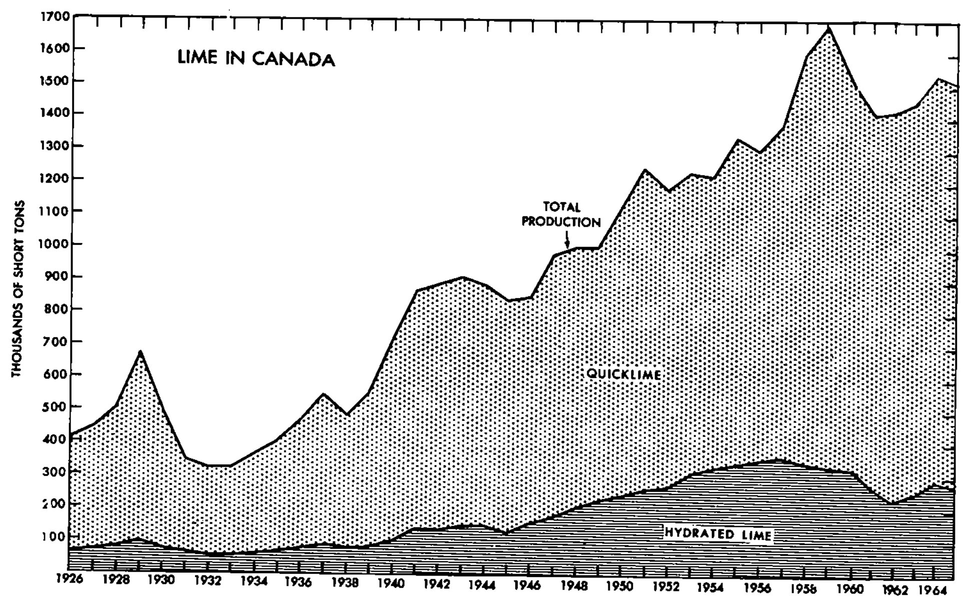
Lime

D.H. STONEHOUSE*

The lime industry in Canada during 1965 experienced little change in production from the previous year. Shipments amounted to 1.5 million tons valued at $17.7 million. Quicklime constituted 82 per cent of the total.

The chemical and metallurgical uses to which lime can be put account for the largest portion of production, with the iron and steel industry being the largest single consumer. A continued decrease in the amount of lime used by the uranium processors was evident during 1965. Uranium production is expected to remain steady until 1970, when an increase is forecast with an attendant increase in lime requirements.

Although lime production is likely to vary with industrial activity, any large change in output will depend on demands of the alkali, uranium and steel industries.



*Mineral Processing Division, Mines Branch

TABLE 1

Production and Trade

	1964		1965P	
	Short Tons	$	Short Tons	$
Production*				
By type				
Quicklime	1,249,394	15,019,966	1,243,301	
Hydrated lime	291,333	4,388,738	273,682	
Total	1,540,727	19,408,704	1,516,983	17,730,045
By province				
Ontario	1,049,798	13,127,550	1,054,422	11,876,403
Quebec	369,054	4,122,665	350,634	3,862,115
Alberta	59,706	1,115,551	57,632	1,065,188
Manitoba	57,196	916,693	50,472	817,285
New Brunswick	4,973	126,245	3,823	109,054
Total	1,540,727	19,408,704	1,516,983	17,730,045
Imports				
Quick and hydrated				
United States	20,551	475,750	25,143	529,411
Britain	152	2,163	124	2,443
France	88	2,316	67	5,143
Total	20,791	480,229	25,334	536,997
Exports				
Quick and hydrated				
United States	102,725	1,170,707	238,318	2,660,268
British Guiana	3,500	33,414	780	6,999
Bermuda	70	2,135	115	2,250
Other countries	48	1,962	121	2,970
Total	106,343	1,208,218	239,334	2,672,487

Source: Dominion Bureau of Statistics.

*Shipments and quantities used by producers. In 1964, 997,632 tons of the total were shipped and 543,095 tons were used at the producing plants.

PPreliminary.

TABLE 2

Lime – Rated Production Capacity*, 1958-65

	No. of Plants Operating*	No. of Kilns*	Approximate Rated Capacity (tons/day)	Average Rated Capacity Plant (tons/day)	Average Rated Capacity Kiln (tons/day)	Production (tons)	Production as % of Capacity**
1958	38	150	7,400	195	49	1,596,422	63
1959	38	155	7,680	202	50	1,685,725	64
1960	35	145	8,010	229	55	1,529,568	56
1961	35	125	7,825	224	63	1,415,290	53
1962	36	126	8,120	226	64	1,424,459	52
1963	34	117	7,830	230	67	1,450,731	55
1964	34	116	7,845	231	68	1,540,727	58
1965	32	112	7,630	238	68	1,516,983P	58P

*At year's end and excluding separate hydrating plants. **Assuming 340 operating days a year.

P Preliminary.

TABLE 3

Lime Producers, 1965

Name of Firm	Plant Location	Type of quicklime
New Brunswick		
Snowflake Lime Limited	Saint John	High-calcium and dolomitic*
Quebec		
Aluminum Company of Canada, Limited	Wakefield	Magnesian*
Bousquet, Adrien	St. Dominique	High-calcium
Dominion Lime Ltd	Lime Ridge	,, *
Domtar Chemicals Limited	Joliette	,, *
Lamothe, N.	Pont Rouge	,,
Quebec Sugar Refinery	St. Hilaire	,,
Shawinigan Chemicals Limited	Shawinigan	,,
Ontario		
Bonnechère Lime Limited	Grattan tp.	High-calcium
Brunner Mond Canada, Limited	Anderdon tp.	,,
Canada and Dominion Sugar Company Limited	Chatham	,,
Canadian Gypsum Company, Limited	Guelph tp.	Dolomitic*
Carleton Lime Products Co.	Carleton Place	High-calcium
Chemical Lime Limited	Beachville	,,
Cyanamid of Canada Limited	Niagara Falls	,,
	Ingersoll	,,
Dominion Magnesium Limited	Haley	Dolomitic
Domtar Chemicals Limited	Hespeler	,, *
	Beachville	High-calcium*
Rockwood Lime Company Limited	Rockwood	Dolomitic*
The Algoma Steel Corporation, Limited	Sault Ste. Marie	High-calcium
Manitoba		
B.A.C.M. Limited	Inwood	Dolomitic*
The Manitoba Sugar Company, Limited	Fort Garry	High-calcium
Selkirk Silica Co. Ltd.**	Spearhill	,,
	Stonewall	Dolomitic
Alberta		
Canadian Sugar Factories Limited	Raymond	High-calcium
	Picture Butte	,,
	Taber	,,
Loder's Lime (Company) Limited	Kananaskis	,, *
Summit Lime Works Limited	Crowsnest	,, *
British Columbia		
Crown Zellerback Canada Limited	Ocean Falls	,,
	Campbell River	,,
Domtar Chemicals Limited	Granville Island	,,

*The hydrated varieties are also produced. **Formerly The Winnipeg Supply and Fuel Company, Limited.

PRODUCTION

Canada produces mostly high-calcium quicklime in addition to dolomitic and magnesian quicklime and the hydrated forms of each type. High-purity limestone is used as the raw material and in 1964, 2.8 million tons served that purpose. Limestone suitable for lime production is available near most of the more populous areas in all provinces except Saskatchewan and Prince Edward Island.

Primary lime was produced in six provinces: Ontario, Quebec, Alberta, Manitoba, British Columbia and New Brunswick. Ontario was by far the leading supplier and, with Quebec, produced 93 per cent of the output in 1965. As indicated in Table 3, all producing provinces supplied high-calcium quicklime, but only plants in Manitoba, Ontario and New Brunswick marketed the dolomitic type. About half the output was used captively either at the producing plant or by parent companies. Operating plants were reduced by 2 to 32, utilizing 112 kilns during 1965. Since 1958 there has been a decrease in the number of operating lime plants, a fluctuating but slightly increased plant capacity, and a definite increase in both average rated plant capacity and average rated kiln capacity.

The amount of secondary lime recovered from chemical operations is large but unknown. Of particular significance is that recovered from the processing of paper pulp. Chemical plants have produced primary lime from limestone on occasion.

Total exports increased by 125 per cent during 1965 to 239,334 tons, of which 238,318 tons were shipped to the United States. At the same time, Canadian imports rose by 22 per cent to 25,334 tons, 25,143 tons of which came from the United States.

TABLE 4

Consumption of Lime
(producers' shipments by use)

	1963		1964	
	Short Tons	$	Short Tons	$
Chemical and Metallurgical				
Iron and steel plants	221,360	2,611,775	282,010	3,311,229
Pulp mills	201,156	2,502,224	190,870	2,344,978
Uranium mills	98,862	1,155,871	47,075	552,575
Nonferrous smelters	61,126	488,640	103,123	790,834
Sugar refineries	35,255	518,155	46,686	694,197
Cyanide and flotation mills	25,523	321,500	18,843	279,792
Glass works	3,209	28,604	4,342	41,218
Fertilizer plants	3,430	37,004	14,090	150,213
Tanneries	5,012	69,928	4,030	62,238
Insecticides, fungicides	1,097	21,450	..	..
Water and sewage treatment	..	..	15,041	255,537
Other	605,312	7,416,781	622,067	7,478,407
Construction				
Finishing lime	78,255	1,807,233	83,556	2,008,185
Masons' lime	37,742	596,156	30,875	522,539
Sand-lime brick	26,749	313,002	31,219	355,892
Agricultural	8,495	103,057	16,939	203,090
Road stabilization	..	..	5,061	84,702
Other	38,148	512,840	24,900	273,078
Total	1,450,731	18,504,220	1,540,727	19,408,704

Source: Dominion Bureau of Statistics.

.. Not available.

CONSUMPTION AND USE

Lime is relatively inexpensive and is desired as an alkali and a chemical for many purposes. Consequently, it is used in many industries. Consumers of lime are divided into five categories: chemical and metallurgical, construction, agriculture, road stabilization, and other industries, as listed in Table 4.

The chemical and metallurgical industries are by far the largest users of lime and consumed 87 per cent of the output in 1964. Most of this was used captively, including most of the 622,067 tons under 'other' that went mainly for the production of calcium carbide, sodium carbonate and calcium chloride at three plants in Ontario and Quebec. In addition, some of the lime used by steel plants and pulp mills was produced captively. Lime is used by the iron and steel industry as a flux in smelting and for neutralizing waste liquors. In paper-pulp production, it is employed in the preparation of dissolving fluids for the soda and sulphite processes. In the recovery of uranium, lime controls the hydrogen-ion concentration and neutralizes waste sludges. Lime is used as a flux in nonferrous smelting and regulates alkalinity in the flotation and cyanidation of minerals. It precipitates impurities from the sucrate during beet-sugar production and is employed in the manufacture of glass as a flux and source of calcium. It is also used in the production of, and as an ingredient in, some fertilizers, in the tanning of leather and in the manufacture of many materials such as calcium carbonate, calcium hydroxide, insecticides, fungicides, pigments, glues and acetylene, and in the recovery of magnesia from sea water.

Slightly less than 10 per cent of Canada's lime output is used by the construction industry. It serves as an ingredient in plaster, mortar, artificial stone, brick and concrete. Agricultural use of lime does not reflect the need of this material as a soil conditioner which is probably much greater. However, the amount being used by agricultural interests continues to increase; in 1964 the number of tons rose to 16,939 from 8,495 tons in 1963. The quantity of lime being used as a soil stabilizer in highway construction is significant enough to be listed separately at 5,061 tons for 1964.

Included in the 'other' grouping in Table 4 are uses in ready-mixed mortar, asphalt paving and water treatment.

PRICES

Quicklime is marketed in lump, pebble, crushed and pulverized form. It may be sold as bulk or in bags. Hydrated lime is normally shipped in bags. Prices vary with the type of product, type of shipment, amount sold, and supply and demand. In 1964 shipments of quicklime and hydrated lime averaged, respectively, $12.02 and $15.06 a ton at the plant.

Limestone

D.H. STONEHOUSE*

Production of limestone in Canada, for all purposes, during 1965 is estimated at 70 million tons. This is comparable to final production statistics for 1964. A significant increase in the quantity of limestone produced for the manufacture of cement was offset by a decrease in the quantity produced for miscellaneous purposes. Although available statistics indicate no gain from 1964, production was maintained at a very high level and represents an increase of 12.5 per cent over 1963 production.

Plants were operated in all provinces except Saskatchewan and Prince Edward Island in 1965 and 91 per cent of the limestone mined for non-lime, non-cement purposes came from two provinces, Ontario and Quebec. The value of limestone produced for use other than in the manufacture of lime and cement, is estimated at $64.5 million for 1965, representing an increase of 4.8 per cent.

Trade with the United States continues to increase with respect to this commodity, although the total tonnage involved is quite small compared to total production. Exports of crushed limestone and refuse amounted to 1.1 million tons at a value of $1.6 million, by far the greatest part of which went to the United States. Imports of crushed stone and refuse consisted of 1.5 million tons valued at $3.5 million. In addition, 1.1 million tons of limestone flux and calcareous stone used for manufacturing lime and cement were imported at a value of $2.6 million, all from the United States.

Exports were from the provinces of Ontario, Alberta and British Columbia, the latter two supplying mostly chemical-grade limestone to areas in northwestern United States, and Ontario supplying a considerable amount of limestone for construction uses. Imports were mostly to the Ontario region, for construction and chemical requirements.

Changes within the industry ranged from minor plant alterations made to improve efficiency and provide a wider range of products, to design and installation of complete new plants, such as the highly-automated Canada Cement Company limestone operation at Brookfield, Nova Scotia.

*Mineral Processing Division, Mines Branch

TABLE 1

Limestone – Production, Trade, Consumption

	1964		1965P	
	Short Tons	$	Short Tons	$
Production[1]				
By province				
Quebec	30,585,457	31,934,376	30,000,000	31,000,000
Ontario	22,217,344	25,243,229	21,702,838	24,881,665
British Columbia	1,931,718	2,757,787	2,600,438	5,387,309
Manitoba	1,021,015	1,095,271	710,525	1,100,475
New Brunswick	792,917	877,402	761,808	926,721
Alberta	128,991	405,784	146,439	445,285
Newfoundland	192,807	351,742	30,036	118,226
Nova Scotia	149,641	475,137	223,167	701,287
Total	57,019,890	63,140,728	56,175,251	64,560,960
	1963		1964	
By type				
General[2]	50,922,301	57,751,631	56,909,844	62,919,534
Marl	99,095	301,690	110,046	221,194
Recrystallized	71,714	755,889	95,455	891,617
Total	51,093,110	58,809,210	57,115,340	64,132,345
By use				
Metallurgical	2,315,546	2,635,770	2,876,659	3,498,967
Pulp and paper	457,412	1,394,360	543,328	1,335,197
Glass	75,031	256,356	75,896	265,439
Sugar refining	81,884	164,163	63,472	113,692
Other chemical uses	515,734	582,814	367,413	375,119
Pulverized for agricultural use	1,087,962	3,034,870	1,195,117	3,253,209
Pulverized for other uses	424,540	1,133,710	1,199,190	1,749,004
Road metal	26,850,247	26,948,831	28,364,591	28,800,655
Concrete aggregate	10,220,885	10,422,776	15,638,544	15,591,168
Rubble and riprap	3,009,855	3,000,866	687,808	740,592
Railroad ballast	1,134,907	1,007,019	1,897,360	1,715,206
Structural[3]	68,079	2,263,558	67,635	1,357,844
Other uses	4,779,314	5,208,228	4,042,877	4,344,636
Total	51,021,396	58,053,321	57,019,890	63,140,728
	1964		1965	
Exports				
Crushed limestone and refuse				
United States	910,869	1,290,911	1,098,048	1,576,299
Leeward and Windward Islands	–	–	25	650
Total	910,869	1,290,911	1,098,073	1,576,949
	1964		1965	
	Short Tons	$	Short Tons	$
Stone, crude; not elsewhere specified				
United States	186,771	358,057	165,314	401,859
Jamaica	–	–	260	8,580
Bermuda	323	1,275	69	2,104
Barbados	–	–	27	188
Other countries	116	11,011	–	–
Total	187,210	370,343	165,670	412,731

Table 1(cont.)

	1964		1965	
	Short Tons	$	Short Tons	$
Imports				
Stone, crushed, incl. stone refuse				
United States	1,045,104	2,815,868	1,488,273	3,384,959
Italy	7,222	115,207	4,796	97,973
Portugal	142	3,200	284	7,242
Belgium-Luxembourg	—	—	61	1,564
Mexico	—	—	25	1,666
Total	1,052,468	2,934,275	1,493,439	3,493,404
Limestone flux and calcareous stone, used for mfg. of lime and cement[4]				
United States	1,269,747	1,776,164	1,138,769	2,630,244
Consumption				
In production of cement	10,275,353		11,039,000[e]	
In production of lime	2,866,000[e]		2,822,000[e]	
Miscellaneous	57,019,890		56,175,251	
Total	70,161,243		70,036,251	

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]Includes sedimentary limestone and minor coloured recrystallized limestone. [3]Includes building, monumental and ornamental stone as well as flagstone and curbstone. [4]U.S. Department of Commerce, *United States Exports of Domestic and Foreign Merchandize* (Report FT410). Values are in U.S. dollars. Symbols:[e]Estimated; [p]Preliminary; —Nil.

DISTRIBUTION OF DEPOSITS

Limestones, acceptable for their physical or chemical qualities, occur near the more heavily populated areas, where they may be used in the booming construction industries as well as in other applications. Most of Canada's production is quarried, processed and used in the southern parts of Ontario and Quebec, although producing deposits occur in all other provinces but Prince Edward Island and Saskatchewan. Suitable and easily accessible deposits are not known in northwestern Ontario nor in eastern Alberta.

Marl, an unconsolidated form of limestone, occurs in every province and is recovered for agricultural purposes where the location and quality warrant.

USES

The uses for limestones are many and varied. The physical properties of a limestone, together with its location, quantity and availability can make it the preferred stone for many applications in the construction industries. The chemical properties of a limestone affect its use in the cement, lime, metallurgical and chemical fields.

In Canada, over three quarters of limestone quarried is used in the construction industries as road metal, concrete aggregate, railroad ballast, rubble and riprap, ornamental and structural stone, terrazzo, stucco, fillers in construction products and as the basic commodity in the manufacture of cement and lime products. A calcium or high-calcium limestone is used in the manufacture of cement, where a low magnesia content is required. Both calcium and dolomitic limestones are used in lime manufacture. For other construction uses the physical properties of the limestones such as texture, hardness and colour are important considerations.

In chemical applications the limestone or lime may or may not appear in the end product. Some major uses in the chemical field are: neutralization of acid waste liquors; manufacture of soda ash from sodium chloride brine; extraction of aluminum oxide from bauxite; production of ammonia, 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.

Limestones are used in the metallurgical industries as a fluxing material, which combines with impurities in the ore to form a fluid slag which can be separated from the metal. A calcium limestone is used in open-hearth operations whereas both calcium limestones and dolomitic limestones are used as a flux in the production of pig iron from iron ore in blast furnaces.

Limestone is used extensively as a filler and, where quality permits, as a whiting or whiting substitute. In such applications both physical and chemical properties must be considered and specifications vary greatly depending on the particular use to which the material is put. In general a uniform, white material passing 325 mesh would meet the physical requirements. Whiting is used in ceramic bodies, plastics, floor coverings, insecticides, paper, wood putty, rubber, paints and as a filler in many other commodities. In paint manufacture the material may be used as a pigment as well as a filler.

Agricultural limestone has been used for many years to correct soil acidity and to add calcium and magnesium to the soil. The amount so used is not as great as it should be to maintain and improve soil conditions; however, through continued promotional efforts of agricultural departments the use of agricultural limestone is increasing. Limestone and lime are used as soil stabilizers, particularly on highway construction projects.

Dolomitic limestone is a source of magnesium metal, produced by Dominion Magnesium Limited, at Haley, Ontario. Dead-burned dolomitic limestone, for use as a refractory, is produced by Steetley of Canada Limited at Dundas, Ontario, and brucitic limestone is the source material for the production of magnesia and lime by Aluminum Company of Canada, Limited, at Wakefield, Quebec.

PRICES

Depending on the type, quality, degree of preparation, local supply and demand, and the quantity involved, limestone prices vary greatly. Screenings and refuse could be sold for 50 cents per ton, ground whiting substitute could bring \$13 to \$14 per ton. Transportation costs provide a major portion of the final price and make it undesirable to move the less expensive grades any great distance.

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Limestone, not further processed than crushed or screened	free	free	25
Flagstone and building stone, not hammered, sawn or chiselled	10	10	20

United States

Limestone, crude, not suitable for use as monumental, paving, or building stone — 20¢ per short ton

Limestone, crude, broken or crushed, when imported to be used in the manufacture of fertilizer — free

Lithium Minerals

J. E. REEVES*

Quebec Lithium Corporation continued to produce spodumene concentrate and to consume it in the manufacture of lithium carbonate and lithium hydroxide monohydrate. Shipments of these chemicals in 1965, containing a little more than a million pounds of lithia (Li_2O) valued at more than $1.1 million, were at about the same level as in 1964. Facilities were made ready for the production of lithium chloride.

The lithium carbonate is mainly exported to the United States and Europe for use in porcelain enamel frits. The U.S. Bureau of Mines reported imports in 1964 of 1,264,000 pounds of Canadian lithium carbonate valued at $564,260 (U.S.), an average of about 44½ cents a pound. A similar amount was probably shipped to the United States in 1965.

Canada imports several lithium chemicals, principally lithium monohydrate and lithium bromide.

The steady growth in consumption of lithium products and the development of technology and new commercial markets give promise of long-range growth. In the short term, production capacity will generally remain much greater than demand.

OCCURRENCES IN CANADA

QUEBEC

The property of Quebec Lithium Corporation in Lacorne township, north of Val d'Or, contains an extensive group of parallel pegmatite dikes bearing a vast quantity of spodumene ore. Indicated reserves are more than 20 million tons in the area near the shaft, with an average of 1.15 per cent Li_2O.

Lithium-bearing pegmatites occur in other parts of Lacorne township and in neighbouring Figuery and Landrienne townships. They are associated with the contact of a large granitic intrusive mass known as the Lacorne batholith. Spodumene is the main lithium mineral in this area, although there are small amounts of lepidolite and lithiophilite.

In several places to the north and west of Chibougamau, pegmatites with abundant spodumene have been found.

MANITOBA

Numerous lithium-bearing pegmatites occur in the Winnipeg River-Cat Lake area, in the south-eastern part of the province. The most significant occurrence is that of Chemalloy Minerals Limited, on the north shore of Bernic Lake. Its flap dip and unusual mineral assemblages make it notably different from most other Canadian deposits. Zones containing large quantities of spodumene and lepidolite (more properly, lithian muscovite), and an unusual concentration of the cesium mineral, pollucite, make this deposit one of considerable interest. A lesser amount of amblygonite, which might be recoverable as a byproduct, also occurs.

* Mineral Processing Division, Mines Branch

The most recent information on lithium mineral reserves in this deposit places them at nearly 5 million recoverable tons, containing an average of more than 2 per cent Li_2O. The principal recoverable mineral is a low-iron spodumene. The main pollucite zone contains 300,000 recoverable tons that average a little more than 20 per cent cesium oxide (Cs_2O).

OTHER OCCURRENCES

Many occurrences of spodumene-bearing pegmatites have been discovered in several areas of northwestern Ontario, most notably in the area south and southeast of Lake Nipigon. Pollucite has been identified in a spodumene pegmatite northeast of Dryden.

In the Northwest Territories to the north and east of Yellowknife, pegmatites containing spodumene, lesser amounts of amblygonite, minor amounts of other lithium minerals and beryl and columbite-tantalite have been described.

WORLD PRODUCTION AND RESOURCES

The United States is the main producer and consumer of lithium minerals, chemicals and metal. Its principal domestic sources of raw material have been the extensive spodumene-bearing pegmatites in North Carolina and the vast brine deposits of Searles Lake, California, from which byproduct dilithium sodium phosphate is obtained and converted to lithium carbonate. By the end of 1965, Foote Mineral Company was well on its way to recovering lithium compounds (initially lithium carbonate) at Silver Peak, Nevada, from brines having an exceptionally high lithium concentration. The use of solar evaporation for concentrating the brines is expected to give the company an economic advantage. Lithium Corporation of America, Inc., continued working towards the extraction of several products, including lithium chloride, from the brines of Utah's Great Salt Lake.

Rhodesia has been the principal source of lepidolite and petalite for markets in Europe and the United States mainly, in the latter country for direct use in the ceramics industry. It also is a source of small quantities of spodumene, amblygonite and eucryptite and has sizable reserves of all these minerals. The present political unrest and the boycotting by some countries of Rhodesian exports make its near future as a source of lithium minerals somewhat uncertain.

TECHNOLOGY

Lithium is a relatively common element that occurs in many different minerals in the earth's crust. As primary commercial products, these minerals occur in sufficient concentration only in a few granitic pegmatites. Of the most common lithium minerals, listed in Table 1, the first five are of economic importance.

TABLE 1

Principal Lithium Minerals

Mineral	Simplified formula	Theoretical Li_2O Percentage	Actual Range Li_2O Percentage
Spodumene	$LiAlSi_2O_6$	8.0	4 – 7.5
Petalite	$LiAlSi_4O_{10}$	4.9	3 – 4.5
Lepidolite	$KLi_2AlSi_4O_{10}$ (F, OH)$_2$	7.7	3 – 5
Amblygonite	$LiAlFPO_4$	10.1	7.5 – 9
Eucryptite	$LiAlSiO_4$	11.9	5.5 – 6.5
Zinnwaldite	$KLiFeAl_2Si_3O_{10}$ (F, OH)$_2$	3.4	2 – 3
Lithiophilite-triphylite	Li (Mn, Fe) PO_4	9.6	2 – 6

Lithium is known to have been also concentrated to some extent, along with the common alkali metals, sodium and potassium, and various other elements, in certain brines in the western United States. It is economically recoverable from some of these brines, generally as a coproduct with compounds of some of the other elements.

In North America the chief method of concentrating spodumene is flotation. In Rhodesia, where the various lithium minerals occur in a high degree of natural concentration, handpicking is used.

Most spodumene concentrate, part of the other mineral concentrates and all the byproduct dilithium sodium phosphate are converted to various lithium chemicals. In Canada, decrepitated spodumene is reacted with sodium carbonate under close environmental control as a first step in the production of lithium carbonate and lithium hydroxide monohydrate.

A small proportion of the spodumene and much of the petalite and lepidolite are consumed without further processing. A small amount of lithium metal is produced.

USES

The ceramics industry is one of the main consumers of lithium chemicals, especially lithium carbonate, and the sole consumer of lepidolite, petalite and spodumene concentrates. These chemicals and concentrates are important primarily because of their content of lithia, a very strong flux, lithium carbonate being used when a high proportion of lithia is required. Petalite is a source of lithia with a low potash, soda and iron content. Lithia permits the development of low-temperature bodies that reduce the cost of refractories and fuel. It lowers the maturing temperature and increases the fluidity and gloss of glasses, glazes and enamels. It makes possible glasses that are harder and that have higher electrical, chemical and thermal resistance.

Another main use is in the manufacture of lubricating greases. Lithium stearate, derived from lithium hydroxide monohydrate, combines the best characteristics of sodium and calcium soaps and permits the greases to be effective over a wide range of temperatures – from -60°F to +320°F – and to be highly water resistant. Lithium greases have grown significantly in importance since their development 25 years ago for use under special operating conditions of aircraft, and have become widely accepted as automotive lubricants.

Lithium chloride and lithium bromide are important in air conditioning and refrigeration. They are extremely hygroscopic and are used primarily for moisture absorption.

Lithium hydroxide monohydrate is added to the electrolyte in nickel-iron alkaline storage batteries to increase their life and output; lithium chloride and fluoride are added to welding and brazing fluxes to remove the oxide film from aluminum and magnesium surfaces; and lithium hypochlorite is used as a bleach.

A newly developing use for lithium compounds, probably lithium carbonate principally, is as an additive to the electrolyte in the Hall cell of aluminum smelters. The strong fluxing action of lithia would reduce power requirements. The declining price of lithium carbonate may give impetus to this development.

Lithium metal is used as a scavenger of oxygen, nitrogen and sulphur in copper and in some brasses and bronzes, and as a reducing agent in the synthesis of vitamins and antihistamines. Butyl lithium is used as a catalyst in the production of synthetic rubber. Alloys of lithium and magnesium or aluminum have promise as light-weight and high-strength structural metals, particularly in space craft.

PRICES

The principal change during 1965 was in the decline in the price of lithium carbonate. According to *Oil, Paint and Drug Reporter* of December 27, 1965, prices of the principal lithium chemicals were:

Lithium carbonate	$0.46
Lithium hydroxide monohydrate	0.54
Lithium chloride	1.23½
Lithium fluoride	1.55
Lithium stearate	0.47½
Lithium hydride	9.50

The quoted price of lithium carbonate near the end of 1964 was 58 cents a pound. The impending production of lithium carbonate at Silver Peak, Nevada, promised a further reduction to 38½ cents a pound.

TARIFFS

Tariffs in effect at the time of writing include:

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Lithium compounds			
Of a class or kind not produced in Canada	free	15	25
Of a class or kind produced in Canada	15	20	25

United States	
Lithium compounds and salts	10.5%
Lithium stearate	1.5¢ a pound plus 10% ad val.
Lithium metal	25%

Magnesite and Brucite

D. H. STONEHOUSE*

Quebec is the only Canadian province which produces magnesite and brucite commercially although deposits occur in several other provinces. One deposit of magnesite in Ontario is receiving consideration as a source of magnesia.

Most magnesia is used in the refractory field and the world demand follows the metallurgical industry very closely. A comparatively new market for magnesium hydroxide has developed in the pulp-processing industry.

Canada produced dead-burned and calcined magnesia valued at close to $4 million during 1965. World production of crude magnesite** during 1964 increased to an estimated 10 million tons, of which 3 million tons came from the USSR, 1.8 million tons from Austria and 1.1 million tons from China. The total quantity of magnesia produced from brine and sea water is unknown but about three quarters of the output of the United States is from these sources.

Magnesia and its products are in a price range that allows them to be traded widely. Although Canadian export statistics do not differentiate the products moved, a total of 905,000 tons of crude refractory materials was exported in 1965 at a value of $1.9 million, somewhat lower than for 1964. United States imported from Canada 1,969 tons of refractory magnesia and 20,759 tons of magnesia brick and other shapes during 1965.

Canadian imports of magnesia products rose to a value of $5 million for 1965, of which one half was for dead-burned and sintered magnesia.

PRODUCERS

Commercial production of magnesia in Canada comes from two plants in western Quebec — one ships dead-burned magnesia, the other markets calcined magnesia and magnesium hydroxide.

A magnesite-dolomite rock is mined from underground at Kilmar by Canadian Refractories Limited. Beneficiation at the plant site consists of heavy-media separation, dead-burning, crushing, and sizing. Small quantities of product are exported to the United States but the greatest part is used in the manufacture of basic refractories in the company's plant at nearby Marelan.

Brucitic limestone is quarried and processed by Aluminum Company of Canada, Limited, at Wakefield. The quarried rock is crushed, sized and calcined; the product is hydrated and separated into magnesia and hydrated lime. The magnesia is sold for use in refractories, fertilizers and chemical processing; the magnesium hydroxide is sold for chemical processing, particularly in the pulp and paper industry.

High-magnesia refractories are produced at four plants in Canada: Canadian Refractories Limited, Marelan, Quebec; General Refractories Company of Canada Limited, Smithville, Ontario; Refractories Engineering and Supplies Limited, Bronte, Ontario; and Norton Company, Chippawa, Ontario. Each plant, except that at Marelan, is dependent upon imported magnesia.

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*Mineral Processing Division, Mines Branch

**Source: U.S. Bureau of Mines *Minerals Yearbook 1964.*

TABLE 1

Magnesite and Brucite — Production and Trade, 1964–65

	1964		1965P	
	Short Tons	$	Short Tons	$
Production[1], Quebec				
Magnesia from dolomitic magnesite and brucite		3,569,619		4,007,241
Exports				
Crude refractory materials[2]				
United States	1,149,842	2,230,307	905,271	1,872,418
Australia	84	2,423	123	4,564
Other countries	146	7,594	22	1,048
Total	1,150,072	2,240,324	905,416	1,878,030
Imported by United States[3]				
Refractory magnesia including fused magnesia and dead-burned magnesia and dolomite	736	41,993	1,969	112,511
Magnesia, brick and other shapes	18,165	2,970,670	20,759	3,381,995
Imports				
Magnesia, dead-burned and sintered				
United States	19,599	1,441,147	23,797	1,832,375
Yugoslavia	6,595	364,303	5,055	305,587
Austria	–	–	3,745	258,587
Greece	1,543	108,646	2,976	226,421
Britain	5	376	430	35,635
Other countries	13	3,591	17	5,085
Total	27,755	1,918,063	36,020	2,663,690
Magnesia, not elsewhere specified				
United States	2,921	300,272	1,660	233,993
Britain	–	–	564	42,602
Netherlands	94	6,474	77	5,500
India	10	1,778	–	–
Total	3,025	308,524	2,301	282,095
Magnesium oxide				
United States	3,531	574,291	771	364,418
Britain	95	44,064	95	52,523
West Germany	–	–	44	7,939
Total	3,626	618,355	910	424,880
Dolomite, calcined				
United States	14,998	283,023	29,417	559,671
Sweden	–	–	339	22,254
Total	14,998	283,023	29,756	581,925
	Thousands of Units	$	Thousands of Units	$
Magnesite firebrick and other shapes				
United States	201	376,802	297	809,646
Britain	319	255,200	195	178,912
France	67	58,934	59	42,564
West Germany	125	110,795	7	18,162
Other countries	21	32,342	20	35,523
Total	733	834,073	578	1,084,807

Source: Dominion Bureau of Statistics except where otherwise indicated.

[1] Includes the value of brucitic magnesia shipped, and of dead-burned magnesia and a small quantity of serpentine used or shipped. Since 1963, some magnesium hydroxide has been shipped. [2] Mainly includes materials other than magnesia. [3] Not recorded separately in the official Canadian trade statistics. The figures shown are reported in *United States Imports of Merchandise for Consumption*, 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. P Preliminary; — Nil.

Other magnesite deposits have been found in British Columbia, the Northwest Territories, Saskatchewan, Ontario, Quebec, Nova Scotia and Newfoundland. However, except for test shipments, no magnesite has been produced from these deposits. Brucitic limestone has been found near Rutherglen, Ontario, but it has been quarried for use as an aggregate in construction rather than for the production of magnesia. Deposits of brucite have been found in other areas of Quebec and Ontario, as well as in British Columbia and Nova Scotia.

Dead-burned dolomitic limestone, commonly referred to as dead-burned dolomite, contains much less magnesia than most basic refractories. It is produced near Dundas, Ontario, by Steetley of Canada Limited but production and export statistics for this commodity are not available.

TABLE 2

Magnesite and Brucite – Production*, 1956–65

1956	$2,783,181
1957	3,046,298
1958	2,529,161
1959	3,050,779
1960	3,279,021
1961	3,064,403
1962	3,431,873
1963	3,439,890
1964	3,569,619
1965p	4,007,241

Source: Dominion Bureau of Statistics

* Brucitic magnesia shipped and dead-burned magnesia and a small quantity of serpentine used or shipped. Since 1963, some magnesium hydroxide has been shipped.

p Preliminary.

TABLE 3

Consumption of Magnesia in Canada

	1964 (short tons)
Refractory brick, shapes, mixes, cements	36,474
Paper, paper products, paper pulp	16,555
Foundry	597
Other uses*	7,099
Total	60,725

* Includes: chemicals, medicinals and pharmaceuticals, paints, rubber products, wire and cable, fertilizers and other miscellaneous products.

TECHNOLOGY

The minerals magnesite and brucite theoretically contain 47.6 and 69.0 per cent magnesia, respectively, and they may be converted to magnesia by calcination. Dolomite, sea water, sea-water bitterns and some brines may also be processed to recover magnesia. Since 1954 there has been an appreciable increase in the recovery of this commodity from brines and sea water in the United States. High-purity products are derived by the calcination of magnesium hydroxide or magnesium chloride resulting from treatment of these solutions.

Calcined and dead-burned magnesia are two semiprocessed products commonly used by industry. Calcined magnesia is chemically active and a product of mild calcination. Dead-burned magnesia forms during intense calcination and is chemically inactive. Periclase is dead-burned magnesia containing small amounts of iron and a minimum of 92 per cent magnesia. Other magnesium compounds such as the hydroxide, carbonate and chloride are also marketed.

Mainly because of consumer demands for higher magnesia and lower calcium and silica contents to meet the increased efficiencies required, the specifications are becoming more stringent.

CONSUMPTION AND USES

Statistics relating to the consumption of magnesia in Canada during 1964 appear in Table 3 and although incomplete, depict the ratio in which major consumption centres use the commodity. Refractory uses account for 60 per cent of reported consumption and the pulp and paper industries used slightly over 27 per cent.

Dead-burned magnesia is employed as an ingredient in such basic refractory products as bricks and shapes, hearth clinker, gunning and ramming mixes, cements and mortars. It has the ability to withstand the effects of basic slags for reasonable periods during metallurgical processing and is particularly popular as a refractory in steel and cement production.

Calcined magnesia is used as a raw material in the production of other magnesium compounds and occasionally in the production of the dead-burned product for use in refractories. It is a source of magnesium metal and an ingredient in magnesium-oxychloride and magnesiumoxysulphate cements which are employed in floor construction and in composition board. Magnesia is also used to control acidity in chemical processing, as a constituent of manufactured fertilizers and in the production of heating elements, rayon, rubber, petrochemicals, magnesian chemicals, welding-rod coatings, certain types of insulation and catalysts.

The most significant recent development associated with the use of magnesia products has been the conversion of some major pulp and paper manufacturing operations to the Magnefite process based on magnesium bisulphite pulping. The change from a calcium to a magnesium based process results in a newsprint of increased strength, permitting greater use of jack pine wood pulp.

In the near future, domestic consumption of dead-burned magnesite for refractories and of magnesium hydroxide for paper-pulp processing is expected to increase greatly.

PRICES

Prices vary with product quality and product demand. The December 27, 1965, issue of *Oil, Paint and Drug Reporter* quotes the following United States prices per short ton.

Magnesia, dead-burned, standard grade, bulk, car lots, Chewela, Washington	$46.00
Magnesia, calcined, technical, heavy, bags, car lots, f.o.b. Lunning, Nevada	
90%	53.00
93%	56.00
95%	61.00
Magnesia, calcined, chemical grade, powdered, bags, car lots, works	88.75

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Magnesite, crude rock	free	free	free
Magnesite, dead-burned or sintered; magnesite, caustic-calcined; plastic magnesia	15%	15%	30%
Magnesium carbonate, imported for use in compounding or manufacture of rubber products	free	20%	30%
Magnesium oxide and magnesium carbonate, not further manufactured than ground, for manufacture of insulating materials	free	free	free
Dead-burned magnesite containing not less than 83% magnesium oxide for manufacture of magnesite fire brick or chrome fire brick	7½%	7½%	30%
Dead-burned dolomite	15%	15%	25%
Micronized dolomite	free	5%	25%

United States

Magnesite	
Crude, per long ton	$ 5.25
Caustic calcined, per long ton	$10.50
Refractory magnesia, including dead-burned magnesite, fused magnesite, and dead-burned dolomite	
Not containing lime or containing by weight not over 4% lime	0.38¢ per lb
Containing by weight over 4% lime	12% ad val.
Refractory and heat-insulating bricks of all sizes and shapes	
Chrome bricks	25% ad val.
Magnesite bricks	0.38¢ per lb + 5% ad val.
Other bricks	3% ad val.

Magnesium

W.H. JACKSON*

Magnesium production in 1965 was 11,133 tons valued at $6,697,506. Exports represent about two thirds of the value of production with the main markets being Britain and West Germany. Shipments to the European market amounted to $3.9 million of the $4.4 million export total. Shipments to the United States, mainly special grades and duty-free under Defence Production sharing, increased slightly to $594,210. Duties inhibit commercial shipments of ingot to the United States but scrap enters free of duty and about 1,177 tons were exported there from Canada in 1965. Canadian imports of magnesium metal and alloys totalled 1,807 tons valued at $1,843,898; all except 16 tons came from the United States.

According to available data, magnesium consumption in Canada increased 19 per cent in 1965 to 4,473 tons. Gains were recorded in castings and extrusions but its use as an alloying agent with aluminum still represented by far the greatest tonnage, amounting to nearly two thirds of total comsumption.

CANADIAN DEVELOPMENTS

Dominion Magnesium Limited, with mine and and smelter at Haley, Ontario, is the only magnesium producer in Canada. It is also the only domestic producer of metallic calcium, and in minor quantities, thorium, barium, strontium, titanium and zirconium.

Magnesium operations at Haley are based on the Pidgeon process of reducing calcined dolomite ($CaCO_3 \cdot MgCO_3$) by ferrosilicon. The ore is a band of Precambrian dolomite lying between a quartzite hanging-wall and a paragneiss foot-wall. Reserves are about 4 million tons to 100-foot depth. Mining is by open pit with benches 20 feet high. The dolomite has exceptional physical characteristics and purity permitting efficient use of smelter capacity. Mill capacity is 400 tons daily. Following crushing and calcining, the ore is mixed with ferrosilicon and fluorspar, briquetted, bagged and charged into horizontal retorts. At high temperature under vacuum, magnesia is reduced and the magnesium content is distilled and collected as crystalline rings called crowns in the water-cooled head sections of the retorts. For the commercial grade of magnesium, these are remelted and cast into ingot forms. Subsequent refining operations produce the higher-purity grades.

Annual smelter capacity was increased from 10,000 to 11,500 tons in 1965 by the addition of two furnaces at a cost of $390,000. The plant now has a total of 544 retorts in 16 furnaces. Production of magnesium crowns was 10,169 tons in 1964 and 11,215 tons in 1965.

*Mineral Resources Division

TABLE 1

Magnesium — Production, Trade and Consumption, 1964–65

	1964		1965P	
	Short Tons	$	Short Tons	$
Production[1] (metal)	9,353	5,587,909	11,133	6,697,506
Imports				
Magnesium metal				
United States	1,594	1,248,046	1,637	1,271,426
Britain	—	—	4	6,259
Total	1,594	1,248,046	1,641	1,277,685
Magnesium alloys				
United States	186	468,237	154	547,276
Britain	1	8,520	12	18,937
Total	187	476,757	166	566,213
Exports				
Magnesium metal				
Britain	..	1,332,564	..	1,833,924
West Germany	..	1,374,416	..	1,476,704
United States	..	255,338	..	594,210
France	..	398,642	..	289,765
Australia	..	77,795	..	78,543
Mexico	..	126,496	..	31,330
Sweden	..	20,623	..	28,920
Other countries	..	365,512	..	122,859
Total	..	3,951,386	..	4,456,255
Consumption (metal)				
Castings	389	..	512	..
Extrusions (structural shapes, tubing)	347	..	587[2]	..
Aluminum alloys	2,494	..	2,959	..
All other products[3]	532	..	415	..
Total	3,762	..	4,473	..

Source: Dominion Bureau of Statistics.

[1] Shipments of metal in all forms (ingots, crowns, powder, and in alloys). [2] Includes a small amount for other wrought products. [3] Including other alloys, and magnesium used for cathodic protection and as a reducing agent.

P Preliminary; — Nil; .. Not available.

TABLE 2

Magnesium — Production, Trade and Consumption, 1956–65

	Production (short tons)	Imports: Alloys (short tons)	Imports: Alloys ($)	Imports: Metal (short tons)	Exports ($)	Consumption (short tons)
1956	9,606	..	366,837	..	5,153,509	1,003
1957	8,385	..	276,742	..	4,535,570	840
1958	6,796	..	255,768	..	2,871,991	711
1959	6,102	..	273,021	..	3,879,588	1,668
1960	7,289	..	336,548	..	3,232,805	2,199
1961	7,635	..	426,566	..	3,608,523	2,776
1962	8,816	..	178,757	..	3,967,932	3,614
1963	8,905	..	181,738	..	3,676,725	3,641
1964	9,353	187	476,757	1,594	3,951,386	3,762
1965P	11,133	166	566,213	1,641	4,456,255	4,473

Source: Dominion Bureau of Statistics.

P Preliminary; .. Not available.

The following grades and purities of magnesium are available: Commercial, 99.90 per cent; High Purity, 99.95 per cent; Special 99.97 per cent; and Refined, 99.99 per cent. These are produced in 20-pound, 5-pound and 1-kilogram ingots, as billets from 4 to 20 inches in diameter and as granules in minus-4 plus-50 mesh size. The other magnesium products are master alloys, rods, bars, wire, structural shapes and magnesium alloys to all specifications.

Other metals are produced at Haley by similar reduction methods. Calcium is discussed in another review in this series. Thorium metal is available as sintered pellets of 98-per-cent purity or as powder of 99.5-per-cent purity. Calcium is sold as powder, sticks or ingot depending on grade. Barium and strontium of 99.0-per-cent purity are available as extruded sticks. Sintered pellets of zirconium and titanium are also produced.

TABLE 3

World Production of Primary Magnesium

(thousand short tons)

	1963	1964	1965^e
United States	75.8	79.5	81.3
U.S.S.R.	35.0^e	35.0^e	35.0
Norway	22.7	25.0^e	26.0^e
Canada	8.9	9.4	11.1
Italy	6.0	6.1^e	6.3^e
Britain	2.7^e	3.0^e	3.0^e
Japan	2.7	3.2^e	3.7
France	2.0	2.0	3.1
China	1.1	1.1	1.1
West Germany	0.5	0.5	0.5
Poland	0.3	0.3	0.3
Total	157.7	165.1	171.4

Sources: U.S. Bureau of Mines *Minerals Yearbook, 1964*, U.S. Bureau of Mines *Commodity Data Summaries*, January, 1966, *Metal Statistics, 1965;* and for Canada, Dominion Bureau of Statistics.

^{e}Estimate.

TABLE 4

Principal Producers of Magnesium 1965

	Raw Material	Process	Estimated Capacity (short tons)
Canada			
Dominion Magnesium Limited	Dolomite	Pidgeon ferrosilicon	11,500
France			
Société des Produits Azotes	Dolomite	Magnetherm ferrosilicon	3,900
West Germany			
Knapsack Griesheim A.G.	..	..	{ 500
Vereinigte Aluminum Werke A.G.	..	..	
Italy			
Societe Italiana per il Magnesio e Leghe di Magnesio, S.P.A.	Dolomite	Ferrosilicon	7,000
Japan			
Furukawa Magnesium Company	Dolomite	Ferrosilicon	8,500
Norway			
Norsk Hydro-Elektrisk	Dolomite, sea water	Electrolytic	27,000
United States			
Alamet Division of Calumet & Hecla, Inc.	Dolomite	Pidgeon ferrosilicon	7,000
Dow Chemical Company Limited	Sea water	Electrolytic	100,000
Nelco Division of Charles Pfizer Company	Dolomite	Pidgeon ferrosilicon	5,000
Titanium Metals Corporation	Recycled $MgCl_2$	Electrolytic	12,000
United Kingdom			
Magnesium Elektron Limited	Dolomite	Pidgeon ferrosilicon	5,000
China (mainland)	..	..	1,100
Soviet Union	Dolomite carnallite	Electrolytic	35,000 to 50,000
Poland	..	..	300

.. Not available.

WORLD DEVELOPMENTS

Estimates place world primary magnesium production at 171,000 tons in 1965. Production by country is listed in Table 3 and nominal plant capacities are listed in Table 4. The outputs of Britain, Italy and France meet only part of their domestic needs. Norway, the United States and Canada export to European countries as import tariffs or quotas permit. European demand is about 50,000 tons a year. Volkswagen in Germany consumed about 38,000 tons for automotive purposes in 1965. Most of Japanese output is used as a reducing agent in titanium production, for alloying with aluminum and in making nodular iron.

United States primary production of magnesium in 1965 was 81,361 tons (79,489 tons in 1964). The constant production rate, with increased shipments amounting to 85,796 tons compared to 74,580 tons in 1964, suggests that increased operating rates are likely. Increased demand for alloying with aluminum, the current high level of mill and foundry shipments and anticipated requirements resulting from the war in Viet Nam indicate continuing high demand. Exports in crude form including scrap were 17,835 tons compared to 13,947 tons in 1964. Imports of all forms totalled 2,979 tons.

Small disposals from the U.S. stockpile, totalling 2,650 tons in 1965, have been sold to domestic consumers, unlike aluminum disposals that were made mainly by selling metal back to the producer. At the end of 1965, the magnesium stockpile objective was 145,000 tons and there were 24,800 tons surplus to this objective.

In Japan, West Germany, Britain and the United States, substantial quantities of secondary magnesium are produced which add to the effective supply. Ordinary commercial grades of magnesium from both electrolytic- and ferrosilicon-process plants compete in normal markets for common magnesium alloys and as additives to aluminum and iron alloys. Higher-purity grades available from some Pidgeon type plants are extremely low in undesirable trace elements. Such magnesium is needed in special markets, mainly for nuclear uses, for the reduction of pure metals, and for special magnesium alloys containing zirconium and thorium.

A new magnesium plant in France, controlled by Pechiney and Ugine organizations and Produits Azotes, was brought into service at Marignac. It employs a semicontinuous thermal reduction process using slag as a resistor and ferrosilicon to reduce the dolomite. Italy uses a ferrosilicon process in which the charge is stacked by hand in large furnaces. Other ferrosilicon plants in areas of higher labour costs use the Pidgeon process similar in most respects to that of Dominion Magnesium. The Norwegian producer and The Dow Chemical Company in the United States are the two large primary producers; both use electrolysis of magnesium chloride as the basis of magnesium production. The Dow Chemical Company, the world's largest producer, plans to increase capacity to 120,000 tons a year by process improvements that will not involve new smelter construction. United States smelter projects in the planning stages include those of Dow near Ogden, Utah, and of Harvey Aluminum (Incorporated) in the Pacific Northwest.

USES

Demand for magnesium as a reducing agent in the smelting of titanium, uranium and beryllium, as sacrificial anodes, and as a component of aluminum alloys and nodular cast iron, together comprise a major outlet for production.

Progress has been made in die-casting technology. For components requiring strength, rigidity and lightness, magnesium is often an alternative to zinc and aluminum. Examples are to be seen in a number of automotive parts, and appliances. Extrusions are used in such applications as lightweight luggage, ladders, drill rods, etc. Mill products, sheet or plate, may be seen in shovels, portable ramps, photoengraving plate and a wide range of defence industry uses. Fuel element cans for nuclear power stations are made in Britain by the impact extrusion method. Lightness and dimensional stability contribute to use in jigs and other fixtures in tooling.

There are a number of magnesium alloys available for high-temperature or high-strength applications that utilize zirconium, thorium or rare earths to achieve the required properties. For most wrought or cast magnesium products, a series of alloys containing up to 9 per cent aluminum is most commonly used.

PRICES

In 1965, the quoted Canadian price of commercial grade magnesium f.o.b. Haley, remained unchanged at 31 cents a pound.

According to *E & MJ Metal and Mineral Markets,* December 27, 1965, prices in the United States were as follows:

Per lb, f.o.b. shipping point, 10,000-lb lots	
Pig ingot, 99.8%	35.25 – 36.65¢
Notched ingot	36.00 – 37.45¢

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Pure magnesium	free	15	25
Alloys of magnesium, ingots, pigs, sheets, plates, strips, bars, rods, tubes	5	10	25
Magnesium scrap	free	free	free
Sheet or plate, of magnesium or alloys of magnesium, plain, corrugated, pebbled, or with a raised surface pattern, for use in Canadian manufacture	free	free	25

United States

Magnesium, unwrought: other than alloys; and magnesium waste and scrap (duty on waste and scrap suspended to June 30, 1967)	40% ad val.
Magnesium alloys, unwrought	16¢ per lb on magnesium content + 8% ad val.
Magnesium alloys, wrought	13.5¢ per lb on magnesium content + 7% ad val.

Manganese

V.B. SCHNEIDER*

No manganese ore is now mined in Canada but small amounts have been mined from occurrences in New Brunswick, Nova Scotia and British Columbia from low-grade bog deposits. Large low-grade deposits occur in New Brunswick and Newfoundland.

Imports of manganese ore in 1965 amounted to 89,480 tons valued at $5.4 million, compared with 62,813 tons valued at $3.9 million imported in 1964. Direct comparisons with years before 1964 are not possible because in 1964 for the first time the Dominion Bureau of Statistics reported the manganese content in ores and concentrates rather than the gross weight. However, imports of ore for 1964 were the largest since 1956 when 208,000 tons (gross weight) were imported. Imports of ferro- and silicomanganese in 1965 amounted to 35,349 tons valued at $4.7 million, compared with 23,574 tons valued at $3.2 million in 1964. Exports of ferromanganese amounted to 3,817 tons, all to the United States, a slight increase over those of 1964. Because of the highly competitive nature of the ferromanganese industry and because approximately two tons of manganese ore must be imported to make one ton of ferromanganese, domestic manufacturers are unable to compete with South African and other foreign ferromanganese in the United States market. Only through improved technology, equipment and efficiency have they been able to hold their own in domestic sales.

Consumption of manganese ore at 118,635 tons was down about 15 per cent from 1964 and Canadian consumption of ferromanganese at 61,352 tons was down some 7 per cent. This does not reflect reduced steel output but rather changes in technology and, to a minor extent, changes in end-products. The emphasis in increased Canadian steel production is for low-carbon steel used for flat-rolled products.

As with other alloying agents, world markets for manganese were much improved during 1965 over the previous eight years. The three most important features that contributed to the improved manganese ore market were the high level of steel production throughout the world, the near-balance between supply and demand, and the final absorption of excessive commercial inventories, which have overhung the market since 1957. The United States is the largest consumer of manganese ore and the U.S. Bureau of Mines reported consumption for 1965 at 2.54 million tons; this is an all-time high, surpassing the previous record of 2.36 million tons in 1957.

There are some 125 manganese minerals but only a few are of economic importance. Most manganese is obtained from two minerals — pyrolusite (MnO_2) and psilomelane, an impure hydrated oxide ($MnO_2.H_2O$, K and Ba variable). These may be accompanied by other oxides such as wad or 'bog manganese', braunite and manganite. The carbonate rhodochrosite ($MnCO_3$) and the silicate rhodonite ($MnSiO_3$), except where they have been oxidized, are usually not of commercial importance.

* Mineral Resources Division

TABLE 1

Manganese – Canadian Trade and Consumption, 1964-65

	1964		1965P	
	Short Tons	$	Short Tons	$
Imports				
Manganese in ores and concentrates*				
Ghana	17,448	958,770	26,981	1,410,349
Brazil	15,530	877,949	17,695	1,094,539
Republic of the Congo (Kinshasa)	6,908	308,328	12,867	768,043
British Guiana	–	–	7,217	335,583
Uruguay	2,598	138,783	6,470	404,567
Republic of South Africa	–	–	6,469	299,267
United States	6,659	902,611	5,653	774,979
India	6,616	386,408	3,537	236,522
Turkey	–	–	2,554	98,040
Other countries	7,054	371,895	37	8,153
Total	62,813	3,944,744	89,480	5,430,042
Ferromanganese including spiegeleisen				
Republic of South Africa	19,606	2,361,174	26,803	3,427,890
Britain	–	–	6,163	804,200
United States	798	170,268	1,450	282,939
Japan	1,291	346,001	78	23,174
France	79	27,276	68	33,002
Other countries	56	15,261	–	–
Total	21,830	2,919,980	34,562	4,571,205
Silicomanganese including silico spiegeleisen				
United States	867	127,681	635	99,585
Norway	827	97,959	152	21,553
Japan	50	5,600	–	–
Total	1,744	231,240	787	121,138
Exports				
Ferromanganese, United States	3,359	428,196	3,817	748,154
Consumption				
Manganese ore				
Metallurgical-grade	136,867		117,143	
Battery- and chemical-grade	1,951		1,492	
Total	138,818		118,635	

Source: Dominion Bureau of Statistics.
*Mn content.
P Preliminary; – Nil.

PRODUCTION AND TRADE

The U.S. Bureau of Mines in its *Commodity Data Summaries*, January 1965, estimated that world mine production in 1965 was 17.2 million tons, 300,000 tons more than in 1964. Russia is by far the largest producer with about 53 per cent of the world's output. The Republic of South Africa, Brazil and India follow in that order with each producing slightly more than 1.4 million tons a year.

World reserves, other than in Russia, are reported by Elyutin, et al.* to be about 1,700 million tons; they further state, "The manganese ore reserves of the deposits explored in the U.S.S.R. by far exceed all the other countries

* Elyutin, V.P. et al. *Production of Ferroalloys Electrometallurgy.* The State Scientific and Technical Publishing House for Literature on Ferrous and Nonferrous Metallurgy, Moscow 1957, translated from Russian and published for the National Science Foundation, Washington, D.C.

together. The largest deposit of manganese ore of world-wide importance is the Chiatura deposit (Georgia SSR)." Most of the remaining known manganese deposits are in India, the Republic of South Africa, Gabon, Ghana, Brazil and British Guiana. The reserves of India and Gabon have been estimated to exceed 100 million tons each; those of Brazil, 150 million; and of the Republic of South Africa, more than 50 million tons.

The United States is the leading importer and consumer of manganese ore. According to the U.S. Bureau of Mines Mineral Industry Series, *Manganese Monthly*, March 8, 1966, U.S. imports of manganese ore for consumption in 1965 amounted to 3,856,118 tons and general imports of ferromanganese (in terms of ore) amounted to an additional 512,834 tons. Imports were received from more than 20 countries but Brazil was by far the leading source, supplying 40 per cent. Brazil was followed by The Democratic Republic of the Congo (Kinshasa), Gabon, Ghana, India and the Republic of South Africa. Imports of ferromanganese into the United States amounted to 256,417 tons (gross weight) valued at $31 million. This is a 12-per-cent increase in value from 1964 and, despite much improved marketing conditions for the U.S. producers, reflected the continuing competition in the United States from foreign-produced ferromanganese. India, France, Republic of South Africa and West Germany were the principal suppliers, accounting for 65 per cent.

In Canada, imports of ferromanganese, silicomanganese and spiegeleisen amounted to some 35,000 tons valued at $4.7 million, an increase in value of about 50 per cent from that of 1964. The Republic of South Africa supplied over 72 per cent of domestic imports, followed by Britain and the United States. With imports of ferromanganese exceeding 57 per cent of the domestic market, it is evident that the problems facing the two Canadian producers are formidable. The use of electrolytic manganese continued to increase and imports into Canada in 1965 amounted to 6.4 million pounds, valued at $2 million. The United States is the largest source followed by the Republic of South Africa and Japan.

The Department of Mines of the Republic of South Africa reports in its Quarterly Information Circular, *Minerals*, October to December 1965 that production of manganese ore there in 1965 amounted to 1.7 million tons, an increase of 272,561 tons from 1964. Local sales in the Republic amounted to some 676,305 tons and exports were 952,422 tons, both higher than in 1964.

TABLE 2

Canadian Manganese Imports, Exports and Consumption, 1956-65
(short tons)

	Imports			Exports	Consumption	
		Addition Agents				
	Manganese Ore	Under 1% Silicon	Over 1% Silicon	Ferro-Manganese	Ore	Ferro-Manganese
1956	207,977	2,191	1,130	59,445	219,141	37,420
1957	131,318	743	2,257	46,733	195,088	37,906
1958	42,060	2,483	2,185	225	46,143	31,242
1959	118,454	2,334	2,989	193	90,311	40,976
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	138,818	66,202
1965P	89,480*	34,562	787	3,817	118,635	61,352

Source: Dominion Bureau of Statistics.
P Preliminary.
* Mn content.

TABLE 3

World Production of Manganese Ore

(short tons)

	1963	1964	1965[e]
U.S.S.R.	7,345,000	7,385,000[e]	..
Republic of South Africa	1,441,503	1,455,271	1,727,822
India (including Goa)	1,300,273	1,392,218	1,400,000
Brazil	1,382,727	1,191,206	1,400,000
China	1,102,000[e]	1,102,000[e]	..
Gabon	712,381	1,045,324	1,100,000
Ghana	434,410	545,068	..
Morocco	369,217	375,974	..
Republic of the Congo (Kinshasa)	297,660	341,385	..
Japan	305,028	311,928	..
Other countries	1,447,801	1,541,626	..
Total	16,138,000	16,687,000	17,200,000

Source: U.S. Bureau of Mines *Minerals Yearbook 1964*, and U.S. Bureau of Mines *Commodity Data Summaries*, January, 1966.

[e]Estimate; .. Not available.

USES AND SPECIFICATIONS

Most of the world's output of manganese ore is used by the steel industry. In the United States, 95 per cent of the manganese ore consumed in 1965 was used by the steel industry; the chemical industry used 4 per cent and the dry-cell battery industry accounted for the remainder. In Canada, 99 per cent was consumed by the steel industry.

The importance of manganese is due principally to its scavenging action in steelmaking furnaces since it is the cheapest material known for desulphurization and dephosphorization of the steel bath. In the proportion of 1 to 2 per cent it increases strength and toughness of steel; in proportions of 12 to 14 per cent it greatly increases toughness and resistance to wear and abrasion. About 14 pounds of manganese is used for every net ton of ingot steel produced.

Electrolytic manganese, made in an electrolytic cell where the manganese is deposited on an electrode and stripped off as thin plates, is used in place of low-carbon ferromanganese to reduce the carbon content of stainless steels and thus eliminate the need for a carbon stabilizer. It serves the aluminum industry in the production of high-purity aluminum 'hardener' alloys; also, it is added either as metal or as a 30-70 manganese-copper master alloy in the production of manganese bronzes. Improvements in technology in recent years now enable ferroalloy manufacturers to produce a low-carbon ferromanganese with 0.07 per cent carbon, maximum, and 85-90 per cent manganese at a price competitive with electrolytic manganese for many applications, particularly in the manufacture of the '200 series' of stainless steels.

METALLURGICAL-GRADE MANGANESE ORE

For making ferromanganese, the manganese-iron ratio should be 7 to 1 or more because the production capacity for the ferro-plant is handicapped as this ratio drops. High silica is undesirable because it increases the quantity of slag, which is attended by a manganese loss. In preparing their furnace charges, ferromanganese producers prefer to blend commercial ores to their own specifications. Since no single ore is generally considered ideal, consumers usually purchase ore from more than one source.

General specifications for metallurgical-grade manganese ore are a minimum of 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. Table 4 shows some analyses of metallurgical-grade ores.

BATTERY-GRADE MANGANESE ORE

Battery-grade manganese ores are used in far smaller quantities than metallurgical-grade ores and known reserves are not large. Battery-grade ores are subject to both chemical and physical specifications but their main prerequisite is a high MnO_2 content, usually 68 per cent or more. The required chemical purity of battery-grade material varies according to the need of the dry-cell manufacturer.

Ores suitable for dry-cell operations are usually suitable for metallurgical applications but the converse is not true. There is no quick analytical procedure to predict their suitability for dry-cell operations. Tests consist of making batteries from individual lots of ore and, after ageing, placing them in service under test conditions. This procedure is time-consuming and of little value in assessing deposits or estimating

TABLE 4
Analyses of Manganese Ores and Concentrates
(per cent)

Country of Origin	Mn	Fe	SiO_2	Al_2O_3	P	Mn/Fe	Moisture
Ghana[1]	52	1.3	7.9	2.6	0.12	39.7	5.1
Ghana[1]	46	1.6	18.6	3.1	0.05	29.0	0.5
Br. Guiana	39	7.2	14.2	19.3	0.07	5.4	0.4
Br. Guiana	52	2.6	7.1	3.2	0.11	20.0	4.8
Egypt	51	6.9	1.4	.8	0.08	7.5	1.0
Egypt	49	8.2	2.2	1.0	0.08	6.0	0.7
Brazil (Amapa)[2]	50	4.1	2.7	6.0	0.07	12.3	4.5
Brazil (Urucum)	45	12.2	1.5	2.1	0.22	3.7	5.6
Mexico[3]	47	1.8	9.7	1.1	0.01	25.5	1.2
Cuba[4]	50	2.5	9.8	2.2	0.07	19.8	1.2
India	49	6.3	9.0	1.6	0.14	7.1	3.5
India	40	15.7	2.3	6.0	0.03	2.5	1.3
Turkey	46	0.9	9.9	1.3	0.02	50.4	6.3
Republic of South Africa	40	16.2	2.3	6.1	0.03	2.5	0.4
Southwest Africa	47	5.6	12.2	1.4	0.04	8.5	0.9
Philippines	49	3.4	8.2	2.9	0.12	14.4	3.2
U.S.S.R. (Chiatura)[5]	53	1.2	..	2.0	0.17	44.2	7.5
U.S.S.R. (Nikopol)[6]	49	1.5	..	1.4	0.20	32.7	12.0

Source: Compiled from a survey of technical and trade publications.
[1]12.5 to 13.5% CaO+MgO. [2]0.18% As. [3]0.25% As and 8.42% CaO, and 1.38% BaO. [4]8.33% As. [5]0.15 to 1.6% CaO+MgO. [6]1.1 to 2.3% CaO+MgO.
.. Not available.

reserves. Recently, considerable research has been conducted to develop fast, accurate tests to determine an ore's suitability for dry-cell use.

Some manganese ores, including those not naturally suited for dry cells, are beneficiated by special electrolytic or chemical means to produce a high-quality MnO_2 (85 per cent or more). This synthetic ore, referred to by many in the battery trade as 'electrolytic manganese', is more effective than the very best natural ores but it is more expensive.

CHEMICAL-GRADE MANGANESE ORE

Chemical-grade manganese ore should contain at least 35 per cent manganese. It is used to make manganese sulphate and manganese fertilizer, and in the production of other salts for use in the glass, dye, paint, varnish and photographic industries. Generally, chemical grade is distinguished by the industry as two types based primarily on a particular customer's requirements for use as an oxiding agent in chemical processes such as the manufacture of hydroquinone, or for the manufacture of potassium permanganate and other permanganate chemicals.

CANADIAN CONSUMERS

Union Carbide Canada Limited, Metals and Carbon Division, uses metallurgical-grade ore to manufacture silicomanganese and high- and low-carbon ferromanganese at its Welland, Ontario, plant. Chromium Mining & Smelting Corporation, Limited produces manganese alloys at its Beauharnois, Quebec, plant.

The main consumers of ferromanganese are The Algoma Steel Corporation, Limited, Sault Ste. Marie, Ontario; Dominion Steel and Coal Corporation, Limited, Sydney, Nova Scotia; The Steel Company of Canada, Limited, and Dominion Foundries and Steel, Limited, both at Hamilton, Ontario; and Atlas Steels Company, a division of Rio Algom Mines Limited, with plants at Welland, Ontario, and Tracy, Quebec.

Electrolytic manganese imported from the United States is used by Atlas Steels Company in making low-carbon stainless steel. It is also used by the aluminum-, magnesium- and copper-alloy industries.

Consumers of battery-grade ore are National Carbon Limited and Mallory Battery Company of Canada Limited, both of Toronto; Burgess Battery Company Limited, Niagara Falls; and Ray-O-Vac (Canada) Limited, Winnipeg.

PRICES

Prices of manganese in the United States according to *E & MJ Metal and Mineral Markets*, December 27, 1965, were as follows:

Manganese ore, per long-ton unit, c.i.f. United States ports, import duty extra	
Minimum 48% Mn (low impurities)	80¢
46% Mn	75-78
Prices vary depending on impurities.	

Manganese metal. Electrolytic metal 99.9%, f.o.b. shipping point, per lb	
Regular	28.85¢
Hydrogen removed	29.60
4% N	33.60
6% N	34.60

Ferromanganese, carload lots, lump, bulk, f.o.b. shipping point, freight equalized to nearest main producer, per long ton	
Standard 74-76% Mn	$167.50 (nominal)
78-82% Mn	173.00 "
low phos.	183.00 "
Imported standard, 74-76% Mn, delivered Pittsburgh/Chicago	160.00–165.00
Medium carbon, per lb Mn, delivered, lump bulk	nominal
"MS" manganese, lb Mn	16.4¢
Low carbon, per lb Mn	
low phosphorous	29
0.10 C	26
0.30% C	24.5
0.75% C	24
"DQ" manganese	23.5

Silicomanganese, per lb, carload lots, f.o.b. shipping point, freight equalized to nearest main producer per lb	
12½–16% Si, 3% C	8 ¢
16 –18% Si, 2% C	8.2
18½–21% Si, 1½% C	8.5

Spiegeleisen, f.o.b. shipping point, per gross ton

	Standard	Controlled Weight
16–19% Mn	$87.00	$88.00
19–21% Mn	89.00	90.00
21–23% Mn	91.50	92.50

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Manganese ore	free	free	free
Electrolytic manganese metal for alloying purposes	free	5%	20%
Ferromanganese and spiegeleisen, not more than 1% Si on Mn content	free	1¢	1¼¢
Silicomanganese, more than 1% Si on Mn content	free	1½¢	1¾¢

United States	(cents)	
Manganese ore*	0.25	per lb of Mn content
Manganese metal, unwrought	1.875	per lb plus 15% ad val.
Ferromanganese		
Not over 1% C	0.6	per lb on Mn content plus 4.5% ad val.
Over 1% but under 4% C	0.9375	per lb on Mn content
Over 4% C	0.625	per lb on Mn content
Spiegeleisen	75	per long ton

*Duty temporarily suspended to 30 June, 1967.

Mercury

J. G. GEORGE*

With the exception of small quantities produced in 1955, 1964 and 1965 in the Bridge River district in southern British Columbia, there has been no mine production of mercury in Canada since 1944 when the Pinchi Lake and Takla mines, both in British Columbia, were closed. The Pinchi Lake and Takla properties, operated as underground mines during World War II by The Consolidated Mining and Smelting Company of Canada Limited and Bralorne Pioneer Mines Limited, respectively, are the two most important known mercury deposits in Canada. The Pinchi Lake mine was, by far, the more important source and during the years it operated, from 1940 to 1944 inclusive, it produced more than 4 million pounds of mercury. The Takla mine, in operation from November 1943 to September 1944, produced about 124,000 pounds. Cinnabar (HgS) is the chief ore mineral at the two properties that lie about 90 miles apart along the Pinchi fault zone that trends north-northwest through central British Columbia in the Omineca Mining Division. Other small quantities of mercury were produced sporadically in Canada prior to 1940 at mines to the east and north of Bralorne and in the vicinity of Kamloops Lake, in the southern part of the province.

Canadian imports of mercury in 1965 were more than triple those of the previous year. Reported consumption in Canada in 1965 was double that in 1964.

WORLD REVIEW

In 1965, Spain and Italy together furnished more than half of the estimated world mine output of 275,000 flasks of mercury (a flask contains 76 pounds). The seven largest producing countries in declining order of output were Spain, Italy, U.S.S.R., Mainland China, U.S.A., Mexico, and Yugoslavia; their combined output accounted for almost 95 per cent of world mine production of mercury.

*Mineral Resources Division

TABLE 1
Canadian Mercury Production, Trade and Consumption, 1964-65

	1964		1965^p	
	Pounds	$	Pounds	$
Production				
British Columbia	5,548	22,848	1,520	13,249
Imports				
Britain	29,000	107,748	474,400	2,077,366
Spain	141,800	407,781	400,400	1,798,505
United States	26,400	99,652	121,200	1,174,229
Yugoslavia	34,200	132,871	41,000	258,358
Other countries	62,500	243,318	34,900	271,129
Total	293,900	991,370	1,071,900	5,579,587
Consumption, metal				
Heavy chemicals	190,846		390,750	
Pharmaceuticals and fine chemicals	3,109^r		109	
Electrical apparatus	2,875		22,405	
Gold recovery	2,653		2,381	
Miscellaneous	8,821		351	
Total	208,304		415,996	

Source : Dominion Bureau of Statistics.
^{p}Preliminary; ^{r}Revised.

TABLE 2
Canadian Mercury Production, Trade and Consumption, 1956-65

	Production, Metal (pounds)	Imports Metal (pounds)	Imports Salts $	Exports, Metal (pounds)	Consumption, Metal (pounds)
1956	-	450,006	1,819	5,953	212,800
1957	-	400,710	24,225	1,425	215,344
1958	-	197,073	10,918	2,830	151,021
1959	-	141,219	6,137	10,458	161,987
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^r
1965^p	1,520	1,071,900	..	..	415,996

Source : Dominion Bureau of Statistics.
^{p}Preliminary; - Nil; .. Not available; ^{r}Revised.

Mine output in the United States declined steadily from 33,223 flasks in 1960 to 14,142 flasks in 1964 but the trend was reversed when 1965 production rose to an estimated 19,582 flasks. The United States is the world's largest consumer but has always produced less than its requirements. United States consumption in 1965 was 76,454 flasks. Accurate statistics are not available on consumption in other foreign countries but Britain, France, Japan, U.S.S.R., West Germany, and others are consuming increasing quantities of mercury. Mainland China and Russia, which normally have been exporters of mercury, virtually ceased exporting early in 1963 and reportedly made substantial purchases of the metal in Europe in the latter part of 1964. Chinese mercury, however, seems to have been made available during 1965 in small and sporadic quantities. The recent increase in world consumption is largely due to world-wide expansion of the plastics industry, that has necessitated building more chlorine-caustic soda plants, and to the rapid growth of the electrical industry.

The year 1965 was a remarkable one for mercury with prices reaching new all-time highs. Demand increased and a shortage developed but production, while increased in many areas, did not match earlier estimates. The shortage and high prices undoubtedly promoted substitution in certain applications. In the latter part of the year, however, prices trended downward and it was expected that this trend would continue into 1966.

At the end of 1965, United States government stockpiles contained a total of 200,365 flasks of mercury; the stockpile objective is 200,000 flasks. These stocks are exclusive of excess mercury held by the U.S. Atomic Energy Commission (AEC). In January 1965, 55,500 flasks of surplus AEC stocks were made available for sale to domestic consumers and by the end of September 30,700 flasks had been sold. The remaining 24,800 flasks, together with an additional 38,000 flasks released by AEC on October 22, 1965, were included in the sales program beginning on that date. This long-range disposal program provided for the release of 1,500 flasks a month which should make it last until the early part of 1969.

TABLE 3

World Production of Mercury* 1961, 1964 and 1965

(flasks of 76 pounds)

	1961	1964	1965P
Spain	51,202	78,322	82,760
Italy	55,376	57,001	57,291
U.S.S.R.e	25,000	35,000	40,000
China (mainland)e	26,000	26,000	26,000
United States	31,662	14,142	19,582
Mexico	18,101	12,560	18,000e
Yugoslavia	15,954	17,318	16,419
Japan	5,437	4,812	4,820e
Peru	3,001	3,275	3,280e
Turkey	1,881	2,615	2,620e
Philippines	3,167	2,496	2,500e
Czechoslovakia e	725	725	725
Chile	1,509	275	370e
Rumania	350	194	200e
Tunisia	54	–	174
Bolivia	–	32	30
Canada	–	73	20
Colombia	191	3	3
World totale	240,000	255,000	275,000

Source: U.S. Bureau of Mines *Mineral Industry Surveys, Mercury in the First Quarter of 1966.*

*Data do not add to totals shown because of rounding where estimated figures are included in detail.

P Preliminary; e Estimate; – Nil.

USES

One of the oldest but now relatively unimportant uses of mercury is for recovering gold and silver from their ores by amalgamation. The chief uses in recent years, in declining order of consumption, have been for electrical apparatus, electrolytic production of chlorine and caustic soda, mildew-proofing paints, industrial and control instruments, pharmaceuticals, insecticides and fungicides, and dental preparations. Its military uses include fulminate for munitions and blasting caps, electric batteries and as a catalyst in the manufacture of chemicals for chemical warfare. Because of its capacity to absorb neutrons, mercury in recent years has been used as a shield against atomic radiation. One of the larger and growing uses of mercury is as a cathode in the electrolytic preparation of chlorine and caustic soda. Actual consumption of mercury in this manufacturing process is small although large quantities are required for the original installation.

TABLE 4

United States Mercury Consumption, by Uses

(flasks of 76 pounds)

Use	1961	1964	1965
Agriculture (includes fungicides and bactericides for industrial purposes)	2,557	3,144	3,116
Amalgamation	278	667	495
Catalysts	707	656	924
Dental preparations	2,154	2,612	1,619
Electrical apparatus	10,255	10,690	14,764
Electrolytic preparation of chlorine and caustic soda	6,056	9,572	8,753
General laboratory use	1,484	18,516*	2,827
Industrial and control instruments	5,627	4,972	4,628
Paint			
Antifouling	915	547	255
Mildew-proofing	5,146	4,898	7,534
Paper and pulp manufacture	3,094	2,148	619
Pharmaceuticals	2,515	5,047	3,261
Redistilled**	9,013	11,405	12,257
Other	5,962	7,734	15,402
Total	55,763	82,608	76,454

Sources: Statistics for 1961 and 1964 from preprint from US Bureau of Mines *Minerals Yearbook 1964;* statistics for 1965 from US Bureau of Mines *Mineral Industry Surveys, Mercury in the First Quarter of 1966.*

*Figure represents combined total; source reference lists separate figures as follows: general laboratory use - commercial, 1,516; government, 17,000.

**Redistilled mercury is also consumed for many of the same uses as virgin mercury.

PRICES AND TARIFFS

Except for a slight decline in February and March 1965, the price of mercury per flask (76 pounds) f. o. b. New York, as quoted in *E & M J Metal and Mineral Markets*, rose continuously from \$475 – \$490 at the beginning of January to an all-time high of \$725 – \$775 at the end of June. Since then the New York price trended downward and closed the year at \$535 – \$540. Average for the year was \$570.75 a flask, or more than 80 per cent higher than in 1964. The London exwarehouse price, as quoted in *Metal Bulletin* (London), rose from £150 per flask (76 pounds) at the beginning of January 1965 to a record high of £265 in mid-June. The £265 price obtained until early September; from then onward the price declined and closed the year at £200.

TABLE 5

Mercury Prices at New York and London

(\$ per flask of 76 pounds)

	New York*	London**
1956	259.92	238.68
1957	246.98	232.36
1958	229.06	214.98
1959	227.48	208.61
1960	210.76	197.86
1961	197.61	181.87
1962	191.21	172.79
1963	189.45	171.42
1964	314.79	280.90
1965	570.75	217.50

* *Engineering and Mining Journal;* ** *Mining Journal* (London), U.S. equivalent.

Imports of mercury into Canada are duty-free. A duty of 25 cents a pound (\$19 a flask) of mercury continued in effect in the United States.

Mica

J.E. REEVES*

According to preliminary statistics, there was a considerable decline in shipments of Canadian phlogopite in 1965. Early in the year, Blackburn Brothers, Limited, closed its mine at Cantley, Quebec, and shortly thereafter discontinued shipping small sheet phlogopite to Japan. Near the beginning of 1966, it closed its dry-grinding plant and brought to an end its long history of participation in the Canadian phlogopite industry. Some scrap phlogopite was produced elsewhere in Quebec.

Imports of lower-cost rough muscovite were considerably lower than in 1964. The total volume of imports of the higher-priced sheet and ground muscovite increased, although their total value was lower. Rough and sheet muscovite are mainly used in the electrical industry and originate principally in India, although much of it comes via the United States. Ground muscovite, for use as a filler, is produced in the United States. According to statistics of the U.S. Bureau of Mines for 1964, Canada imported 2,348,954 pounds of ground muscovite, worth $131,925 (U.S.), or nearly half of the 5,190,700 pounds shown in Table 1.

Small-sized sheet phlogopite was exported to Japan and scrap phlogopite to the United States, but statistics are no longer recorded separately.

WORLD REVIEW

World production of mica increased slightly from 1963 to 1964 and then appears to have declined in 1965. Nearly all the production in the United States is scrap and flake muscovite for grinding. India is the largest source of muscovite sheet; the Malagasy Republic is the only other source of phlogopite besides Canada. Extensive world trade takes place.

*Mineral Processing Division, Mines Branch.

TABLE 1

Mica — Production, Trade and Consumption

	1964		1965P	
	Pounds	$	Pounds	$
Production, shipments				
Trimmed	20,454	35,679	..	..
Rough	68,100	14,820	..	..
Ground	615,968	27,659	..	..
Scrap	493,640	7,867	..	..
Total	1,198,162	86,025	886,550	29,560
Imports				
Rough				
United States	542,000	14,075	226,000	4,792
Brazil	2,000	4,803	2,000	4,166
Total	544,000	18,878	228,000	8,958
Sheet and ground				
United States	5,190,700	512,038	5,770,200	422,477
India	103,000	48,891	153,900	50,310
Britain	45,600	5,567	83,100	8,062
Brazil	700	1,587	400	856
Total	5,340,000	568,083	6,007,600	481,705
Fabricated				
United States	..	737,086	..	579,730
Britain	..	4,519	..	21,622
Sweden	..	—	..	4,023
Total	..	741,605	..	605,375

	1963	1964
Consumption, available data		
Paints and wall-joint sealers	1,972,000	1,632,000
Rubber	646,000	694,000
Electrical apparatus	428,000	510,000
Paper and wallboard	272,000	290,000
Asphalt products	36,000	282,000
Other products	78,000	764,000
Total	3,432,000	4,172,000

Source: Dominion Bureau of Statistics.

P Preliminary; — Nil; .. Not available.

TECHNOLOGY

Mica is important because of its unusual physical characteristics. It has consistent and relatively high dielectric properties, high-temperature resistance and low thermal conductivity, and its perfect basal cleavage permits it to be readily split into very thin sheets that are flexible, elastic, strong and generally transparent. The preparation of sheet mica is done mostly by hand and requires experience. When ground to a fine powder, mica retains its flaky particle shape, which is advantageous in its many uses as a filler and dusting agent.

TABLE 2

Mica — Production, Trade and Consumption, 1956–65

(pounds)

	Production*	Imports**	Exports**	Consumption
1956	1,843,811	324,900	277,800	4,524,810
1957	1,282,416	501,900	362,200	4,028,926
1958	1,504,933	1,047,700	300,100	3,547,396
1959	813,834	1,340,400	423,800	3,622,000
1960	1,702,605	1,838,800	488,800	3,448,000
1961	1,816,160	1,475,800	222,400	3,782,000
1962	1,204,034	2,306,300	200,200	2,954,000
1963	1,183,041	1,737,600	..	3,432,000
1964	1,198,162	5,884,000	..	4,172,000
1965P	886,550	6,235,600	..	

Source: Dominion Bureau of Statistics

*Producers' shipments. **Rough and sheet mica. Includes ground mica in 1964 and 1965.

P Preliminary; .. Not available.

TABLE 3

World Production of Mica

(thousand pounds)

	1963	1964	1965e
United States	218,749	229,701	220,000
India	75,121	65,898	84,400
Norway	—	8,800	..
Republic of South Africa	4,719	6,800	..
Brazil	3,289	3,289	2,800
Malagasy Republic	2,128	1,504	..
Canada	1,183	1,198	887
Australia	1,100	1,100	..
Other countries	93,711	91,710	..
Total	400,000	410,000	336,000

Source: U.S. Bureau of Mines *Minerals Yearbook, 1964*, and U.S. Bureau of Mines *Commodity Data Summaries*, January, 1966.

e Estimate; .. Not available; — Nil.

High-quality muscovite possesses the best dielectric properties of all types of mica and is used extensively for insulation at high frequencies and voltages and in capacitors. Its high strength and transparency make it useful for glazing. It may be colourless, reddish, green or brown and is found in granitic pegmatites. The wet-grinding of clean muscovite scrap, waste and flake yields a polished, well-delaminated powder with a high reflectivity.

Phlogopite, or amber mica, varies considerably in dielectric strength, hardness, structural strength and other properties but is of some value because of its high thermal resistance. In southwestern Quebec and southeastern Ontario it is commonly found in irregular veins with green apatite and pinkish calcite. Its properties vary in relation to its composition and it may range from almost colourless to a deep brown.

USES

Mica is used in three forms: natural sheet, splittings and ground mica.

Natural sheet mica is used for insulation in electrical and electronic equipment and appliances for home and industry. In small amounts it is used in thermal insulation and for glazing boiler gauges and furnace windows. It is sold according to variety, size and quality, depending on the intended application. A trend toward the use of substitute materials has become established but the highest-quality muscovite continues in high demand.

Mica splittings are bonded together in the manufacture of built-up sheet, tape and cloth. Suitable processes of forming the products and curing the binder result in a wide variety of these flexible insulation products. Built-up sheet has replaced natural sheet, within the limits of its physical and electrical characteristics. It can be cut or moulded into washers, tubes and many other forms. Most of the splittings used are muscovite.

Mica paper and mica board have been developed as substitutes for built-up sheet, using ground mica and a binder and essentially some modification of paper-making techniques. Mica paper has the advantage of more consistent thickness.

Most of the mica consumed is ground mica. Dry-ground mica, muscovite or phlogopite, is used for dusting asphalt products, and rubber tires and tubes; as a filler in wall-joint sealing compounds and some paints and as an aid against loss of circulation of drilling mud in oil-well drilling. Wet-ground muscovite is used as an extender pigment in paints, a filler in plastic products and hard rubber, a mould lubricant and dusting agent in the manufacture of rubber tires and, to a minor extent, for adding decorative effects to wall-paper.

SPECIFICATIONS

NATURAL BLOCK MUSCOVITE

Block muscovite is graded for size and quality according to Designation D351-57T of the American Society for Testing and Materials. The criteria for grading size are the area of minimum rectangle and the minimum dimension of one side; the standard for grading visual quality is the degree of staining by included impurities.

NATURAL PHLOGOPITE SHEET

In Canada, phlogopite sheet is graded in terms of its linear dimensions. The following sizes are in common use: 1 × 1, 1 × 2 and 1 × 3 inches.

No formal quality grading for phlogopite has been established, but the softer, lighter-coloured varieties are generally regarded as having the better electrical qualities.

GROUND MICA

The only formal specification is for mica pigment. ASTM Designation D607-42 requires a wet-ground muscovite with a maximum bulk density of 10 pounds per cubic foot, very low moisture and impurity contents, and a particle size that is 93 per cent minus 325 mesh. For other uses, the specifications are a matter of agreement between producer and consumer.

Dry-ground mica is sold in a wide range of particle sizes, from as coarse as minus 20 mesh for use as a dusting agent, to as fine as minus 200 mesh for other purposes. Wet-ground mica is generally at least minus 200 mesh. Mica ground in a fluid-energy mill is becoming more important because of the increasing demand for a particle size below 325 mesh.

PRICES

Prices for mica in the United States, according to *E & MJ Metal & Mineral Markets* of September 13, 1965, included:

Punch mica, per lb	$ 0.07–$ 0.12
Wet-ground mica, per short ton	160.00– 180.00
Dry-ground mica, per short ton	34.00– 75.00
Scrap mica, per short ton	30.00– 40.00

Mineral Pigments and Fillers

D.H. STONEHOUSE*

Natural mineral pigments have been replaced to a major degree by synthetic pigments, which are obtained from the chemical and metallurgical processing of metals and minerals. Iron oxide is the only true natural mineral pigment produced in Canada. Among the artificial pigments produced in Canada are synthetic iron oxide and titanium dioxide. The quantity of mineral pigments consumed is relatively small but these materials have many applications wherein they impart colour and opacity to products.

Other synthetic pigments include chromium oxide, lithopone, litharge, red lead, white lead, zinc oxide, blanc fixe, satin white, copper oxide, cobalt oxide and tin oxide.

Although not strictly regarded as a pigment, whiting is being used in increasing quantities as a pigment extender in paint. In this application perhaps it should be considered a filler. Many industrial minerals are used as fillers to impart some desirable physical property to a product or to replace a more expensive commodity used in the process. Although crushed rock, gravel and lightweight or heavy aggregates, as used in masonry and concrete, can be considered fillers, it is usual to think of fillers as finely ground material. Other terms in common use for fillers, depending on specific applications, are loading materials, diluents or carriers.

Mineral commodities produced and consumed in Canada as fillers include: asbestos, barite, bentonite, clays, diatomite, limestone, mica, nepheline syenite, shale, silica and talc. However, there are no separate statistics available to indicate the production of any commodity for specific filler use nor to indicate shipments for such use. The application of each of the above commodities as fillers is discussed in separate reviews of these minerals.

*Mineral Processing Division, Mines Branch

TABLE 1

Iron Oxide – Production, Trade and Consumption

	1964		1965[p]	
	Short Tons	$	Short Tons	$
Production, shipments				
Natural (crude and calcined)	1,033	79,250	235	22,325
Exports				
Natural and synthetic iron oxide				
United States	2,163	405,692	2,527	452,375
France	85	15,134	80	14,266
Britain	61	28,660	55	13,341
Netherlands	–	–	45	7,493
Other countries	99	24,147	88	17,717
Total	2,408	473,633	2,795	505,192
Imports				
Natural and synthetic iron oxide				
United States	1,542	352,660	1,296	300,625
West Germany	921	123,018	646	85,080
Spain	482	25,235	443	23,530
Britain	126	34,939	143	39,169
Total	3,071	535,852	2,528	448,404
	1962		1963	
Consumption by the paint industry				
Calcined and synthetic iron oxide	1,955	470,000	2,009	520,000
Ochres, siennas, umbers	150	56,000	168	74,000

Source: Dominion Bureau of Statistics.
[p] Preliminary.

TABLE 2

Iron Oxide – Production, Trade and Consumption, 1956–65

(short tons)

		Imports				Consumption*		
							Paint Industry	
	Production	Natural and Synthetic	Ochres Siennas, Umbers	Oxides Fillers Colours etc.	Exports, Natural and Synthetic	Coke and Gas Industries	Natural and Synthetic	Ochres, Siennas, Umbers
1956	8,803	..	1,162	6,237	3,203	8,745	2,166	220
1957	7,518	..	946	4,826	3,440	5,999	1,895	263
1958	1,632	..	680	4,923	2,401	237	1,826	158
1959	1,235	..	833	6,103	2,624	100	1,889	138
1960	909	..	615	4,908	2,523	..	1,858	150
1961	808	..	649	4,903	2,208	..	1,755	130
1962	771	..	..	..	1,865	..	1,955	150
1963	978	..	..	..	2,218	..	2,009	168
1964	1,033	3,071	..	..	2,408	..	..	..
1965[p]	235	2,528	..	..	2,795	..	..	..

Source: Dominion Bureau of Statistics.
*Partial.
[p] Preliminary; .. Not available.

IRON OXIDE

PRODUCTION

A significant decrease in production of natural pigment-grade iron oxide was evident in 1965. The plant at Red Mill, Quebec, which is operated by The Sherwin-Williams Company of Canada, Limited, continued to process ore trucked from nearby bog deposits. Milling consisted of air-drying, calcining, pulverizing and sizing.

At Prescott, Ontario, Ferrox Iron Ltd. produced iron oxide concentrates of high quality for use as a constituent in the production of ferrites and iron powder. Fine grinding has produced pigment-grade material for test purposes only.

Shipments of natural iron-oxide pigments in 1965 amounted to 235 tons valued at $22,325, a drop from 1,033 tons valued at $79,250 in 1964. The reduction is evidence of the competition of synthetic pigments, which offer a wide range of colour as well as excellent quality. Statistics on the production of synthetic iron-oxide pigments are not available.

Northern Pigment Company, Limited, at New Toronto, Ontario, is a leading producer of synthetic iron oxide; much of its output is exported.

During 1965, total exports rose to 2,795 tons valued at $505,192 from 2,408 tons valued at $473,633 for the previous year; total imports dropped from 3,071 tons and $535,852 in 1964 to 2,528 tons and $448,404 for 1965. Trade was mainly with the United States.

USES AND SPECIFICATIONS

Pigments containing iron oxide are used in paints, wood and paper stains, linoleum, mortar colours, roofing granules, rubber, plastics, imitation leather and floor tile. Iron oxide is used also as a polishing compound and as a rust inhibiter. Specifications are based on tests to determine the mass colour or appearance when "rubbed out" in oil, the tinting strength or appearance when diluted with zinc oxide oil paste, particle size, oil absorption, opacity and chemical composition. Because synthetic iron oxides can be produced more uniformly in a wide variety of shades, they are in greater demand than are natural iron oxides.

PRICES

Prices vary considerably, particularly with quality or grade. The average price of the refined natural iron oxide produced in Canada in 1965 was $95 a ton at the plant.

United States prices for various types of iron oxides were quoted by the December 27, 1965 *Oil, Paint and Drug Reporter* as ranging from 6½ to 16½ cents a pound.

TITANIUM DIOXIDE

PRODUCTION

Ilmenite is mined in the Allard Lake and St. Urbain areas of Quebec principally for the production of titanium-dioxide slag, which in turn is used in the manufacture of titanium-dioxide pigments. Quebec Iron and Titanium Corporation controls the world's largest known reserves of ilmenite and, from its operation near Havre St. Pierre, ships ore to company smelters at Sorel, Quebec, where it is concentrated, roasted and reduced in electric furnaces to form titania slag and iron. Much of the slag is exported to the United States for use in making titanium-dioxide pigments and some is sent to two Canadian pigment-producing companies. Refined titanium dioxide is produced by Canadian Titanium Pigments Limited at Varennes, Quebec, and by Tioxide of Canada Limited at Ville-de-Tracy, Quebec. Combined capacity of these two plants is over 60,000 tons per year.

Continental Titanium Corp. also mines ilmenite in the St. Urbain area of Quebec. The material is sold mainly as a heavy aggregate, although a proposal has been made to produce a ceramic-grade titanium dioxide.

The value of titanium-dioxide slag shipped during 1965 is recorded at about $20 million. Imports of titanium-dioxide pigment were further reduced during 1965 to 1,565 tons valued at $0.7 million, while imports of extended material dropped to 9,534 tons and $1.8 million in value. Exports remained reasonably uniform during 1964-65.

TABLE 3

Titanium Dioxide – Trade and Consumption

(short tons)

	1964		1965[p]	
	Short Tons	$	Short Tons	$
Production	..	21,270,144	..	19,955,350[e]
Imports				
Titanium dioxide, pure				
United States	693	360,725	783	429,021
Britain	1,120	470,562	712	283,348
West Germany	26	11,843	70	29,695
Total	1,839	843,130	1,565	742,064
Titanium dioxide, extended	10,443	2,000,248	9,534	1,816,869
Exports				
Titanium dioxide				
United States*	3,298	1,344,287	3,202	1,344,580
	1962		1963	
Consumption				
Refined titanium dioxide				
Industrial chemicals	83		159	
Other chemicals	443		500	
Linoleum and coated fabrics industry**	2,608		2,181	
Paint and varnish	18,293		20,589	
Paper	3,268		3,645	
Rubber	951		972	
Synthetic textiles	..		40	
Toilet preparations	28		21	
Other non-metallic products	604		785	
Total	26,278		28,892	
Extended titanium dioxide pigments				
Paints	10,935		8,588	
Estimated TiO_2 content	3,237		2,542	

Source: Dominion Bureau of Statistics.
*As reported by United States Imports for Consumption, FT 125. Values $ U.S.
**Includes also asphalt roofing manufacturers.
[p] Preliminary; .. Not available; [e] Estimated.

Consumption data, Table 3, indicate an increase in the use of refined product particularly in paints.

USES AND SPECIFICATIONS

The use of titanium dioxide as a pigment is based on a number of characteristics, among which are its high refractive index or high opacity, its whiteness, and its chemical inactivity. The material must be ground to a very fine, uniform powder. When all properties are combined, the titanium-dioxide pigment is far superior to other white pigments for use in paints. As an extended pigment it is used in paints, papers, linoleum, rubber goods, textiles, ceramics and plastics. Specifications are based on tests similar to those used for all pigments.

PRICES

In 1965, titanium-dioxide pigments quoted in *Canadian Chemical Processing*, were as follows: delivered in Eastern Canada, bagged, in 20-ton carlots and per 100 pounds:

Anatase	
A-WD	$22.00
Other	23.75
Rutile	25.50
30% TiO_2 extended pigment	10.00 and $10.55
50% TiO_2 extended pigment	15.50 – 15.80
Non-pigment grades	24.30 – 24.90

WHITING

PRODUCTION

Whiting is either finely ground calcium carbonate prepared from chalk, marble or limestone, or the precipitate from a solution or suspension containing lime. Whiting obtained from chalk differs physically from that obtained from the other sources in that the particles are more rounded and thus have greater surface area and greater absorptive capability. The tonnage of limestone processed for whiting in Canada is small but has increased greatly over the past few years to an estimated 42,000 tons in 1965, from plants in Quebec, Ontario, Manitoba and British Columbia. The trend is towards larger production as techniques are improved and the acceptance of darker material for some applications becomes greater.

The terms "whiting" and "whiting substitute" refer to the product derived from chalk and limestone respectively although the trend is towards accepting the term "whiting" as all-encompassing.

TABLE 4

Whiting – Production, Imports and Consumption

	1964		1965p	
	Short Tons	$	Short Tons	$
Production				
Stone processed for whiting	23,022	284,024	42,000e	360,000e
Imports*				
Whiting				
United States	6,044	233,326	6,781	232,403
Britain	1,454	26,416	1,623	37,154
France	1,143	10,580	685	8,748
Total	8,641	270,322	9,089	278,305
Consumption, available data				
Ground chalk, whiting and whiting substitute				
Paints	20,438			
Linoleum, oilcloth and floor tile	15,163**			
Rubber goods	12,424**			
Asbestos products	323			
Paper	2,815			
Adhesives	602			
Ceramics	1,229			
Tanneries	273			
Soaps and toilet preparations	151			
Pharmaceuticals	172			
Wire and cable	1,354			
Miscellaneous chemicals	2,255			
Miscellaneous	5,285			
Total	62,484			

Source: Dominion Bureau of Statistics.
*True and precipitated whiting only. **Includes pulverized, off-white limestone.
p Preliminary; e Estimated.

TABLE 5

Whiting — Production, Imports and Consumption, 1956–65

(short tons)

	Production[1]	Imports[2]	Consumption[3]
1956	17,448	11,356	34,241
1957	21,527	9,844	31,374
1958	11,900	11,121	37,268
1959	11,633	10,322	64,933
1960	10,319	8,835	52,226
1961	14,301	8,408	62,442
1962	13,356	8,142	53,756
1963	16,195	9,789	65,082
1964	23,022	8,641	62,484
1965P	42,000e	9,089	..

Source: Dominion Bureau of Statistics.
[1]Rock processed for whiting substitute. [2]Whiting only. [3]Whiting and whiting substitute; includes some ground, off-white limestone.
P Preliminary; e Estimated; .. Not available.

USES AND SPECIFICATIONS

The finest grades of whiting are used in cosmetics and for dentifrices. Other uses, which absorb the largest part of production, are in paints, rubber, paper, linoleum, ceramics and putty. The physical properties required in each application relate to whiteness, particle size and shape, workability, and freedom from grit. High chemical purity is also important. Because of its extender qualities whiting is used in cold-water paints and in the lower quality oil-base paints, however, its low opacity and high oil absorbency discourage its more extensive use in paints. These faults are remedied by addition of a coating to the precipitated whiting particles for use as an extender in paints and inks.

In most instances the customer can set his own standards and although the pigment qualities of most whiting compounds are poor, the relatively low costs make them attractive for use as extenders, carriers or fillers.

During 1965, imports totalled 9,098 tons, the largest part of which came from the United States. The imports from Britain and France were processed from chalk, whereas most of that from the United States came from limestone.

Available consumption data indicate the paint industry to be the largest single user of whiting.

PRICES

The following United States prices for the three main types of whiting were quoted in the *Oil, Paint and Drug Reporter* of December 27, 1965. They refer to one ton of bagged material, in a carlot, at the producing plant. They are unchanged from the previous December.

Calcium carbonate	
Natural, dry-ground, 325 mesh	$13.50
Natural, water-ground, 10 to 30 microns	22.00 – 23.00
Chalk, 325 mesh	36.00 – 38.00
Precipitated	
Dense	30.00 – 38.50
Ultrafine	117.50 – 167.50

Molybdenum

V.B. SCHNEIDER*

Production of molybdenum in Canada in 1965 increased for the sixth consecutive year. Shipments of molybdenum contained in molybdenite (MoS_2) concentrates, molybdic oxide (MoO_3) and ferromolybdenum reached an all-time high of 10.2 million pounds valued at $17.5 million; the previous high was established in 1964 when some 1.2 million pounds valued at $2.1 million were shipped. Canadian production in 1965 has probably elevated Canada to third position as a world producer of molybdenum following the United States and Russia. Domestic consumption of molybdenum at 1.7 million pounds was also at an all-time high, reflecting increased demand for alloy steels in Canada.

Non-Communist world production of molybdenum in 1965 was about 100 million pounds, an increase of 22 million pounds from 1964. The United States Bureau of Mines in its *Commodity Data Summaries, January 1965,* estimates that the Communist-bloc countries produced 16.5 million pounds of molybdenum in 1965, which is little or no change from recent years.

The shortage of molybdenum that developed in 1963 continued into 1966 despite increased production and the release by the General Services Administration of 3 million pounds of molybdenum considered to be more than the United States National Stockpile objective. Early in 1966, U.S. Congress lowered the National Stockpile objective from 68 to 55 million pounds; the excess will be released for domestic consumption in 1966.

In the last five years, the unprecedented growth in demand for molybdenum in the United States resulted from technological developments and increased economic activity. In Europe and Japan the same conditions prevailed and there was a wider acceptance of molybdenum for applications that had long existed in the United States. Alloy steels, other than stainless and tool steels, constituted the largest use for molybdenum but over the last five years consumption of molybdenum in stainless steels has doubled. Much of this has been in corrosion-resistant grades used by the chemical manufacturing industry. A new development is in stainless steel for automotive trim; 1 per cent Mo added to stainless trim increases corrosion resistance even under severe conditions such as exposure to de-icing salts. Many industry authorities suggest that the current molybdenum shortage will continue well into 1967 and, depending on the war in Viet Nam, could become worse with the shortage extending into 1968. Beyond that, the expansion programs under way in the United States, Canada, and Chile should insure more than sufficient molybdenum to meet all expected demands. With an adequate assured supply available new uses probably will be developed, a situation closely resembling that of nickel in its development during the nineteen-twenties.

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* Mineral Resources Division

TABLE 1

Molybdenum — Production, Imports and Consumption, 1964—65

	1964		1965p	
	Pounds	$	Pounds	$
Production (shipments)[1]	1,224,712	2,057,383	10,165,370	17,508,987
Imports				
Molybdic oxide[2]				
United States	452,800	521,162	649,700	647,942
U.S.S.R.	37,700	186,079	105,800	444,740
Britain	—	—	4,000	8,473
Total	490,500	707,241	759,500	1,101,155
Ferromolybdenum				
United States[3]	271,605	391,631	398,460	525,967
Consumption (Mo content)				
By type				
Molybdic oxide	892,264		..	
Ferromolybdenum	277,327		..	
Molybdenum metal	31,309		..	
Molybdenum wire	7,449		..	
Other forms[4]	53,105		..	
Total	1,261,454	..	1,702,589	..
By end-use				
Ferrous and nonferrous alloys	1,209,350		..	
Lubricants and pigments	44,505		..	
Electrical and electronic products	7,599		..	
Total	1,261,454	..	1,702,589	..

Source: Dominion Bureau of Statistics.

[1] Producers' shipments of molybdic oxide and molybdenum concentrates (Mo content).
[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). Imports of ferromolybdenum are not available separately in official Canadian trade statistics. [4] Molybdic acid, calcium molybdate, sodium molybdate.

p Preliminary; .. Not available.

Molybdenite (MoS_2), the disulphide of molybdenum, is the most common mineral of molybdenum and is the only one mined commercially today. It contains 60 per cent molybdenum and 40 per cent sulphur. It has a specific gravity of from 4.6 to 4.7. It resembles graphite in softness and structure but differs in colour of streak and readily yields sulphur fumes on charcoal. Graphite has a much lower specific gravity (2.1 to 2.2) than molybdenite.

PRODUCTION

CANADA

Canadian production in 1965 came from seven mines, four in Quebec and three in British Columbia. The producers in Quebec, accounting for 17 per cent of the Canadian output, were Molybdenite Corporation of Canada Limited; Preissac Molybdenite Mines Limited; Anglo-American Molybdenite Mining Corporation; and Gaspé Copper Mines, Limited, a wholly-owned subsidiary of Noranda Mines Limited. The producers in British Columbia were Endako Mines Ltd.; Brynnor Mines Limited, a wholly-owned subsidiary of Noranda Mines Limited (the Boss Mountain Division of Noranda Mines Limited was transferred to Brynnor in June); and Bethlehem Copper Corporation Ltd. Only Molybdenite Corporation, Gaspé Copper Mines and Bethlehem recovered molybdenum in 1964.

TABLE 2

Molybdenum – Production, Trade and Consumption, 1956–65
(pounds)

	Production[1]	Exports[2]	Imports			Consumption[6]
			Calcium Molybdate[3]	Molybdic Oxide[4]	Ferro-molybdenum[5]	
1956	842,263	1,318,200	322,295	955,308	495,748	855,468
1957	783,739	6,009,800[7]	285,576	477,304	237,233	698,420
1958	888,264	1,892,200	135,333	304,822	196,000	519,124
1959	748,566	3,748,300	75,987	305,762	164,366	928,505
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	131,358	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
1965p	10,165,370	..	..	759,500	398,460	1,702,589

Source: Dominion Bureau of Statistics.

[1] For 1956 producers' shipments of molybdenum concentrates (Mo content); from 1957 molybdic oxide and molybdenum concentrates (Mo content). [2] For 1956 exports of molybdenum concentrates (gross weight); for 1957 to 1959 inclusive, molybdic oxide and molybdenum concentrates (gross weight). [3] Gross weight, including vanadium oxide and tungsten oxide. [4] Gross weight. [5] U.S. exports to Canada reported in *United States Exports of Domestic and Foreign Produce*. Gross weight. [6] Molybdenum addition agents (Mo content) reported by consumers. [7] Includes 4,892,600 pounds of molybdic oxide exported to the U.S., derived from molybdenum concentrates imported from the U.S. for roasting in Canada.

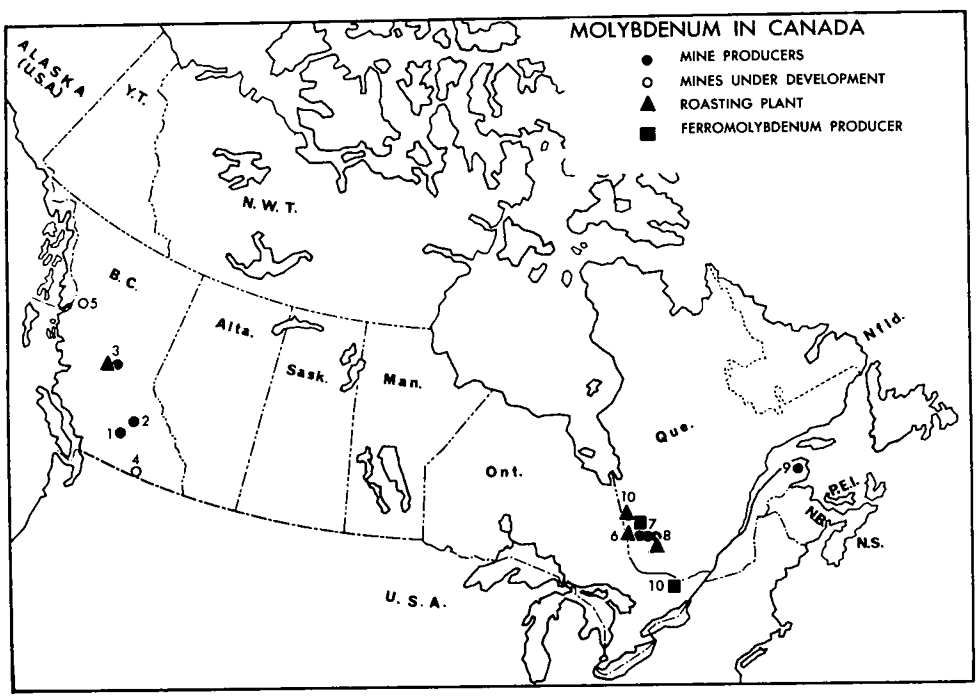
p Preliminary; .. Not available.

In Quebec, Molybdenite Corporation's mine is at Lacorne just north of Val d'Or. The company also operates a roasting plant at the mine site to convert its MoS_2 concentrates to technical-grade molybdic oxide, the material from which all types of molybdenum salts and compounds are produced. Rated mill capacity is 900 tons of ore a day. In 1965 the company milled 253,000 tons of ore grading 0.24 per cent MoS_2 from which 683,202 pounds of molybdenum were recovered; bismuth was recovered as a byproduct. Ore reserves at year's end were 304,000 tons grading 0.26 per cent MoS_2. The company's concentrates were converted and shipped as MoO_3 in 1965 whereas in previous years some or all of the company's sales were as MoS_2 concentrates. Preissac Molybdenite Mines Limited, in which Molybdenite Corporation of Canada Limited holds a substantial interest, commenced production in September 1965 at its mine in the Lake Preissac area about 5 miles north of Cadillac. The company has a roaster for converting molybdenite to molybdic oxide and facilities for converting the oxide to ferromolybdenum. Scheduled production rate is 1.2 million pounds of Mo a year in concentrates, as oxide, or as ferromolybdenum. Anglo-American Molybdenite Mining Corporation commenced operations in August at its mine about 3 miles north of Cadillac. Ore reserves were reported by the company at three million tons grading 0.36 per cent MoS_2; mill capacity is 1,200 tons a day and bismuth is recovered as a byproduct. Gaspé Copper Mines, Limited recovers molybdenite concentrates as a byproduct of its copper operations at Murdochville, Quebec. Recovery in 1965 amounted to 493,492 pounds of Mo. Completion of the company's Copper Mountain mine development and concentrator expansion program, scheduled for 1967, will probably increase molybdenum recovery to a million pounds a year.

In British Columbia, Brynnor Mines Limited commenced operations at its Boss Mountain mine in May and produced an estimated 1.3 million pounds of Mo in concentrates. Production in 1966 is expected to be about three million pounds. Endako Mines Ltd. began operations in June at its mine near Endako, which had a rated capacity of 10,000 tons a day. By the end of the year the mill had demonstrated capacity to operate at 15,000 tons a day. Production totalled 6,638,217 pounds of molybdenum; 1 million pounds were converted at the mine site to molybdic oxide in the roaster, which has an oxide capacity of 10 tons a day. The remaining 5.6 million pounds were shipped in concentrates to Europe and Japan. Production in 1966 will probably exceed 11 million pounds. Bethlehem Copper Corporation Ltd. recovers molybdenum concentrates as a byproduct of its copper operations in the Highland Valley. Its molybdenite recovery circuit, which first operated in 1964, was shut down for most of 1965 and Mo recovery amounted to only 30,000 pounds. The company hopes to operate the molybdenite recovery circuit throughout 1966 so Mo recovery might reach 250,000 pounds.

Masterloy Products Limited roasted concentrates at its plant at Duparquet, Quebec, and produced ferromolybdenum at its plant near Ottawa, Ontario.

Red Mountain Mines Limited, formed to operate the Torwest Resources (1962) Ltd. molybdenum property near Rossland, B.C., will begin production early in 1966 at an initial rate of 400 tons of mill feed a day. British Columbia Molybdenum Limited, a subsidiary



MINE PRODUCERS
(numbers refer to numbers on map)

1. Bethlehem Copper Corporation Ltd.
2. Brynnor Mines Limited (Boss Mountain)
3. Endako Mines Ltd.
6. Preissac Molybdenite Mines Limited
7. Anglo-American Molybdenite Mining Corporation
8. Molybdenite Corporation of Canada Limited
9. Gaspé Copper Mines, Limited.

MINES UNDER DEVELOPMENT

4. Red Mountain Mines Limited (1966)
5. British Columbia Molybdenum Limited (1967)

PROCESSING PLANTS

3. Endako Mines Ltd.
6. Preissac Molybdenite Mines Limited
8. Molybdenite Corporation of Canada Limited
10. Masterloy Products Limited.

of Kennecott Copper Corporation, started construction work at its property immediately south of Alice Arm and 90 miles north of Prince Rupert in the late spring of 1965. Construction of the concentrator and related facilities will begin in the spring of 1966. Ore production is scheduled to reach 6,000 tons a day in the second half of 1967. The operation will produce from 4 to 5 million pounds a year of molybdenum in concentrates.

The recent successful development of new properties and the continuing molybdenum shortage has stimulated widespread exploration for molybdenum properties in Canada. In B.C., Phelps Dodge Corporation of Canada, Limited continued to diamond drill its molybdenite prospect at Haven Lake, 80 miles west of Burns Lake. Amax Exploration, Inc., a subsidiary of American Metal Climax, Inc., diamond drilled several properties in B.C. and will continue the program in 1966 on three of the properties tested in 1965. Amax's property on Hudson Bay Mountain has been turned over to another division of American Metal Climax, Inc. for exploration and development. An adit is being driven to explore a large mineralized zone outlined by surface drilling. According to a communication from the company the adit with planned lateral work may total 11,000 feet. In Ontario and Quebec many known molybdenite occurrences are being restudied. Pax International Mines Limited continued to explore its property at Ryan Lake, Ontario. Molybdenum Limited announced plans to sink a shaft and to conduct exploration drifting on Evenlode Mines Limited's High Lake molybdenite property in the Kenora Mining Division of Ontario.

Based on information released by the mines now in production and those being prepared for production, the Mineral Resources Division estimates that Canadian molybdenum reserves are about 340 million pounds of contained Mo in ore containing 0.25 per cent or more MoS_2.

UNITED STATES

United States is the largest producer and consumer of molybdenum and molybdenum products. In 1965, production and shipments each amounted to some 77 million pounds, an all-time high. According to the 1965 annual report of American Metal Climax, Inc., U.S. consumption at 53 million pounds was also an all-time high. According to the U.S. Bureau of Mines *Molybdenum Monthly*, February 24, 1966, exports of molybdenum ore, concentrates and oxide in 1965 totalled 26.7 million pounds of contained Mo, compared with 24.9 million pounds in 1964. The all-time high in exports was 35.7 million pounds in 1961.

The Climax mine of Climax Molybdenum Company, a division of American Metal Climax, Inc., is the largest producer of molybdenum in the world. According to the company's 1965 annual report, Mo production from the Climax mine was 50 million pounds. The Ceresco Ridge portion of the Climax orebody recorded its first full year of production and contributed approximately 4,000 tons to the mine's daily average of 39,900 tons.

Climax Molybdenum also announced that construction continued on a new plant at Climax, Colorado. This plant will utilize a hydrometallurgy process to recover oxidized molybdenum, which to date has been lost in the tailings. About 5,700 tons of ore that contain much oxide material will be treated daily for recovery of molybdenum after the sulphide recovery process is completed. Production in this new plant is scheduled for the second quarter of 1966 and recovery should be about 3 million pounds of Mo a year. Climax Molybdenum is also spending $25 million to bring its Urad, Colorado, mine into production in mid-1967. Production of up to 7 million pounds a year is expected. The company also completed its conversion plant at Rotterdam, Holland, and announced that April 1966 was to be the start-up date; the plant has the capacity to convert the molybdenum in 12 million pounds of concentrates to molybdic oxide.

Molybdenum Corporation of America (Molycorp) is second to Climax Molybdenum Company as a producer of molybdenum consumer products. During 1965 it completed preparations for production at its Questa mine and mill. Annual production will be about 10 million pounds of Mo in concentrates, to be converted in the company's conversion facilities at Washington and York, Pennsylvania. The Questa property is in Taos County in north central New Mexico on the western slope of the Taos Range of the Sangre de Cristo Mountains. Mining will be by open pit for at least 10 years.

Among the major producers of byproduct molybdenum from copper operations are Kennecott Copper Corporation, Bagdad Copper Corporation, Phelps Dodge Corporation, San Manuel Copper Corporation, Union Carbide Nuclear Company, American Smelting and Refining Company and Duval Corporation. Kennecott, the world's second largest producer of molybdenum concentrates reported production of 19.3 million pounds of contained Mo in 1965, some 5.4 million pounds more than in 1964. This includes production in the United States and Chile.

According to the *Congressional Record – Senate*, April 25, 1966 – the United States stockpile of molybdenum in ores and concentrates as of January 19, 1966, was 69,034,253 pounds, of which 1,034,253 pounds were surplus to stockpile objectives. A review of stockpile requirements early in 1966 by the Office of Emergency Planning revealed that the stockpile objective could safely be lowered to 55 million pounds, thus creating an excess to requirements of 14 million pounds.

OTHER COUNTRIES

For many years Chile has been second in the non-Communist world as a producer of molybdenum, obtained as a byproduct of its large porphyry-copper operations. Since 1939, molybdenite concentrate has been recovered by Braden Copper Company from the copper ores of its El Teniente mine. In 1958 The Anaconda Company installed a molybdenite-recovery unit at its Chuquicamata copper property. The copper ore of Anaconda's El Salvador mine also contains considerable molybdenum. Most of Chile's output of molybdenite concentrate is exported to Western Europe. Early estimates indicate that Chilean production for 1965 was about 9.3 million pounds of contained Mo. Phelps Dodge Corporation reported recovery of 1,450 tons of MoS_2 concentrate from its copper concentrator at Toquepala, Peru.

China, North Korea and the U.S.S.R. also produce molybdenum but data on their output are not available. Reports indicate that three large molybdenum deposits were discovered during the nineteen-fifties in China, somewhere in the middle section of the Ch'in Ling Mountains of Shensi Province and in Shansi and Kirin provinces. The U.S. Bureau of Mines has estimated that production in the Sino-Soviet bloc totalled 16.5 million pounds in 1965.

TABLE 3

World Production of Molybdenum in Ores and Concentrates

(short tons)

	1963	1964	1965[e]
United States	32,506	32,803	38,500
U.S.S.R.	6,250e	6,600e	6,600
Chile	3,200	4,297	4,500
China	1,650e	1,650e	1,650
Canada	417	612	5,082
Peru	588	431	..
Japan	366	306	300
Other countries	473	501	..
Total	45,450	47,200	58,250

Source: Dominion Bureau of Statistics, U.S. Bureau of Mines *Minerals Yearbook, 1964;* U.S. Bureau of Mines *Commodity Data Summaries*, January 1966.

[e] Estimate; .. Not available.

CONSUMPTION AND USES

About 67 per cent of molybdenum is consumed in the form of molybdic oxide followed in order by ferromolybdenum and molybdenum powder. Molybdenum is used in lesser amounts in calcium, sodium and ammonium molybdate, in molybdenum disulphide and in molybdenite concentrate added directly to molten steel.

Small additions of molybdenum promote uniform hardness and strength in heavy steel sections. This ability to improve combinations of strength and toughness is the most notable effect of molybdenum as a steel additive.

Metallic molybdenum is a refractory metal produced in the form of bars, sheet, plate, tube and wire. It is superior to most other metals in high-temperature applications and is used extensively in electronics and for missile parts that have a short working life. The design of solid-fuel rocket engines, which will operate beyond the melting point of molybdenum, will reduce the role of this metal in certain missile parts.

The number of uses for molybdenum chemicals has been increasing in recent years. As a catalyst, molybdenum is applied in processes designed to raise the octane rating of gasoline,

The molybdenum operation of Endako Mines Limited in central British Columbia, shortly after it began operations in June 1965.

Stripping operations at the Endako mine.

TABLE 4

United States Consumption of Molybdenum by Use

(thousand pounds of contained molybdenum)

	1963	1964	1965[e]
Steel			
High-speed	2,089	2,155	..
Other alloys	22,869	27,489	..
Miscellaneous*	931	1,095	..
Grey and malleable castings	3,287	3,525	..
Rolls (steel mills)	1,907	2,181	..
Welding rods	238	249	..
High-temperature alloys	1,396	1,522	..
Molybdenum metal wire, rod and sheet	1,548	1,371	..
Chemicals			
Catalysts	688	963	..
Pigments and other colour compounds	908	865	..
Miscellaneous**	1,617	1,704	..
Total	37,478	43,119	46,937

Source: U.S. Bureau of Mines *Minerals Yearbook, 1963*

and in desulphurization. About 55 per cent of the molybdenum consumed by the pigment industry is employed in the production of molybdenum orange. The use of molybdenum as a trace element in soil conditioners, though still small, is becoming increasingly important.

Molybdenum is of great strategic value to the United States not only for its particular alloying properties but also because it can be used as a partial substitute for tungsten, nickel, chromium and vanadium in low-alloy and certain high-speed steels.

Among the more important Canadian consumers of molybdenum primary products are: in Ontario – Atlas Steels Division of Rio Algom Mines Limited, Welland; The Algoma Steel Corporation, Limited, Sault Ste. Marie; Dominion Foundries and Steel, Limited, Hamilton, Welmet Industries Limited, Welland; Canadian General Electric Company Limited, Toronto; The Steel Company of Canada, Limited, Hamilton; and Dominion Colour Corporation Limited, New Toronto; in Quebec – Crucible Steel of Canada Ltd., Sorel; Canadian Steel Foundries Division of Hawker Siddeley Canada Ltd., Montreal; and Dominion Brake Shoe Company, Limited, Joliette; in Nova Scotia – Dominion Steel and Coal Corporation, Limited, Sydney.

PRICES

E & MJ Metal and Mineral Markets of December 27, 1965 quotes molybdenum prices in the United States as follows:

	($ per lb)
Molybdenum powder, carbon-reduced, f.o.b. shipping point	3.35
Molybdenum concentrate, contained Mo, 95% MoS_2 f.o.b. shipping point Climax, cost of containers extra.	1.55
Molybdic trioxide, contained Mo, f.o.b. shipping point:	
bags	1.74
cans	1.75
Ferromolybdenum, contained Mo, packed, f.o.b. shipping point, 0.12 – 0.25% C, powdered, per lb Mo, lots 5000 lb:	
lump	2.04
powder	2.10
Calcium molybdate, contained Mo, lumps, packed	1.78

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Calcium molybdate and molybdic oxide	free	free	5%
Molybdenum strip	free	free	30%
Molybdenum wire, rod and tubing, and molybdenum imported by manufacturers of radio tubes and parts	free	free	30%
Ferromolybdenum	free	5%	5%
Molybdenum ores and concentrates	free	free	free
United States	(¢ per lb contained Mo)		
Molybdenum ores and concentrates	24		
Calcium molybdate, ferromolybdenum and compounds of molybdenum	20 plus 6%		
Molybdenum metal:			
unwrought	20 plus 6%		
wrought	25.5%		
waste and scrap (duty on scrap suspended to June 30, 1967)	21%		

Natural Gas

D.W. RUTLEDGE *

The nineteen-sixties can be regarded as the period during which the Canadian natural gas industry was attaining major status. In 1955 its contribution to the mineral value of Canada was only $15 million and it ranked with the lesser known minerals. In 1965 the value of production was over $193 million and it ranked sixth. In addition, the value of liquid hydrocarbons extracted from raw natural gas reached a significant $92 million in 1965. During the past five years the rate of growth of gas output has averaged 23 per cent per annum and the prospects are for continuing good growth. Today, natural gas supplies 17 per cent of Canada's primary energy requirements and gas resources have been developed to a stage where recoverable reserves constitute over 34 years of supply based on the 1965 production rate.

COMPOSITION AND USES

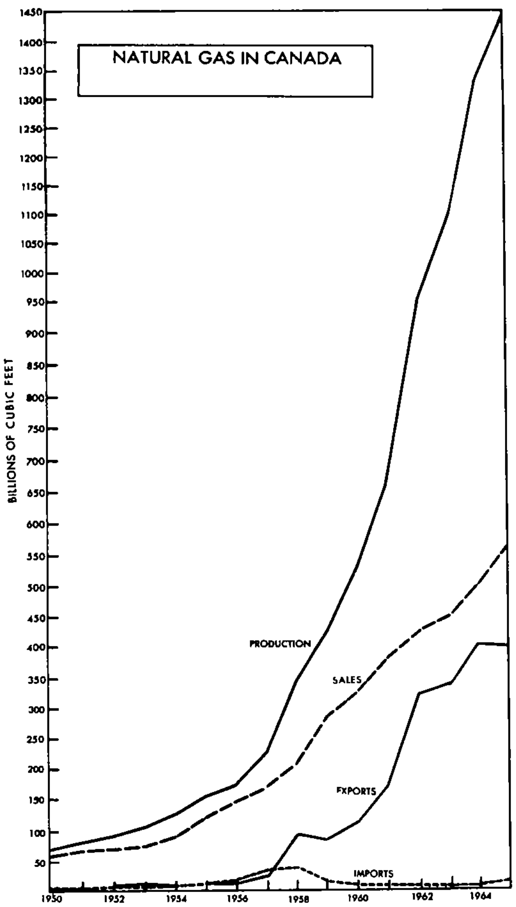
Marketed natural gas consists chiefly of methane (CH_4) but small amounts of other combustible hydrocarbons such as ethane (C_2H_6) and propane (C_3H_8) may be included. Methane is nonpoisonous and odourless but a characteristic odour is usually introduced into marketed natural gas as a safety measure. 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 differ considerably 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 often 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 but gas is also 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 produces the desired temperatures 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 feedstock 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 from the sour gas (hydrogen sulphide bearing) fields in western Canada.

*Mineral Resources Division

Note: All volumes of gas are given at 14.73 pounds per square inch absolute (psia) except where noted.
Mcf = 1,000 cubic feet.



PRODUCTION

In 1965, net new production of natural gas exclusive of withdrawals from storage and gas flared and wasted, totalled 1,442,448 million cubic feet or 3,960 million cubic feet a day. The rate of increase of 8.7 per cent was considerably smaller than the 19-per-cent increase of 1964. Table 1 lists the main gas-producing fields in Canada. The quantities listed in the table are gross outputs and, while most of this gas is marketed, only a minor portion of the output from several fields is available for marketing. In the Harmattan-Elkton, Harmattan East, Carson Creek, and Lookout Butte fields, the gas is cycled to recover the liquid hydrocarbons in the reservoir

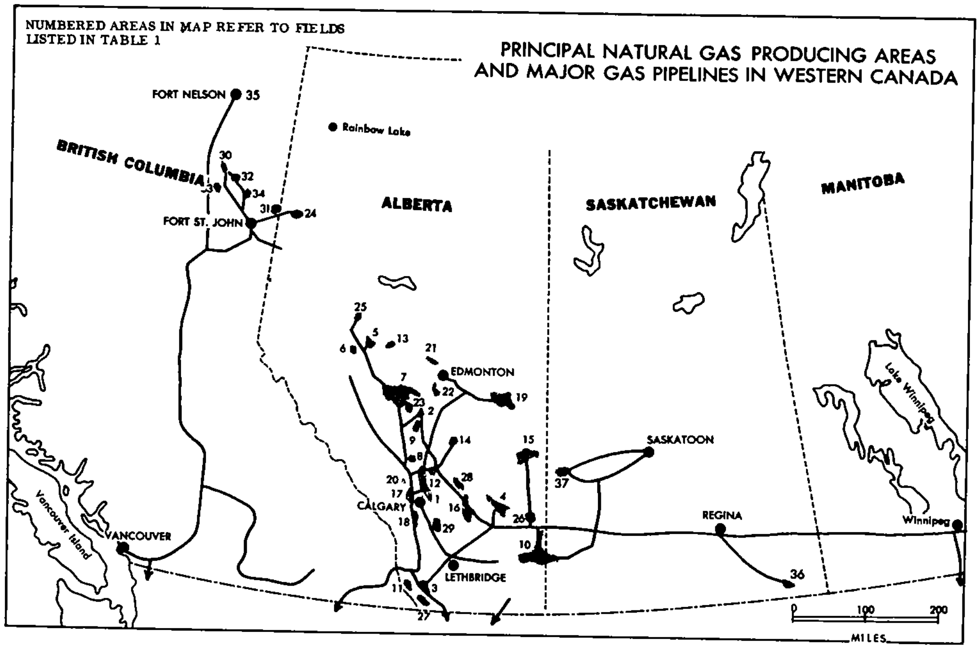
TABLE 1

Natural Gas Fields Producing 10 Million Mcf or More

(numbers in brackets refer to map locations)

	1964 (Mcf)	1965 (Mcf)
Alberta		
Crossfield (1)	80,635,737	80,047,286
Westerose South (2)	69,253,614	69,818,581
Cessford (4)	65,004,470	65,944,437
Windfall (5)	52,886,732	61,216,601
Waterton (11)	51,335,462	52,934,072
Medicine Hat (10)	41,692,395	50,847,295
Homeglen-Rimbey (9)	50,737,457	47,410,943
Pine Creek (6)	55,718,714	46,602,419
Harmattan East (8)	31,626,514	46,118,163
Carstairs (12)	36,654,864	41,106,832
Pembina (7)	40,146,487	40,204,455
Harmattan-Elkton (8)	34,094,248	39,409,002
Carson Creek (13)	32,843,099	33,831,918
Gilby (9)	25,273,346	29,322,497
Provost (15)	27,779,541	28,911,344
Pincher Creek (3)	34,737,409	27,843,779
Nevis (14)	25,685,971	26,351,508
Hussar (16)	19,798,864	23,219,878
Jumping Pound (17)	21,549,071	20,947,762
Wildcat Hills (20)	16,879,268	20,571,964
Turner Valley (18)	20,796,276	19,378,600
Minnehik-Buck Lake (23)	14,974,439	16,915,190
Leduc-Woodbend (22)	16,555,267	16,114,083
Viking-Kinsella (19)	21,095,058	15,476,949
Bindloss (26)	16,454,730	14,805,719
Wayne-Rosedale (28)	10,454,371	13,736,032
Kaybob (25)	12,356,561	13,152,796
Sylvan Lake (2)	1,428,153	13,144,293
Lookout Butte (27)	11,777,799	13,075,726
Olds (12)	1,629,116	12,879,773
Fort Saskat-chewan (21)	9,792,975	12,490,882
Okotoks (29)	10,289,153	11,140,378
Wimbourne (12)	573,278	10,812,953
Worsley (24)	13,934,722	10,770,787
Westlock (21)	8,343,703	10,714,429
Countess (16)	12,643,866	10,232,907
British Columbia		
Jedney (30)	21,530,222	20,767,485
Laprise Creek (30)	14,835,933	18,477,613
Clarke Lake (35)	157,986	16,965,910
Beg (33)	11,390,482	12,749,785
Boundary Lake (31)	12,467,240	12,640,617
Nig Creek (32)	12,114,908	12,451,447
Rigel (34)	10,535,612	11,793,574
Buick Creek (34)	11,234,488	10,232,471
Saskatchewan		
Steelman (36)	14,587,470	9,731,503
Coleville-Smiley (37)	14,146,062	13,309,758

Source: Provincial government reports. Volumes shown are gross production figures measured at pressure base of 14.65 psia, standard pressure for provincial government statistics.



and the dry gas is returned to formation to maintain pressure. The gas will eventually be reproduced. The very sour dry gas from the Pine Creek field is injected into the Windfall reservoir to partly replace gas extracted there. These reinjections are conservation measures designed to allow maximum extraction of the liquid hydrocarbons in the reservoir.

Table 3 shows gross new production; that is, it excludes gas previously produced and reinjected as this has already been recorded in previous gross production. This table also shows net production which is gross production less gas flared or wasted.

EXPLORATION AND DEVELOPMENT

ALBERTA

The main areas of interest in the search for gas were essentially the same as in 1964. Exploration was concentrated in regions with large or potentially large reserves such as Edson, Gold Creek, Obed, Marten Hills, Calling Lake, Brazeau River and the southern Foothills. In the Rainbow Lake region, the main goal of exploration has been to find oil, but the numerous gas occurrences encountered incidental to this search indicates that the area could become an important source of gas.

Follow-up drilling near two major 1964 Devonian gas discoveries, Gold Creek and Obed, proved successful. At Gold Creek, 25 miles southeast of Grande Prairie, four additional condensate-rich, sour-gas wells were drilled northwest and west of the discovery well. All have 'pay' sections greater than 200 feet in the Wabamun (D-1) formation, and one well had more than 400 feet of gas-bearing formation. Thus the gas reserves per acre are very large. The Gold Creek gas is extremely rich in condensate; one well produced more than 1,000 barrels a day during testing. Pan American Petroleum Corporation, Richfield Oil Corporation, Sinclair Oil Corporation and Scurry-Rainbow Oil Limited are the main operators or land-owners at the Gold Creek pool. Shell Canada Limited's one-well, Smoky River pool, 6 miles to the west, was not extended in 1965; two dry holes were drilled just to the east. In the Obed region, 35 miles west of Edson, the Imperial Oil Limited - Western Decalta Petroleum Limited team drilled a second gas well 2 miles northwest of their 1964 discovery well.

The main productive zone is the Winterburn (D-2) formation. Because of the high hydrogen sulphide content (25 per cent) the value of the sulphur in the gas is approximately equal to the value of the methane gas. Twenty-five miles northeast of Obed, an important gas discovery was made in a Leduc (D-3) reef in the well Fina-Pan Am-HB Malboro 4-29-55-19W5. This well apparently has located the southward extension of the Pine Creek-Beaver Creek reef trend.

Delineation of the two Mississippian Elkton gas pools of the Edson field continued. The addition of 14 wells raised the field total to 33. Most of the new wells were fill-in holes to confirm the continuity of the gas reservoirs between the earlier widely-spaced wells. Gas reserves are estimated at 1,700,000 million cubic feet. In the Brazeau River region, 20 to 40 miles southeast of the Edson field, renewed exploratory interest was evident after several years of relative inactivity. The recent laying of the Carstairs-Edson gas pipeline through the Brazeau area has encouraged further exploration and resulted in two gas discoveries in 1965, one 5 miles northwest and the other 8 miles southeast of the four-well Brazeau River field. HB Brazeau River 10-2-46-14W5 intersected gas and light oil in the Mississippian Shunda formation and gas and condensate in the Elkton formation. Tenneco-BL Brazeau 10-3-44-12W5 located a gas-condensate reservoir in the Elkton.

In the southern Foothills, a fourth very sour gas well, Shell 3 Panther River 9-30-30-10W5, was completed. The Panther River gas carries 87 per cent hydrogen sulphide, making it possibly one of the largest undeveloped sulphur reserves in Alberta. Shell Canada Limited is conducting experimental production tests at Panther River to establish the feasibility of producing gas to recover the sulphur.

TABLE 2

Pressure Maintenance Injection and Storage of Natural Gas

(Mcf)

	1964		1965	
	Input	Reproduction	Input	Reproduction
Alberta				
Bow Island	1,524,861	1,258,706	1,342,917	2,113,787
Carson Creek	29,456,791	–	33,045,731	–
Carstairs	–	–	1,240,512	377,821
Cold Lake	–	–	1,002	–
Crossfield	–	–	355,605	–
Duhamel	151,773	–	99,400	–
Golden Spike	3,997,483	–	7,239,812	–
Harmattan East	27,520,743	–	43,076,015	–
Harmattan-Elkton	34,094,248	–	36,014,326	–
Jumping Pound	2,420,485	1,723,724	1,995,701	1,210,171
Leduc Woodbend	6,779,918	–	5,404,846	768
Lookout Butte	11,158,467	–	12,434,087	–
Pembina	14,223,032	–	13,203,599	–
Pincher Creek	66,705	980,173	–	812,206
Sundre	592,815	–	318,812	–
Turner Valley	1,391,098	505,040	3,293,901	439,082
Westerose	953,062	–	753,960	–
Windfall	56,939,541	–	48,199,577	–
Total (14.65 psia)	191,271,022	4,467,643	208,019,803	4,953,835
Volume adjusted to 14.73 psia	190,238,158	4,443,518	206,896,496	4,927,084
Ontario	26,176,247	23,980,409	37,977,530	29,625,974
Saskatchewan	3,712,816	1,787,642	2,791,034	2,927,793
Total, Canada	220,127,221	30,211,569	247,665,060	37,480,851

Source: Provincial government reports.

– Nil.

TABLE 3

Production of Natural Gas

	1964r		1965p	
	Mcf	$	Mcf	$
Gross new production				
New Brunswick	105,055		105,359	
Ontario	13,815,967		12,619,867	
Saskatchewan	62,281,321		59,739,391	
Alberta	1,184,754,869		1,278,469,418	
British Columbia	146,105,999		170,588,242	
Northwest Territories	34,297		43,068	
Total, Canada	1,407,097,508		1,521,565,345	
Waste and flared				
Saskatchewan	21,795,526		16,970,490	
Alberta	47,028,591		52,642,839	
British Columbia	10,609,053		9,503,946	
Total, Canada	79,433,170		79,117,275	
Net new production				
New Brunswick	105,055	112,303	105,359	111,677
Ontario	13,815,967	5,759,876	12,619,867	5,260,716
Saskatchewan	40,485,795	4,160,782	42,768,901	4,395,735
Alberta	1,137,726,278	149,594,796	1,225,826,579	165,702,873
British Columbia	135,496,946	13,324,698	161,084,296	17,848,199
Northwest Territories	34,297	14,404	43,068	18,088
Total, Canada	1,327,664,338	172,966,859	1,442,448,070	193,337,288
Processing shrinkage				
Saskatchewan	1,951,250		2,018,387	
Alberta	100,821,717		114,121,327	
British Columbia	6,070,358		5,964,714	
Total,Canada	108,843,325		122,104,428	
Net supply, Canada	1,218,821,013		1,320,343,642	

Source: Dominion Bureau of Statistics.

p Preliminary; r Revised.

TABLE 4

Comparison of 1964 and 1965 Production

	1965 Net New Production, Increase or Decrease (%)	Share of Production (%) 1964	1965
Alberta	+7.7	85.5	85.0
British Columbia	+18.9	10.3	11.1
Saskatchewan	+5.6	3.1	2.9
Ontario	-8.6	1.0	0.9
New Brunswick	+0.3	negligible	negligible
Northwest Territories	+25.6	negligible	negligible

In the Rainbow Lake region, in the far northwestern corner of Alberta, gas occurrences have been known at Zama Lake for several years, but not until the major oil discovery early in 1965 did the region undergo intensive exploration. Gas, as well as oil, has been found in numerous wells. The oil-discovery well, Banff Aquit Rainbow West 7-32-109-8W6 intersected 23 feet of net gas pay in the Slave Point formation, 17 feet in the Sulphur Point, and 251 feet overlying the main oil zone in the Keg River reef. Later wells intersected gas reservoirs in several horizons. No plans have been announced for immediately marketing the gas, but this solution gas will be re-injected into the reservoirs until economic conditions and good engineering practice make its sale possible.

TABLE 5

Value of Gas Produced, 1964–65

	1964		1965P	
	Total Value ($)	Average Value (¢ per Mcf)	Total Value ($)	Average Value (¢ per Mcf)
Alberta	149,594,796	13.1	165,702,873	13.5
British Columbia	13,324,698	9.8	17,848,199	11.0
Saskatchewan	4,160,782	10.3	4,395,735	10.3
Northwest Territories	14,404	42.0	18,088	42.0
Ontario	5,759,876	41.7	5,260,716	41.7
New Brunswick	112,303	106.9	111,677	106.0
Total, Canada	172,966,859	13.0	193,337,288	13.4

Source: Dominion Bureau of Statistics.

P Preliminary.

TABLE 6

Production, Trade and Total Sales, 1955–65

(Mcf)

	Production	Imports	Exports	Sales in Canada
1955	150,772,312	11,165,756	11,356,252	117,800,311
1956	169,152,586	15,695,359	10,828,338	143,725,649
1957	220,006,682	30,550,944	15,731,072	159,893,877
1958	337,803,726	34,716,151	86,971,932	202,057,485
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
1965P	1,442,448,070	15,673,069	403,908,528	567,944,000

Source: Dominion Bureau of Statistics.

P Preliminary.

TABLE 7

Liquid and Sulphur Production from Canadian Natural Gas, 1955–65

	Propane (barrels)	Butane (barrels)	Condensate/ Pentanes Plus (barrels)	Sulphur (long tons)
1955	796,482	492,051	1,028,516	25,976
1956	925,716	591,638	1,078,145	29,879
1957	1,111,355	747,709	1,121,440	89,916
1958	1,123,797	748,972	1,094,653	165,116
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
1965P	10,371,256	6,957,833	27,864,189	1,589,586

Sources: Dominion Bureau of Statistics and provincial government reports.

P Preliminary; r Revised.

TABLE 8

Wells Drilled

	Oil		Gas		Dry		Service		Total	
	1964	1965	1964	1965	1964	1965	1964	1965	1964	1965
Alberta	912	877	243	220	667	856	9	3	1,831	1,956
Saskatchewan	628	697	27	57	529	519	11	11	1,195	1,284
British Columbia	42	113	35	41	61	93	2	2	140	249
Manitoba	72	26	–	–	34	38	1	–	107	64
Yukon and Northwest Territories	–	1	3	2	15	15	–	–	18	18
Total, western Canada	1,654	1,714	308	320	1,306	1,521	23	16	3,291	3,571
Ontario	33	23	55	68	128	97	45	16	261	204
Quebec	–	–	–	–	10	2	–	–	10	2
Atlantic Provinces	–	1	–	–	1	2	–	–	1	3
Total, eastern Canada	33	24	55	68	139	101	45	16	272	209
Total, Canada	1,687	1,738	363	388	1,445	1,622	68	32	3,563	3,780

Source: Canadian Petroleum Association.

– Nil.

By the end of 1964, eleven gas wells had been completed over a wide area in the Marten Hills region northeast of Lesser Slave Lake, and large gas reserves were indicated in the Lower Cretaceous Wabiskaw and Devonian Wabamun formations. The lack of markets for this gas brought development in the Marten Hills to a halt, and no wells were drilled there in 1965. However, Pan American Petroleum Corporation, the main operator in the region, announced that development drilling would be considerable in 1966. In the Calling Lake-Corrigall Lake district southeast of the Marten Hills, the search for gas in the buried erosional edge of the Upper Devonian resulted in three additional gas discoveries. One of these was drilled by Hudson's Bay Oil and Gas Company Limited several miles north of its two 1964 finds near Corrigall Lake. Production from all three wells was from the Nisku formation. Texaco Exploration Company completed two Wabamun gas wells just north of Calling Lake, midway between the Marten Hills and Corrigall Lake pools. Development of the shallow gas reserves in the Marten Hills and Calling Lake regions, and also in the Tawatinaw area to the south, will proceed rapidly because of a recent commitment by Pan American, Hudson's Bay, and The British American Oil Company Limited to supply Trans-Canada Pipe Lines Limited with 3 trillion cubic feet of gas from these areas over a 25-year period, commencing in 1968.

One of the better gas discoveries in the southern Plains was BA Lake McGregor 10-28-16-21W4 which produced 17 million cubic feet a day, absolute open flow, from a 34-foot pay zone in the Basal Blairmore. Follow-up drilling resulted in another good gas well and two dry holes.

Development drilling in gas fields decreased in 1965. One hundred gas development wells were drilled compared to 124 in 1964. Many wells in the southern half of the province were uncapped and put on production. The Wimborne and Sylvan Lake field are notable examples. A number of wells were drilled in the larger southeastern fields such as Medicine Hat and Provost. The Alberta Oil and Gas Conservation Board designated 16 more tracts as gas fields.

TABLE 9

Footage Drilled in Canada, by Provinces, 1964–65

	Exploratory		Development		All Wells	
	1964	1965	1964	1965	1964	1965
Alberta	3,820,539	4,451,934	6,528,671	5,754,130	10,349,210	10,206,064
Saskatchewan	1,656,310	1,621,479	2,543,935	2,938,629	4,200,245	4,560,108
British Columbia	295,458	489,039	367,993	592,017	663,451	1,081,056
Manitoba	65,249	93,694	181,672	70,826	246,921	164,520
Northwest Territories	113,061	119,581	–	–	113,061	119,581
Total, western Canada	5,950,617	6,775,727	9,622,271	9,355,602	15,572,888	16,131,329
Ontario	227,443	173,953	257,429	176,915	484,872	350,868
Quebec	23,905	11,963	–	–	23,905	11,963
Atlantic Provinces	9,853	4,917	–	2,941	9,853	7,858
Total, eastern Canada	261,201	190,833	257,429	179,856	518,630	370,689
Total, Canada	6,211,818	6,966,560	9,879,700	9,535,458	16,091,518	16,502,018

Source: Canadian Petroleum Association.

– Nil.

BRITISH COLUMBIA

Drilling in British Columbia increased to a much greater extent than it did in the other provinces. Exploration was reasonably successful. Eight gas discoveries were made on the Plains east of the Foothills, and one in the Foothills. The latter discovery is considered one of the more significant because it indicated an entirely new area of Triassic gas. The well, Triad BP Sumlumka a-43-B, is situated on a major structure 70 miles southwest of Fort St. John. After stimulation, dry sour gas flared at a rate of greater than 25 million cubic feet a day from a thick pay section just below a depth of 8,600 feet.

On the Middle Devonian reef trend east and northeast of Fort Nelson several more very productive gas wells were drilled. Pacific Apache Ft. Nelson a-61-F, Imperial Clarke Lake b-6-A, Socony Mobil Sierra c-78-C, and Socony Mobil Sierra c-91-D all recorded excellent flow rates. The first two wells are located at the southwestern and eastern extremities of the Clarke Lake field, respectively. The last two wells are several miles south of the Kotcho Lake field.

There are now more than 2 dozen shut-in Devonian gas wells between the Clarke Lake field and the Alberta and Northwest Territories boundaries. Many of them have thick pay zones and high output potential, but production must await available markets and extension of the gas pipeline from the Clarke Lake field.

Gas-field development was minor in the Triassic and Cretaceous production areas in the Fort St. John-Laprise Creek region. Farther north, the Devonian Clarke Lake field was enlarged from eight to twelve wells.

SASKATCHEWAN AND MANITOBA

Only a little of the drilling done in Saskatchewan has been aimed specifically at finding or developing natural gas, largely because exploration has not indicated any major 'gas prone' tracts and structures such as are known in Alberta and British Columbia. Much of the natural gas produced in Saskatchewan is solution gas, a byproduct of oil production. Thus, much of the province's gas comes from the Steelman and Coleville-Smiley fields, primarily oil producers, although the latter area also has separate gas pools. The main gas-producing area, not associated with oil production, is the Hatton field – the eastward extension of Alberta's Medicine Hat field. Expansion of the limits of the Hatton field was mainly responsible for a substantial increase in Saskatchewan gas-well development drilling in 1965. About 20 gas wells were drilled there, mainly at the southeast corner and northern end of the field. Altogether, 52 development wells were drilled in gas pools in Saskatchewan, compared to 23 in 1964.

Underground storage has become an important factor in Saskatchewan's chain of gas supply in the past few years. Saskatchewan Power Corporation continued solution mining at the Regina and Prud'homme underground storage projects in 1965. The two caverns at Regina, with a combined capacity of 360 million cubic feet, went into operation late in the year. Enlargement of the caverns is continuing. Gas injection into the 100,000 Mcf Prud'homme cavern began in September.

YUKON AND NORTHWEST TERRITORIES

Drilling continued at about the same pace as in the previous year. Eighteen wells were drilled, the same number as in 1964, but footage increased slightly, to 119,600 feet. Two gas discoveries were made. In the northern Yukon Territory, Socony Mobil Oil of Canada, Ltd., - Western Minerals Ltd. Birch YT B-34 tested at 5.5 million cubic feet a day through restricted choke from a depth of 4,430 feet in Permo-Pennsylvanian strata. This well is in the same area as the Western Minerals Chance No. 1 oil-gas discovery of 1959. The other gas discovery was Pure-Pan Am Trainor Lake No. C-39, 25 miles northeast of the 1964 Island River gas discovery. The well is unofficially reported to have produced from the Middle Devonian Slave Point formation at a rate of 9 million cubic feet a day. A well drilled on the Mackenzie River delta, BA-Shell-IOE Reindeer D-27, produced a showing of gas from the Upper Cretaceous. This is the most northerly well yet drilled on the mainland of the Territories.

EASTERN CANADA

In Ontario, exploratory drilling resulted in nine gas wells. Six of these were Silurian, one was Ordovician, and two were Cambrian. Two of the Silurian wells were drilled offshore in Lake Erie off Welland County. None of the discoveries appears to have found major new fields. Development drilling resulted in 59 gas-well completions, predominantly in the Silurian. Lake Erie continued to be one of the main gas development areas, with 26 gas-field wells completed there. Development of known gas pools slightly increased the province's gas reserves.

Exploratory work continued in the Hudson Bay Lowlands and the adjoining offshore area. Oil company holdings remained essentially unchanged at 55.8 million acres. Richfield Oil Corporation held 50 million offshore acres under federal exploration permits. Industry and government geophysical surveys increased substantially in 1965. Work consisted of airborne magnetometer and conventional marine seismic and gas exploder seismic surveys. Geological reconnaissance included inspection of bottom sediments by divers.

Intensive exploration was also carried out off the east coast, and land holdings were nearly doubled to 114 million acres. Much of the Gulf of St. Lawrence was taken up under new permits. On Pan American Petroleum Corporation's 31-million-acre block on the Grand Banks of Newfoundland, Pan Am and Imperial Oil Limited jointly carried out marine seismic surveys, drilled 24 shallow core-holes, and conducted gas-detection tests of sea water. Socony Mobil Oil of Canada, Ltd. drilled five core-holes near Sable Island.

In Quebec, two exploratory wells were drilled compared to 10 in 1964. Total footage of the wells, both drilled on Anticosti Island, was just under 12,000 feet. Minor shows of gas were reported.

On the west coast of Newfoundland, two dry wells totalling 4,917 feet were drilled on the Port au Port peninsula by Golden Eagle Oil and Gas Limited and British Newfoundland Exploration Limited. Another group commenced drilling a well farther north, at Parsons Pond. Oil and gas showings were reported in this well.

RESERVES

The Canadian Petroleum Association's compilation shows that, after allowance for the year's production, Canada's reserves of natural gas increased in 1965 by 2.3 per cent to a year-end recoverable total of 44.4 trillion (44.4×10^{12}) cubic feet. This represents a very small expansion compared to the 17.4-per-cent increase in 1964. The newly discovered occurrences at Rainbow Lake have not yet been taken into account, but evidently a large amount of natural gas is present in that region.

The Alberta Oil and Gas Conservation Board estimated the province's established gas reserves at 37.6 trillion cubic feet, slightly more than the CPA estimate. The main increases in reserves were due not to 1965 discoveries, but rather to reserve appreciation of known accumulations. The largest increase assigned to an individual area was at Gold Creek, south of Grande Prairie, where drilling resulted in an estimated additional 470 billion cubic feet. Among other areas of important increases were Edson, Brazeau River, Crossfield East, Pembina, and Harmattan-Elkton. The 30-mile-long Edson gas field has been subdivided into two pools as the result of additional drilling. In British Columbia, a slight decrease in reserves was recorded, mainly a production loss. While the potential of the Devonian reef gas-bearing region is considered great, drilling in 1965 added comparatively little to reserves there.

TABLE 10

Estimated Year-end Recoverable Reserves of Natural Gas
(Mcf)

	1964	1965
Alberta	35,198,661	36,356,749
British Columbia	6,931,445	6,750,244
Saskatchewan	1,040,669	973,594
Eastern Canada	161,243	187,820
Northwest Territories	55,383	100,394
Manitoba	3,473	3,490
Total	43,390,874	44,372,291

Source: Canadian Petroleum Association.

NATURAL GAS PROCESSING

Pipeline and consumer specifications and conservation requirements necessitate the processing of a large proportion of Canadian natural gas near the wellhead. In Alberta in 1965, 16.6 per cent of the marketable gas produced in the province was nonprocessed dry gas. The remaining 83.4 per cent was from gas-processing plants located near the source fields. Because of expanding demand for gas liquids such as propane and butane, more efficient processing, commonly referred to as 'deep-cut' processing, is being increasingly used to extract as much of these liquids as possible. Approximately 43 per cent of the marketable gas produced in Alberta was reprocessed by Pacific Petroleums, Ltd. Their large plant on the Alberta-Saskatchewan boundary removed additional quantities of propane, butane and pentanes plus that were not removed in plants at the fields.

Hydrogen sulphide, a common constituent of unprocessed Canadian natural gas that must be removed at the field processing plant, was generally regarded as a nuisance a few years ago when a surplus of sulphur existed. The elemental sulphur extracted from the hydrogen sulphide has recently become a valuable byproduct because of heavy demand and sharp increases in the price of sulphur. For some very sour gases, the value of the sulphur is now greater than that of the residue gas.

At the end of 1965, 91 gas plants were in operation in Alberta, four in British Columbia, six in Saskatchewan, and two in Ontario. The addition of 700,000 Mcfd capacity during 1965 raised total raw gas input capacity to 6,100,000 Mcfd. The increase in plant capacity was considerably less than in 1964 but expected because there were no new significant sales contracts for gas during the past year. All except two of the nine plants completed in 1965 were of small or medium size. One of the large plants was Westcoast Transmission Company Limited's installation at the Clarke Lake field near Fort Nelson, British Columbia. This plant has a capacity of 200 million cubic feet a day. It was built in 1964 and put on stream early in 1965. In Alberta, the largest new plant was placed on stream near Edson in November by Hudson's Bay Oil and Gas Company Limited. This plant has a capacity of 309,000 Mcfd and processes gas from the Edson field. New gas plants were completed in the Wimborne, Sylvan Lake, Crossfield East, Braeburn, Willesden Green, south Harmattan, and Cessford fields.

TABLE 11

Processing Plant Capacities by Fields, 1964
(millions of cubic feet a day)

Fields Served	Raw Gas Capacity	Residue Gas Produced
Alberta		
Acheson	6	5
Alexander	55	53
Black Butte, Aden	10	10
Bonnie Glen, Glen Park, Wizard Lake	35	30
Boundary Lake South	25	22
Crossfield	190	152
Crossfield Cardium	3	2
Carbon	155	150
Carson Creek	100	re-inj.
Carstairs, Crossfield	225	202
Cessford (6 plants)	209	201
Cessford, Connorsville	5	5
Chigwell (2 plants)	12	10
Countess	22	21
Enchant	5	5
Gilby (6 plants)	78	74
Golden Spike	26	22
Harmattan-Elkton, Harmattan East	246	re-inj.
Homeglen-Rimbey, Westerose South	367	314
Hussar (2 plants)	90	90
Innisfail	15	10
Judy Creek, Swan Hills, Virginia Hills	55	40
Jumping Pound, Sarcee	110	90
Kaybob	41	40
Kessler	6	6
Leduc-Woodbend	35	31
Lookout Butte	43	re-inj.
Minnehik-Buck Lake	57	51
Morinville, St. Albert-Big Lake, Campbell-Namao	25	25
Nevis	56	48
Nevis, Stettler, Fenn-Big Valley	45	35
Okotoks	30	13
Olds	44	34
Oyen	3	3
Pembina (11 plants)	120	95
Pembina (Cynthia)	10	9
Pembina (Lobstick)	25	22
Pincher Creek	204	145
Prevo	5	4
Princess (2 plants)	15	15
Provost (2 plants)	93	87
Redwater	11	3
Retlaw	7	7
Samson	3	3
Savanna Creek	75	63
Sedalia	5	5
Sibbald	6	5
Sylvan Lake	22	20
Three Hills Creek	10	9
Turner Valley	100	85
Waterton	180	121
Wayne-Rosedale (3 plants)	37	35
Wildcat Hills	96	83
Windfall	215	132
Wood River	5	5
Worsley	55	52
Pipeline near Edmonton	70	66
Pipeline near Empress	1,000	965
Saskatchewan		
Alida, Nottingham, Carnduff	9	6
Coleville	60	59
Smiley	4	3
Steelman, West Kingsford	38	30
Cantuar	25	24
Dollard	2	2
British Columbia		
Fields in Fort St. John area	395	300
Boundary Lake (2 plants)	27	25
Clarke Lake	200	170
Ontario		
Fields in southwestern Ontario (3 plants)	22	22

Source: *Natural Gas Processing Plants in Canada (Operators List 7)*, January 1966, Department of Mines and Technical Surveys.

TRANSPORTATION

Additions to gas-pipeline systems during the year amounted to approximately 1,500 miles, and brought the total of all transmission, distribution, and gathering lines to nearly 43,400 miles. For the fourth consecutive year, Trans-Canada Pipe Lines Limited added 34-inch loops along the system in Saskatchewan and Manitoba. The 84 miles of loop added in 1965 leaves only 89 miles of the system unlooped between the Alberta-Saskatchewan boundary and Iles Des Chênes, just south of Winnipeg, Manitoba. No parallel lines have been added east of Winnipeg as Trans-Canada is awaiting a decision from government regulatory agencies as to whether the company will be given a permit to construct and operate a pipeline through the United States from Emerson, Manitoba, to Sarnia. Such a line would be built in preference to looping the existing northern Ontario line and would involve sale of gas also in the United States. By late 1965, Trans-Canada's facilities east of Winnipeg were operating at capacity on peak days, and in fact, curtailment to customers supplied on an interruptible basis was necessary at times. Trans-Canada built lines to supply two new areas in 1965. A 44-mile 6-inch lateral was completed from the main line at Moosomin in eastern Saskatchewan to Russel, Manitoba. This line delivers gas to Inter-City Gas Utilities Ltd. Near the eastern end of the Trans-Canada system, 40 miles of pipeline were laid from Candiac, Quebec, to Philipsburg at the Quebec-Vermont boundary. Gas deliveries to Vermont Gas Systems, Inc., commenced in February 1966, via this system.

In British Columbia, the 30-inch Fort Nelson gas pipeline of Westcoast Transmission Company Limited went into service early in 1965. This 220-mile line joins Westcoast's main system 65 miles southwest of Fort St. John, and carries gas from the Clarke Lake field, the province's largest developed gas reserve.

In the largest gas pipeline construction project in Alberta, The Alberta Gas Trunk Line Company laid 173 miles of 30-inch extension of the Plains Division from Carstairs to the Edson gas field. By means of this line, the Edson field has become one of the largest and most westerly sources of supply for the Trans-Canada pipeline. Other Alberta construction included the completion of 70 miles of gas transmission line from the Paddle River field to Edmonton by Northwestern Utilities, Limited. This company also connected its large gas reserves of the Beaverhill Lake field, east of Edmonton, to the company system. Other gas pipeline construction in Alberta consisted mainly of the laying of gathering systems in new producing areas and the addition of short transmission lines to tie these areas in with existing systems.

In Saskatchewan, Saskatchewan Power Corporation laid a total of 154 miles of gas transmission lines, 53 miles of gathering lines, and 111 miles of distribution lines. A 9-mile 16-inch loop was laid from the Success compressor station to the Trans-Canada pipeline, and a 12-inch line was constructed from the latter system to Regina. The new gathering lines, of 4 to 16 inches, were laid mainly in the Medicine Hat-Hatton, Hoosier, and Coleville fields. In southeastern Saskatchewan, Steelman Gas Ltd. and Provo Gas Producers Limited completed more than 140 miles of pipeline to gather gas from six fields southeast of Steelman. Gas from these new sources will be processed at the Steelman gas plants.

In western Manitoba, Inter-City Gas Utilities Ltd. laid about 140 miles of transmission and distribution lines to supply gas to eight towns including Dauphin and Grandview.

TABLE 12

Gas Pipeline Mileage in Canada, 1962–65

	1962	1963r	1964	1965p
Gathering				
New Brunswick	6	6	6	6
Ontario	1,314	1,049	1,043	1,043
Saskatchewan	298	309	389	421
Alberta	2,540	2,920	3,071	3,150
British Columbia	409	409	409	409
Total	4,567	4,693	4,918	5,029
Transmission				
New Brunswick	13	13	13	13
Quebec	25	25	25	65
Ontario	3,141	3,265	3,365	3,395
Manitoba	496	631	731	897
Saskatchewan	2,566	2,832	3,081	3,133
Alberta	4,293	4,311	4,776	4,984
British Columbia	1,311	1,311	1,319	1,319
Total	11,845	12,388	13,310	13,806
Distribution				
New Brunswick	32	32	33	33
Quebec	1,144	1,203	1,263	1,323
Ontario	10,865	11,700	12,297	12,647
Manitoba	947	1,117	1,178	1,228
Saskatchewan	1,425	1,536	1,637	1,748
Alberta	3,100	3,224	3,383	3,523
British Columbia	3,427	3,647	3,843	4,023
Total	20,940	22,459	23,634	24,525
Total, Canada	37,352	39,540	41,862	43,360

Source: Dominion Bureau of Statistics.

p Preliminary; r Revised.

In Ontario, Union Gas Company of Canada, Limited, added 30 miles of 34-inch loop east of London in a continuation of its program to increase the capacity of the system between Lambton County gas storage reservoirs and Oakville. The National Energy Board issued permits to a subsidiary of Northern and Central Gas Company Limited (formerly Northern Ontario Natural Gas Company Limited) to build a gas transmission line from Earlton, Ontario, to the Rouyn-Noranda area. Work was started on the distribution systems in Noranda and Rouyn. Northern and Central commenced work on a 56-mile 10-inch lateral to Atikokan, Ontario, and made commitments to supply the Texas Gulf Sulphur Company near Timmins.

MARKETS AND TRADE

Sales of natural gas in Canada increased 12.6 per cent compared with 11.7 per cent in 1964 and averaged 1,560 million cubic feet a day in 1965. Ontario was the largest consuming province for the third consecutive year. Sales in British Columbia increased more sharply than in any other province. In Quebec province, sales fell below the 1964 level despite the increased commercial and industrial activity in the main consuming area, Montreal. Competition from fuel oil in this area is perhaps the heaviest encountered by gas anywhere in Canada. Industrial sales accounted for half of all sales in Canada, and residential and commercial sales for 33 per cent and 17 per cent.

Exports of natural gas to the United States averaged 1,100 million cubic feet a day, or about the same as in 1964. This is in contrast to the several preceding years when exports increased substantially each year. Exports accounted for only 42 per cent of total sales compared to 45 per cent a year earlier. Canadian natural gas was exported at seven points along the International Boundary: at Huntingdon and Kingsgate in British Columbia; at Carway, Aden and Coutts, Alberta; at Emerson, Manitoba; and at Cornwall, Ontario. Forty-eight per cent of the exported gas moved through the Alberta-California pipeline via Kingsgate. The pipeline of Westcoast Transmission Company Limited at Huntingdon carried slightly less than 26 per cent of the exports, and the Trans-Canada pipeline lateral at Emerson accounted for just over 18 per cent. Early in 1966, Trans-Canada Pipe Lines Limited began exporting gas from Quebec to Vermont.

TABLE 13

Sales of Natural Gas in Canada 1965[p]

	Mcf	$	Average $/Mcf	Number of Customers Dec. 31/65
New Brunswick	60,000	189,000	3.15	2,187
Quebec	31,244,000	31,240,000	0.99	218,737
Ontario	219,198,000	189,096,000	0.86	690,836
Manitoba	33,164,000	22,644,000	0.68	95,084
Saskatchewan	56,169,000	25,545,000	0.45	114,997
Alberta	169,996,000	53,997,000	0.32	260,573
British Columbia	58,113,000	43,832,000	0.75	187,124
Total, Canada	567,944,000	366,543,000	0.65	1,569,538
Previous totals				
1961	370,739,542	226,678,494	0.61	1,227,658
1962	412,061,509	257,589,445	0.62	1,308,085
1963	451,598,298	287,584,177	0.64	1,397,138
1964	504,503,388	327,982,720	0.65	1,459,619

Source: Dominion Bureau of Statistics.

[p] Preliminary.

In August 1965, the National Energy Board authorized Trans-Canada Pipe Lines Limited to export an additional 26 million cubic feet a day on a long-term basis to Midwestern Gas Transmission Company through Emerson, Manitoba. Importation of this additional gas, scheduled to begin November 1, 1966, must be approved by the United States Federal Power Commission. Meanwhile, Trans-Canada is supplying Midwestern's additional requirements through a short-term contract by which additional gas is supplied on an interruptible basis. Westcoast Transmission Company Limited started deliveries to El Paso Natural Gas Company through an interim contract which permits delivery of an additional 50 million cubic feet a day above previous authorizations pending approval of a long-term contract to supply another 200 million cubic feet to El Paso.

TABLE 14
Sales of Natural Gas in Canada, on Percentage Basis

	1964	1965
Ontario	38.51	38.60
Alberta	31.88	29.93
Saskatchewan	9.08	9.89
British Columbia	8.45	10.23
Quebec	6.57	5.50
Manitoba	5.50	5.84
New Brunswick	0.01	0.01
Total	100.0	100.0

Source: Dominion Bureau of Statistics.

TABLE 15
Natural Gas — Supply and Demand
(MMcf)

	1964r		1965p	
Supply				
Gross new production*	1,407,097		1,521,565	
Field waste and flared gas	-79,433		-79,117	
Processing shrinkage	-108,843		-122,104	
Net new production		1,218,821		1,320,344
Removed from storage	30,212		37,481	
Placed in storage	-220,127		-247,665	
Net withdrawals from storage		-189,915		-210,184
Net supply of domestic gas		1,028,906		1,110,160
Imports		8,046		15,673
Total supply		1,036,952		1,125,833
Demand				
Exports		404,143		403,909
Residential sales	163,626		183,867	
Industrial sales	257,402		285,009	
Commercial sales	83,475		99,068	
Total domestic sales		504,503		567,944
Consumption and losses in production		73,732		80,071
Pipeline consumption, losses and metering differences		44,102		53,077
Line pack changes		684		550
Gas unaccounted for		9,788		20,282
Total demand		1,036,952		1,125,833
Total domestic consumption		632,809		721,924
Average daily domestic consumption		1,728		1,977

Sources: Dominion Bureau of Statistics and provincial government reports.

*Excludes gas reproduced from storage.

p Preliminary; r Revised.

Although imports of natural gas comprise a relatively small proportion of Canada's gas supply – less than 3 per cent – they nearly doubled in 1965 to an average of 43 million cubic feet a day. All imports entered directly into Ontario except for a negligible quantity imported into Alberta. The appreciable increase in imports was the result of implementation of a new contract and import authorization whereby Union Gas Company of Canada, Limited, is substantially increasing its purchases of gas at Windsor from Panhandle Eastern Pipe Line Company. Because of inadequate capacity of the Trans-Canada pipeline in Ontario at times of peak demand, Trans-Canada Pipe Lines Limited received Canadian and U.S. government permission to import natural gas at Niagara Falls on a short-term basis.

Installation of a natural gas gathering line in Alberta.

Nepheline Syenite

J.E. REEVES*

The Canadian nepheline syenite industry maintained its rapid growth in production in 1965. Shipments exceeded those in 1964 by about 13 per cent. Exports, which constitute about three quarters of the total shipments, increased about 9 per cent. Overseas markets, particularly in Europe and Australia, took an ever-increasing share. The preference for nepheline syenite by glass manufacturers, its growing acceptance by other manufacturing industries, and the ability of the producers to maintain and when necessary improve the level of quality of the products, indicate that the growth should continue.

PRODUCERS

The large Blue Mountain deposit in Methuen Township, northeast of Peterborough, Ontario, is the only one being exploited in Canada. Two companies, Industrial Minerals of Canada Limited and International Minerals & Chemical Corporation (Canada) Limited, operate quarries and dry processing plants, principally for the production of glass-grade nepheline syenite. Both companies also produce fine-ground, high-quality grades and lower-quality, relatively high-iron byproducts.

OTHER CANADIAN OCCURRENCES

Nepheline-bearing rocks are relatively common in Canada but generally cannot be beneficiated sufficiently for use as a feldspathic raw material in the ceramics industry.

In the Bancroft area of southeastern Ontario a discontinuous band of nepheline gneiss and nepheline pegmatite extends for many miles. From 1937 to 1942 these rocks were mined in small quantity but proved unsuitable for use in glass and various other ceramic products. A relatively high but variable nepheline content, and an excess of iron-bearing minerals make the production of uniform-quality products difficult.

Nepheline syenite occurs in several places in southern British Columbia, notably in national parkland in the Ice River area near Field and in the vicinity of Big Bend on the Columbia River.

Nepheline is common in the alkaline rock complexes in northern Ontario and southern Quebec but is nowhere of any known commercial significance.

FOREIGN PRODUCTION

Norway and the USSR also produce nepheline-bearing ceramic raw materials. On Stjernøy, an island off the northern coast of Norway, a large deposit of nepheline syenite, similar in appearance to the Blue Mountain deposit, is being mined to produce high-quality products containing more than 24 per cent alumina (Al_2O_3), about 17 per cent potash (K_2O) plus soda (Na_2O) and 0.08 per cent iron (in terms of Fe_2O_3). At Kirovsk in the Kola Peninsula, the USSR mines

*Mineral Processing Division, Mines Branch

TABLE 1

Nepheline Syenite — Production, Exports and Consumption, 1964–65

	1964		1965P	
	Short Tons	$	Short Tons	$
Production (shipments)	290,300	3,097,172	328,813	3,548,947
Exports				
United States	196,443	2,214,853	208,217	2,381,102
Britain	16,863	199,173	17,403	257,148
Netherlands	3,774	45,850	8,765	99,850
Venezuela	3,360	45,186	3,690	48,541
Australia	1,939	39,230	2,703	60,224
Italy	716	15,404	2,330	45,436
Puerto Rico	1,200	16,980	1,450	20,913
Belgium and Luxembourg	1,613	35,050	1,303	28,478
Other countries	1,063	18,459	1,339	27,010
Total	226,971	2,630,185	247,200	2,968,702
Consumption*	1963		1964	
Glass	33,442		33,247	
Glass fibre	3,204		3,415	
Mineral wool	601		372	
Other ceramic products	6,908		7,344	
Other products	523		998	
Total	44,678		45,376	

Source: Dominion Bureau of Statistics.

*Available data.

P Preliminary.

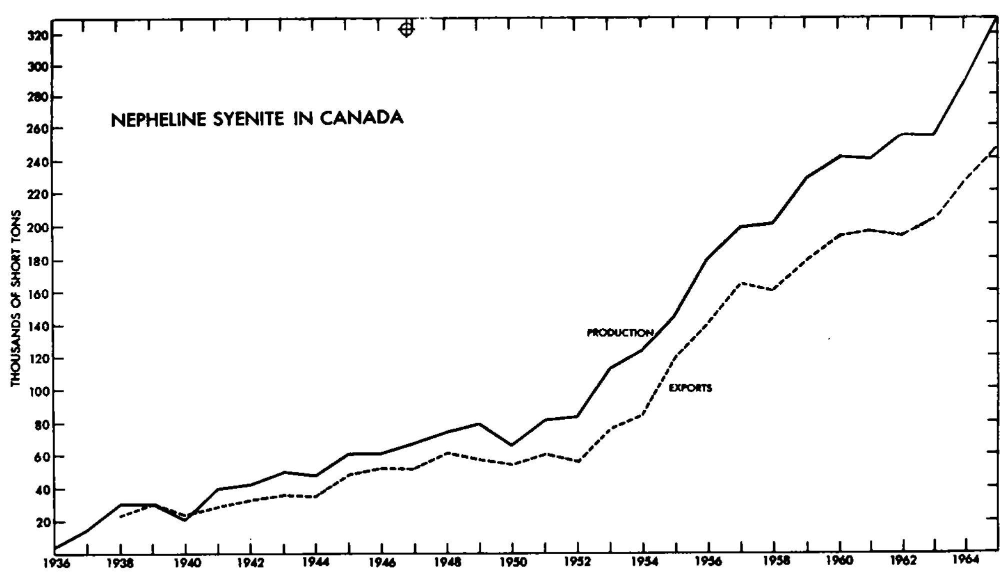


TABLE 2

Production and Exports, 1956–65

(short tons)

	Production	Exports
1956	180,006	139,305
1957	200,016	164,342
1958	201,306	160,081
1959	228,722	178,120
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
1965p	328,813	247,200

Source: Dominion Bureau of Statistics

p Preliminary.

an apatite-nepheline rock associated with an alkaline rock complex and produces a nepheline concentrate containing about 29 per cent Al_2O_3, 11 per cent Na_2O, 9 per cent K_2O and 3 to 4 per cent Fe_2O_3. It is used in the manufacture of green glass and as a source of aluminum.

TECHNOLOGY

Nepheline syenite is a quartz-free rock consisting essentially of nepheline (a sodium aluminum silicate) and feldspar (sodium and potassium aluminum silicates). The Blue Mountain deposit contains approximately 50 per cent soda feldspar, about 20 to 25 per cent of both nepheline and potash feldspar and small quantities of the iron-bearing minerals magnetite, biotite and hornblende. Large parts of the deposit have comparatively little mineralogical variation. This consistency and the relative ease with which the iron-bearing minerals can be removed by high-intensity, dry magnetic separators make the production of uniform high-quality products possible.

Ground and beneficiated nepheline syenite is commercially valuable because of its comparatively high alumina and alkali content and its relatively low melting temperature. Typically, products from the Blue Mountain deposit contain between 23 and 24 per cent Al_2O_3, about 15 per cent total alkali (with a soda-potash ratio of about 2:1) and no more than 0.08 per cent Fe_2O_3.

USES AND SPECIFICATIONS

The glass industry is the dominant consumer of nepheline syenite, accounting for nearly three quarters of the total consumption in Canada. Nepheline syenite is important as a source of alumina and alkalis and lowers the melting temperature of the glass batch. Canadian glass producers have entirely substituted nepheline syenite for feldspar. The particle size specification is minus 30 plus 200 mesh, US Standard. For clear glass, the iron content, expressed as Fe_2O_3, must be less than 0.1 per cent.

Nepheline syenite is used to a smaller extent in the whiteware industry as both a body and a glaze ingredient. Because of its lower fusion temperature, many Canadian manufacturers of sanitaryware, dinnerware, wall tile and pottery have substituted it for feldspar. The particle size must be mainly minus 325 mesh and the iron content less than 0.1 per cent Fe_2O_3.

Because of its relatively low fusion temperature, fine-ground nepheline syenite is used as a frit ingredient for porcelain enamels. Specifications are similar to those for whitewares. Small quantities of fine-ground material are finding increasing acceptance as a filler in paints and foam rubber.

Lower-grade, lower-priced byproducts are used to some extent in glass fibre, in glaze for brick and tile, in the body and glaze of sewer pipe and in ground-coat enamels – in all of which the higher iron content is of little importance. Some crude is used in the manufacture of mineral wool.

PRICES

The price of glass-grade nepheline syenite is $10 a short ton, in bulk, f.o.b. plant. *Canadian Chemical Processing* of October 1965 quoted prices as follows: in bags, car lots, f.o.b. works, $11.50 to $28.50 per short ton.

Nickel

A.F. KILLIN*

Production and consumption of nickel in the Free World set records in 1965. Consumption of nickel increased with an increase in production and consumption of stainless steels and of nickel-alloy steels. At 365,000 tons (estimated), consumption of nickel was 9 per cent higher than in 1964. Production kept pace with consumption but not to the extent that inventories, depleted in 1964, could be replenished.

Canada, the world's largest nickel producer, increased production to 261,155 tons valued at $435,332,054, which was 32,659 tons and $56,011,544 more than in 1964.

Exports of the three major nickel products increased to 258,480 tons valued at $389,954,932 – a total of 19,584 tons and $32,186,818 more than in 1964. Exports of nickel in concentrates and matte increased by 7,561 tons; in oxide sinter by 5,156 tons and in anodes, cathodes, shot, etc., by 6,867 tons.

In the United States, the General Services Administration (GSA) announced a step-up in annual rate of nickel disposal from the government stockpile from 15 million to 25 million pounds and indicated that a further increase in rate of disposal might be announced. The major Canadian producers and the United States producer have agreed to purchase 164 million pounds of nickel from GSA.

All segments of the nickel industry are optimistic about the rate of nickel consumption in the future. One Canadian producer has estimated an increase in consumption to about 600,000 tons by 1975. Most foreign and domestic producers have started to expand existing plants. Present and future expansion plans are covered in the sections on Canadian and world developments.

CANADIAN OPERATIONS AND DEVELOPMENTS

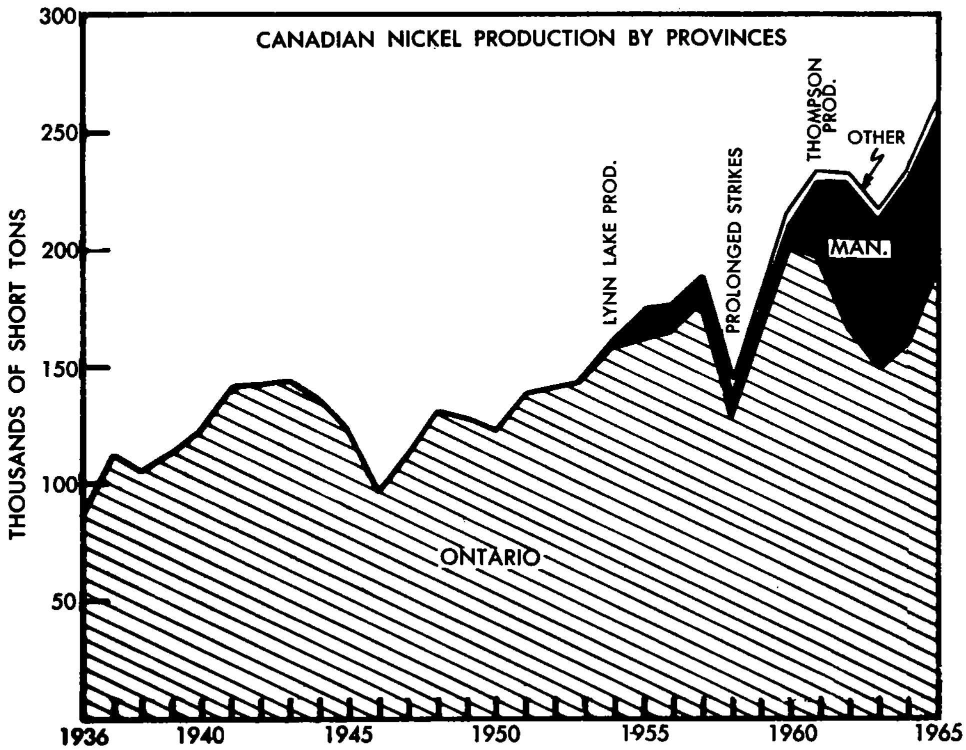
Canada continues to supply about 80 per cent of the Free World's nickel. The International Nickel Company of Canada, Limited (INCO) and Falconbridge Nickel Mines, Limited are the world's two largest nickel producers and supply about 72 per cent of Canada's output. Both companies have established expanded research facilities. INCO, Falconbridge and Sherritt Gordon Mines, Limited, Canada's other main producer, are active in the search for new deposits.

QUEBEC

Production of nickel in 1965 was 3,305 tons from two small producers. Lorraine Mining Company Limited near Belleterre started production in March 1965. The company operated a 400-ton-a-day mill and shipped a bulk nickel-copper concentrate to the Copper Cliff, Ontario, smelter of INCO. Underground exploration and development was continued.

Marbridge Mines Limited, owned jointly by Falconbridge Nickel Mines and Marchant Mining Company Ltd., produced 350 tons of nickel-copper ore a day from its mines near

*Mineral Resources Division



Malartic. The ore was trucked to the nearby mill of Canadian Malartic Gold Mines Limited for concentration and a bulk nickel-copper concentrate was shipped to the Falconbridge smelter for treatment. Development of a newly discovered orebody about 3,000 feet south of the original shaft started in 1965 and development ore from this orebody was being milled in the second half of the year.

In the Ungava region of New Quebec, New Quebec Raglan Mines Limited, the successor company to a merger between Raglan Quebec Mines Limited and Bilson Quebec Mines Limited (a subsidiary of Falconbridge), continued exploration of its property in the Ungava nickel belt. New Jersey Zinc Exploration Company (Canada) Ltd. was exploring a low-grade nickel-copper occurrence in Gaspé Provincial Park.

ONTARIO

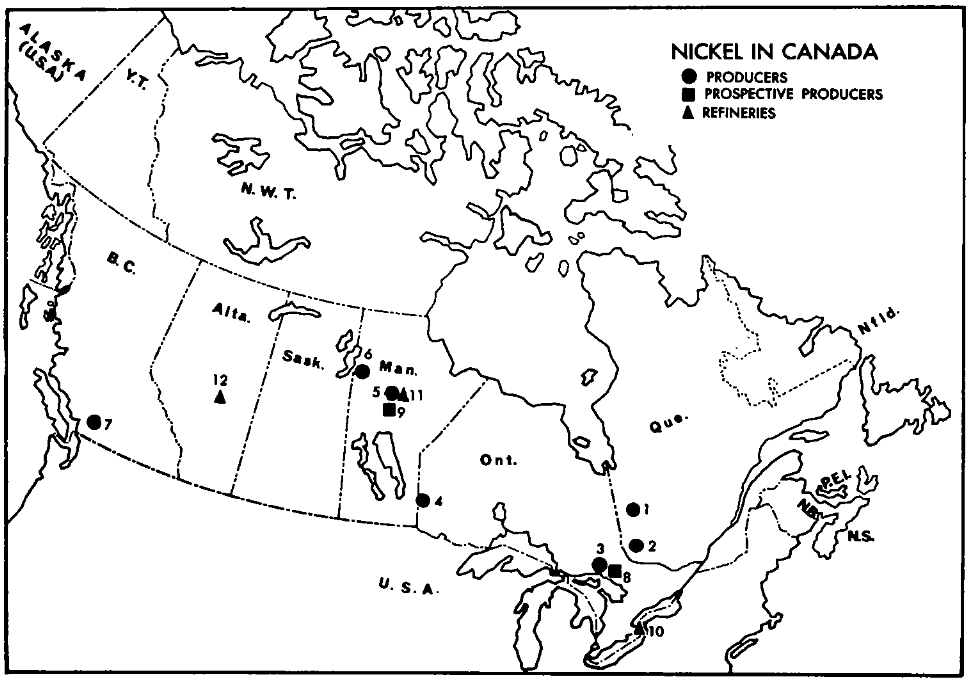
The largest nickel-producing companies in the world are in the Sudbury Basin district of Ontario. Production from the mines of INCO and Falconbridge there and from Metal Mines Limited at Gordon Lake in northwestern Ontario totalled 192,655 tons, 30,561 tons more than in 1964.

INCO increased production from its eight mines and two smelters in the Sudbury district and from its refinery at Port Colborne. The operating mines were: the Creighton, Frood-Stobie, Garson, Levack, Murray, Clarabelle, Crean Hill and MacLennan. A major expansion plan was announced by the company that includes sinking a 7,150-foot shaft at the Creighton mine, increased production at the Frood-Stobie mine, bringing into production of the Totten (1966), Copper Cliff North (1967), Kirkwood (1967), Coleman (1967), and Little Stobie (1968) mines, building a new 22,500-ton-a-day concentrator at the Stobie mine, and modernization and expansion of the roasting and matte-cooling sections of the Copper Cliff smelter. Production capacity at INCO plants in Canada will be about 500 million pounds of nickel in 1968.

Ore reserves at the INCO mines in Ontario and Manitoba increased 2,436,000 tons to 306,203,000 tons containing 9,274,000 tons of nickel-copper, despite the mining of 19,750,000 tons of ore in 1965.

Falconbridge Nickel Mines, Limited continued production from its six mines, three mills and a smelter in the Sudbury area. A new blast furnace was installed at the smelter and a 6,000-ton-a-day mill was under construction at the Strathcona mine on the north rim of the Sudbury basin. Shaft sinking and underground development at the Strathcona orebody were carried out in preparation for production in 1967. Production capacity at Falconbridge will be increased from 65 million to 100 million pounds of nickel a year by 1967.

Falconbridge's ore reserves increased 3,024,000 tons in 1965 to 55,260,000 tons with a combined nickel-copper content of 1,162,000 tons.



PRODUCERS

(numbers refer to numbers on map)

1. Marbridge Mines Limited
2. Lorraine Mining Company Limited
3. *Sudbury area*
   Falconbridge Nickel Mines, Limited (5 mines, 1 smelter)
   The International Nickel Company of Canada, Limited (8 mines, 2 smelters)
4. Metal Mines Limited
5. The International Nickel Company of Canada, Limited (Thompson mine and smelter)
6. Sherritt Gordon Mines, Limited
7. Giant Mascot Mines, Limited

PROSPECTIVE PRODUCERS

8. *Sudbury area*
   Falconbridge Nickel Mines, Limited (Strathcona mine)
   The International Nickel Company of Canada, Limited (5 mines)
9. *Thompson area*
   The International Nickel Company of Canada, of Canada Limited (2 mines)

REFINERIES

10. The International Nickel Company of Canada, Limited (Port Colborne)
11. The International Nickel Company of Canada, Limited (Thompson)
12. Sherritt Gordon Mines, Limited (Fort Saskatchewan)

TABLE 1

Nickel — Production, Trade and Consumption, 1964-65

	1964		1965P	
	Short Tons	$	Short Tons	$
Production[1]				
All forms				
Ontario	162,094	267,764,039	192,655	319,771,106
Manitoba	62,365	104,772,910	63,284	106,798,018
Quebec	2,338	3,928,771	3,305	5,552,450
British Columbia	1,699	2,854,790	1,911	3,210,480
Total	228,496	379,320,510	261,155	435,332,054
Exports				
In ores, concentrates, matte or speiss				
Britain	44,398	72,302,999	47,067	77,025,888
Norway[2]	27,937	39,364,238	32,810	49,887,419
Japan	1,879	1,807,394	2,124	2,072,463
United States	494	710,042	326	449,145
West Germany	58	64,133	—	—
Total	74,766	114,248,806	82,327	129,434,915
In oxide sinter				
United States	23,485	33,289,679	27,069	38,593,770
Britain	6,490	9,063,987	7,388	10,564,385
West Germany	1,873	2,882,335	2,333	3,661,098
Belgium and Luxembourg	1,013	1,590,676	1,001	1,572,092
France	516	810,274	976	1,532,399
Australia	1,239	1,737,068	741	1,052,022
Sweden	262	408,868	469	732,001
Italy	668	1,041,729	473	743,010
Austria	136	213,545	300	471,739
Mexico	29	44,162	95	150,130
Japan	86	138,345	49	80,063
Other countries	3	4,894	62	94,151
Total	35,800	51,225,562	40,956	59,246,860
Nickel and nickel alloy scrap				
United States	959	524,485	861	539,226
West Germany	52	810	56	2,258
Japan	—	—	25	2,200
Norway	—	—	30	27,258
Finland	—	—	22	41,115
France	4	2,869	20	12,847
Britain	48	29,513	22	19,643
Other countries	18	3,521	10	9,752
Total	1,081	561,198	1,046	654,299
Anodes, cathodes, ingots, rod and shot				
United States	92,152	137,252,374	110,137	162,749,253
Britain	26,133	38,569,061	15,135	22,244,989
West Germany	2,842	4,587,418	2,218	3,601,545
Japan	2,224	3,701,963	1,902	3,158,612
France	579	968,517	1,309	2,170,941
Australia	1,050	1,688,340	1,129	1,718,095
India	613	1,020,592	909	1,510,332
Sweden	368	590,374	499	809,278
Italy	436	704,352	422	686,418
Argentina	321	547,220	345	614,955
Mexico	222	370,242	244	404,167
Brazil	347	580,199	244	400,643
Belgium and Luxembourg	84	141,120	151	253,932
Other countries	959	1,571,974	553	949,997
Total	128,330	192,293,746	135,197	201,273,157

Table 1 (cont.)

	1964		1965p	
	Short Tons	$	Short Tons	$
Nickel and nickel-alloy fabricated materials, n.e.s.				
United States	2,080	3,615,747	2,296	4,437,245
Republic of South Africa	26	102,721	350	931,615
Switzerland	13	26,160	250	491,080
India	112	206,681	52	91,344
New Zealand	42	183,357	50	214,712
Britain	81	266,084	43	145,514
Mexico	35	59,344	32	54,572
West Germany	22	37,305	22	38,990
Japan	26	47,868	24	40,518
British Guiana	26	20,200	16	9,790
Other countries	95	286,057	45	135,310
Total	2,558	4,851,524	3,180	6,590,690
Imports				
Anodes, cathodes, ingots, rod and shot				
Norway	10,162	17,372,685	12,082	20,790,906
United States	274	593,866	90	228,079
West Germany	8	18,974	–	–
Total	10,444	17,985,525	12,172	21,018,985
Alloy ingots, blocks, rods and wire bars				
United States	606	1,521,774	610	1,800,080
West Germany	–	–	4	16,583
Britain	2	4,301	...	949
Total	608	1,526,075	424	1,817,612
Nickel and nickel-alloy fabricated materials, n.e.s.				
United States	1,465	4,354,450	2,154	6,660,215
Britain	53	184,698	53	204,176
West Germany	18	49,754	34	84,419
Sweden	15	62,674	23	90,227
Other countries	5	17,857	–	–
Total	1,556	4,669,433	2,264	7,039,037
Consumption[3]				
All forms	6,899		..	

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.

Symbols: p Preliminary; – Nil; ... Less than one ton; n.e.s. Not elsewhere specified; .. Not available.

Metal Mines Limited, Ontario's third nickel producer was exploring and developing a recently discovered orebody at its Gordon Lake property. Production from the established orebody continued and nickel-copper concentrates were shipped to the Copper Cliff smelter of INCO.

Sheridan Geophysics Limited optioned the Aer nickel property in Denison township, Sudbury area, from Associated Arcadia Nickel Corporation Limited. Underground development had indicated about 800,000 tons of nickel-copper ore and a 1,000-ton-a-day mill was under construction at the property. Initial production at 500 tons of ore a day is scheduled for 1966.

INCO was exploring a nickel-copper occurrence in the Shebandowan area by surface exploration and diamond drilling. Shaft sinking and underground exploration are planned for 1966.

TABLE 2

Nickel — Production, Trade and Consumption, 1956-65
(short tons)

	Production[1]	Exports				Imports[2]	Consumption[3]
		In Matte etc.	In Oxide Sinter	Refined Metal	Total		
1956	178,515	70,715	1,767	104,356	176,838	2,554	5,545
1957	187,958	73,694	1,706	103,258	178,658	2,091	4,532
1958	139,559	67,659	1,393	85,168	154,220	2,155	4,099
1959	186,555	65,657	4,157	102,111	171,925	1,857	4,059
1960	214,506	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	5,869
1964	228,496	74,766	35,800	128,330	238,896	10,444	6,899
1965P	261,155	82,327	40,956	135,197	258,480	..	..

Source: Dominion Bureau of Statistics.

[1]Refined metal, and nickel in oxide and salts produced plus recoverable nickel in matte and concentrates exported. [2]Nickel in bars, rods, strips, sheets and wire; nickel and nickel-silver in ingots; nickel-chromium in bars. [3]To 1959, producers' domestic shipments of refined metal; after 1959, consumption of nickel, all forms (refined metal, oxide and salts) as reported by consumers.

P Preliminary; .. Not available.

Texmont Mines Limited continued surface and underground exploration of its nickel orebody in Bartlett and Geikie townships about 20 miles southwest of Timmins. Indicated ore reserves are 4.7 million tons averaging 1 per cent nickel.

MANITOBA

Nickel production in Manitoba increased from 62,365 tons in 1964 to 63,284 tons. INCO continued production and development at its Thompson mine. It was preparing the Birchtree mine, about 3 miles from Thompson, for production in 1967 and the Soab mine, 40 miles from Thompson, for production in 1968.

Sherritt Gordon Mines, Limited at Lynn Lake continued production of nickel-copper concentrates for shipment to its refinery at Fort Saskatchewan, Alberta. Sherritt Gordon also produced refined nickel from nickel matte purchased from Société Le Nickel, which operates lateritic nickel deposits in New Caledonia.

Sufficient ore was outlined in the lower section of Sherritt's Lynn Lake mine O zone to replace the 1,363,583 tons mined from the orebodies in 1965. Ore reserves at the end of the year were 12,600,000 tons averaging 0.84 per cent nickel and 0.49 per cent copper. This reserve total allows for increased dilution expected with deeper mining.

Bowden Lake Nickel Mines Limited continued surface diamond drilling at its nickel property at Wabowden Lake in north-central Manitoba. Falconbridge is directing the exploration program.

BRITISH COLUMBIA

British Columbia's only nickel mine produced concentrates containing 1,911 tons of nickel, an increase of 212 tons from 1964. Giant Mascot Mines, Limited continued production and exploration at its Pride of Emory mine near Hope and shipped nickel-copper concentrates to Japan. Ore reserves were reduced by about 260,000 tons in 1965 after the mining of over 330,000 tons of ore. On-property exploration for new ore continued.

TABLE 3

Producing Companies, 1965

Company and Location	Mill Capacity (tons ore/day)	Ore Produced 1965 (1964) (short tons)	Grade (%) Ni	Cu	Developments
Quebec					
Lorraine Mining Company Limited, Belleterre	400	162,533	0.65	1.42	Continued development of known orebody. Extensive underground exploration for new ore.
Marbridge Mines Limited, Malartic	350 (milled at Canadian Malartic Gold Mines Limited)	125,313 (146,338)	2.25	—	Development of known ore; exploration and development of new orebody 3,000 ft. south of production shaft.
Ontario					
Falconbridge Nickel Mines, Limited (Falconbridge, East, Onaping, Hardy, Fecunis and North mines), Falconbridge	3,000 (Falconbridge) 1,500 (Hardy) 2,400 (Fecunis)	2,246,918 (1,960,000)	1.53	0.76	Development at depth in Falconbridge and East mines. North orebody developed for mining from Fecunis shaft. Shaft sinking and development at Strathcona mine, and construction of 6,000-ton-a-day mill at Strathcona.
The International Nickel Company of Canada, Limited (Creighton, Frood-Stobie, Garson, Levack, Murray, Crean Hill, Clarabelle and MacLennan mines), Copper Cliff	30,000 (Copper Cliff) 12,000 (Creighton) 6,000 (Levack)	16,704,143 (14,007,969)	..	..	Sinking of shaft to 7,150 ft. below collar started at Creighton. MacLennan mine brought into production. Expansion of production at Stobie; preparation of the Totten, Copper Cliff North, Kirkwood, Coleman and Little Stobie mines for production.
Metal Mines Limited, Werner Lake Division, Gordon Lake	700	..	..	..	
Manitoba					
The International Nickel Company of Canada, Limited, Thompson mine, Thompson	6,000	..	..	..	Continued exploration and development of Thompson orebody. Sinking of No. 3 shaft; deepening of No. 1.
Sherritt Gordon Mines, Limited, Lynn Lake	3,500	1,363,583 (1,362,693)	..	..	Continued exploration and development of O and N zones.
British Columbia					
Giant Mascot Mines, Limited, Hope	1,250	330,954 (324,635)	0.76	0.34	Extensive exploration by drifting and diamond drilling discovered new orebodies in 1,500, 2,000, and 2,200 zones.

Source: Company reports.

.. Not available; — Nil.

TABLE 4

Prospective Producing Companies*, 1965

Company and Location	Type of Ore	Mill Capacity (tons ore/day)	Production to Start	Destination of Concentrates
Ontario				
Falconbridge Nickel Mines, Limited, Strathcona mine, Sudbury	Ni, Cu	6,000	1966–67	Own smelter
The International Nickel Company of Canada, Limited, Sudbury				
Totten mine	Ni, Cu	Treated at central mill	1966	Own smelter
Kirkwood, Coleman, Copper Cliff North and Frood-Stobie expansion	Ni, Cu	Central mill	1967	Own smelter
Little Stobie mine	Ni, Cu	22,500 (will also treat Frood-Stobie ore)	1968	Own smelter
Manitoba				
The International Nickel Company of Canada, Limited				
Birchtree mine, Thompson	Ni, Cu	Ore will be treated at Thompson	1967	Own smelter
Soab mine, 42 miles southwest of Thompson	Ni, Cu	Ore will be treated at Thompson	1967	Own smelter

Source: Company reports.

* Includes only companies with announced production plans.

TABLE 5

World Production of Nickel

(short tons)

	1963	1964
Canada	217,030	228,496
Russia	98,000	100,000
New Caledonia	32,200	52,283
Cuba	16,200	20,000
United States	11,432	12,185
Finland	3,231	3,490
Republic of South Africa	2,700	2,700
Other	7	46
Total	380,800	419,200

Source: *American Bureau of Metal Statistics Yearbook, 1964;* for Canada, Dominion Bureau of Statistics.

WORLD DEVELOPMENTS

INCO continued with plans to develop a lateritic nickel deposit near Lake Izabal in Guatemala. Initial production is scheduled in 1967 at 25 million pounds of nickel in a nickel-iron product.

Falconbridge Nickel Mines, Limited suspended development of its lateritic deposits in the Dominican Republic because of political instability in that country.

Société Le Nickel was expanding its production facilities in New Caledonia and expects to produce 35,000 tons of nickel in ferronickel in 1966. The company has entered into a partnership with Kaiser Aluminium & Chemical Corporation of the United States to form two new companies. One of these, controlled by Le Nickel, will produce about 17,500 tons of nickel in ferronickel a year at a plant in New Caledonia. The second company, controlled by Kaiser, will market the product in the United States.

Société Minière et Métallurgique de Larymna-Larco completed construction of a nickel smelter at Larymna, Greece. The plant, to produce about 8.8 million pounds of electrolytic nickel a year, is scheduled for production in 1966. Société Le Nickel is building the plant and managing production.

Production of electrolytic nickel and ferronickel continued in Japan. Sulphide concentrates were imported from Canada and lateritic ores from New Caledonia and Indonesia.

Additional nickel was made available in the United States by sales of metal and ferronickel from government stockpiles. Government surplus over stockpile requirements was in excess of 280 million pounds at the start of the year. In addition to periodic sales to small businesses, the government negotiated the sale of 164 million pounds of nickel-bearing materials from the stockpile to the major North American producers. These sales were to be made over a four-and-a-half-year period at the prevailing market price. Of the total sold, INCO agreed to buy 70 million pounds, The Hanna Nickel Smelting Company 64 million pounds, Sherritt Gordon 13 million pounds and an undisclosed amount of the remainder will be purchased by Falconbridge.

CONSUMPTION AND USES

Nickel's suitability as an alloying agent is its chief attraction in almost all of its uses. Stainless steel remains the largest single outlet for nickel followed by its use in high nickel-iron alloys. The addition of nickel to iron or other metals increases hardness, toughness, ductility and corrosion resistance at low and high temperatures. Table 6 shows the consumption of nickel by use in 1964 and in 1965. Table 7 shows the consumption of nickel by countries in these years. The greatest gain in consumption by use was in the field of high-nickel alloys (Table 6) that were used in chemical, marine, electronic, nuclear power and aero-space applications. The use of nickel in coinage is increasing as the shortage of silver intensifies.

TABLE 6

Nickel Consumption by Use, 1964-65
(millions of pounds)

	1964	1965e
Stainless steels	234	247
Nickel plating	109	111
High-nickel alloys	82	101
Constructional alloy steels	88	91
Iron and steel castings	70	80
Copper and brass products	25	31
Other	62	69
Total	670	730

Source: The International Nickel Company of Canada, Limited.
e Estimated.

TABLE 7

Nickel Consumption by Country, 1964-65
(millions of pounds)

	1964	1965e
United States	308	350
Common Market countries	127	135
Great Britain	87	90
Japan	71	67
Sweden	30	32
Canada	16	18
Other	31	38
Total	670	730

Source: The International Nickel Company of Canada, Limited.
e Estimated

PRICES

	Canada (cents a pound)	United States* (cents a pound)
INCO, electrolytic, f.o.b., Port Colborne, Ontario and Thompson, Manitoba	84	79
Falconbridge, electrolytic, f.o.b. Thorold, Ontario	84	79
Sherritt Gordon, briquettes, f.o.b., Niagara Falls, Ontario, and Fort Saskatchewan, Alberta	84	79
Nickel oxide sinter (Ni-Co content), points in Ontario (freight allowed)	81.50	
Points outside Ontario (less freight allowance of 1.25¢ a pound)	81.50	
Buffalo, N.Y., or other established U.S. points of entry		75.25

*Includes 1¼ cents-a-pound import duty.

The price of nickel in the United States was reduced when the import duty of 1.25 cents a pound was suspended in September to 77.75 cents a pound.

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
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
Rods, consisting of 90% or more nickel when imported by manufacturers of nickel electrode wire for spark plugs for use exclusively in manufacture of such wire for spark plugs in their own factories ..	free	free	10
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	20
Anodes of nickel	5	7½	10
Nickel,and alloys containing 60% by weight or more of nickel, in powder form, for use in Canadian manufactures	free	free	free
Nickel or nickel alloys, namely: matte, sludges, spent catalysts and scrap, and concentrates other than ores, for recovery of the nickel or attendant byproducts	free	free	free
Articles of 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
Ferronickel	free	5	5

United States	
Ore, matte, and oxide	free
Unwrought; waste and scrap (duty suspended until June 30, 1967)	free
Bars, plates, sheets and strip, all the foregoing wrought of nickel (whether or not cut), pressed, or stamped to nonrectangular shapes: not cut, pressed nor stamped to nonrectangular shapes	(% ad val.)
Plates and sheets, clad	24
Other:	
not cold worked	10
cold worked	14
Rods, angles, shapes and sections, all the foregoing wrought of nickel; nickel wire	
Rods and wire:	
not cold worked	10
cold worked	14
Angles, shapes and sections	18
Nickel powders and flakes	
Flakes	10¢ per lb.
Powders (Duty suspended until June 30, 1967)	free
Pipes and tubes and blanks thereof, pipe and tube fittings, all the foregoing of nickel	
Pipes and tubes and blanks thereof:	(% ad val.)
not cold worked	6.25
cold worked	8.75
Pipe and tube fittings	18
Electroplating anodes, wrought and cast of nickel	10

Niobium (Columbium) and Tantalum

V.B. SCHNEIDER*

St. Lawrence Columbium and Metals Corporation continued to be the only Canadian producer of columbium concentrates. The company reported that mine shipments in 1965 amounted to 2.3 million pounds of contained columbium pentoxide (Cb_2O_5) in pyrochlore concentrates. St. Lawrence Columbium is the world's largest producer of Cb_2O_5 concentrates and is one of three mines that produced columbium concentrates as a primary product. The others were Distribuidora e Exportadora de Minerios e Adubos, S.A. (Dema) at its mine near Araxa, Brazil, and Norsk Bergverk A/s at its mine near Sove, Norway. However, the Sove mine, which commenced operations in 1953 and was the first operation selling pyrochlore concentrates, closed in September 1965. In all other columbium operations the concentrate is recovered as a by-product, usually of tin recovery operations. Nigeria, which once was the principal source of columbium concentrates, is the largest source of byproduct columbium; it is also a principal source of tantalum, which is not recovered in Canada.

St. Lawrence Columbium has expanded production each year since it began operations in 1961. During 1965 the average daily milling rate was increased from 1,050 to 1,120 tons with actual daily milling rates ranging from 900 to 1,300 tons depending on the grade and type of ore treated. The company reports that its sales in Canada increased from 3 per cent in 1964 to 4.6 in 1965; sales to the United States increased by 22 per cent from 1964 to 1965.

Masterloy Products Limited continued to be the only Canadian producer of ferrocolumbium. According to a company report, the demand for ferrocolumbium continued strong throughout the year and production in 1966 is expected to exceed 250 tons of ferrocolumbium on a 60-per-cent Cb basis.

*Mineral Resources Division

TABLE 1

Niobium (Columbium) and Tantalum Production,
Trade and Consumption, 1964-65

	1964		1965P	
	Pounds	$	Pounds	$
Production, shipments				
Columbium pentoxide (Cb_2O_5)	2,163,359	2,282,522	2,300,000	2,350,000
Imports[1] from United States				
Columbium and columbium alloys wrought and unwrought, waste and scrap	67	3,172	3	1,920
Tantalum and tantalum alloys, wrought and unwrought, waste and scrap	5,086	42,032	721	160,204
Tantalum and tantalum alloy powder	10,510	19,620	—	—
Exports[2] to United States				
Columbium ore and concentrates	1,940,133	921,428	1,860,631	958,244
Consumption by steel industry				
Ferrocolumbium and ferro-tantalum columbium (Cb and Ta-Cb content)	74,000		..	

Source: Dominion Bureau of Statistics.
[1] From U.S. Department of Commerce, *Exports of Domestic and Foreign Merchandise, Report FT 410*. Values in US currency. [2] From United States Department of Commerce *Imports of Merchandise for Consumption, Report FT 125*. Values in U.S. currency.
P Preliminary; — Nil; .. Not available.

CANADIAN OCCURRENCES

NORTHWEST TERRITORIES

There are many columbium-tantalum occurrences in the Yellowknife area of Great Slave Lake. The presence of columbite-tantalite has been noted in many pegmatite dikes in association with beryl, spodumene and amblygonite.

BRITISH COLUMBIA

The placer deposits on Bugaboo, Vowell, and Forster creeks, about 45 miles southeast of Golden, consist of columbium-bearing gravel. In 1956, Quebec Metallurgical Industries Ltd.*, at Billings Bridge, Ontario, processed gravity concentrates from these deposits to produce high purity columbium oxide, columbium alloys and columbium sponge. The project was discontinued as uneconomical.

*Name changed March 1963 to Q.M.I.Minerals Ltd.

MANITOBA

Small amounts of Ta_2O_5 are associated with the lithium-bearing pegmatites in the Bernic Lake area. The most significant occurrence at present is that of Chemalloy Minerals Limited. However, Ta_2O_5 would have to be recovered as a by-product of a cesium-lithium operation.

ONTARIO

The columbium-uranium deposits of Nova Beaucage Mines Limited are six miles west of North Bay in an area covering the Manitou Islands of Lake Nipissing. Estimates of tonnage and grade vary considerably but the reserves in the zone east of Newman Island, on which considerable exploration work has been conducted, are reported to amount to 2.7 million tons averaging 0.69 per cent Cb_2O_5 and 0.042 per cent uranium oxide (U_3O_8). In 1959 and 1960, investigations related to concentration of the company's pyrochlore were conducted at Kimberley, B.C., at the company's plant at North Bay, and at the Mines

Branch of the Department of Mines and Technical Surveys in Ottawa. The original financing of Nova Beaucage was provided by Inspiration Limited. In 1958, The Consolidated Mining and Smelting Company of Canada Limited (COMINCO) acquired controlling interest in the property and supplied funds for research and management through December 1960. At that time COMINCO decided not to exercise further stock options and the management agreement terminated.

Dominion Gulf Company has outlined two areas of columbium mineralization in Chewett township; one area contains an estimated 20 million tons of material averaging 0.5 to 0.8 per cent Cb_2O_5. Laboratory test-work was conducted in 1960 and 1961 to develop an economical recovery process but no action had been taken to the end of 1965 to bring the property into production. The Chewett ore has so far not proven to be amenable to beneficiation methods for recovery of pyrochlore concentrates. The company has developed two alternative recovery processes that lead directly to good-quality columbium pentachloride, with recoveries of about 90 per cent, that would then have to be reduced to columbium metal.

Trappe. Few outcrops are to be seen as the overburden varies from six to 100 feet in thickness and in places may be as much as 200 feet thick.

St. Lawrence Columbium and Metals Corporation has calculated that there are 62.7 million tons of indicated and proven pyrochlore ore containing 500 million pounds of Cb_2O_5 on the explored part of its property. This calculation concerns only ore containing, as a computed average, a minimum of eight pounds of Cb_2O_5 a ton or an average grade of 0.4 per cent Cb_2O_5. The company conducts an open-pit mining operation with a daily milling rate in 1965 of 1,120 tons a day. In 1965 the company initiated a $2-million program to convert from open-pit to underground mining. Shaft sinking to the 2,000-foot horizon commenced and development work is expected to be completed by the end of 1966. Underground mining is scheduled to commence early in 1967 on the 1,385-foot level at 4,000 tons a day. Ore reserves within a radius of 1,000 feet of the shaft have been calculated at 3.3 million tons grading 0.456 per cent Cb_2O_5, all above the 1,000-foot horizon. According to the company, the flexibility of the operations is such that increasing the mill capacity will present no problems.

TABLE 2
Production of Pyrochlore Concentrates by St. Lawrence Columbium and Metals Corporation, 1962–65
(pounds)

	1962	1963	1964	1965
Concentrates	1,839,319	2,941,303	4,150,388	4,541,745
Contained Cb_2O_5	971,624	1,521,701	2,163,135	2,333,967
Shipment of concentrates	1,909,433	2,692,935	4,222,424	4,510,182
Avg. % Cb_2O_5 in concentrates	52.82	51.76	52.1	51.4

Source: Company report.

QUEBEC

Large pyrochlore deposits near the town of Oka, 20 miles west of Montreal, are controlled by: Quebec Columbium Limited, jointly owned by Molybdenum Corporation of America and Kennecott Copper Corporation; Columbium Mining Products Ltd., jointly owned by Headway Red Lake Gold Mines, Limited, and Coulee Lead and Zinc Mines Limited; and St. Lawrence Columbium and Metals Corporation.

The mineral deposits associated with and contained in what is referred to as the Oka complex are about two miles east of Oka, at La

Columbium Mining Products Ltd. believes it has reserves amounting to 100 million tons assaying 0.3 per cent Cb_2O_5. In 1965 the company continued exploration and development work on its property and on improving its milling process. It also entered into negotiations with Continental Ore Corporation of New York, for the sale of 2.6 million pounds of Cb_2O_5 a year for 10 years after production commences. Senior financing is being arranged and the company hopes to be in production by the fall of 1968.

WORLD PRODUCTION

Non-Communist world production of columbium and tantalum concentrates in 1965 amounted to some 6,809 tons of which 6,374 were columbium concentrate (columbite or pyrochlore) and 435 were tantalum concentrate (tantalite).

Columbium is extracted commercially from the minerals columbite and pyrochlore; tantalum is extracted from the mineral tantalite. Tantalite and columbite have the theoretical compositions (FeMn)O.Ta_2O_5 and (FeMn)O.Cb_2O_5. They are seldom if ever found pure as tantalum and columbium replace one another in widely variable proportions between the theoretical limits. Concentrates from different sources show a range in content of tantalum pentoxide (Ta_2O_5) from 0.8 per cent to 82 per cent, and of columbium pentoxide (Cb_2O_5), from 3.5 per cent to 78 per cent. Combined contents of the two oxides in columbite-tantalite concentrates usually total about 80 per cent. Pyrochlore is essentially $(NaCa)_2\ Cb_2O_6F + ThO_2$ and rare-earth elements; Ta_2O_5 can replace Cb_2O_5 in pyrochlore but is seldom present in any appreciable amount.

The Araxa pyrochlore deposit in the State of Minas Gerais, Brazil, is thought to be the largest deposit so far discovered. It is very high grade, containing 3.5 per cent Cb_2O_5, and is known to contain many thousands of tons of columbium with estimates ranging as high as 2.9 million tons. The deposit is owned jointly by Brazilian interests, Molybdenum Corporation of America (Molycorp) and Pato Consolidated Gold Dredging Ltd., a subsidiary of International Mining Corp. Management of the Pato-Molycorp joint venture will be through Niobium Corp., New York, controlled one third by Pato and two thirds by Molycorp. In January 1965, International Mining Corp. bought 118,816 shares of Molybdenum Corporation of America from Kennecott Copper Corporation. Prior to 1964, production at the Araxa deposit was delayed by conditions imposed by the Brazilian government on the export of columbium concentrates.

Nigeria is the perennial leader in the production of columbium concentrates (columbite); in 1965 Brazil was the principal source of tantalum concentrate (tantalite) with Norway and the Republic of the Congo (Leopoldville) in second and third positions.

In Norway the Sove mine, in the Fen area, near Ulefoss, which is 72 miles southwest of Oslo, produced a 50-per-cent Cb_2O_5 concentrate. This concentrate, with a columbium-tantalum ratio ranging from 30 to 100:1 was shipped to the European market for use mainly in the manufacture of ferrocolumbium. As mentioned previously, this operation ceased in 1965 but mining rights to the deposit have been granted to two new companies who have agreed to combine their efforts in an attempt to work the deposit profitably. If they are successful they have agreed to commence production by mid-1967.

TABLE 3
Non-Communist World Production of Columbium-Tantalum Concentrates
(short tons)

	1964	1965^e
Nigeria	2,662	2,540
Canada	2,075	2,255
Brazil	89	1,419*
Republic of the Congo (Leopoldville)	54	124
Mozambique	100	115
Norway	205	138
Malaysia	63	100
Communist-bloc	. .	. .
Other countries	1,126	118
Total	6,374	6,809

Source: U.S. Bureau of Mines, *Minerals Yearbook 1964;* U.S. Bureau of Mines *Commodity Data Summaries,* January 1966; *London Metal Bulletin,* January 28, 1966, and company reports.

*Export licences granted.
^{e}Estimated; . . Not available.

CONSUMPTION AND USES

The United States is the largest consumer of columbium and tantalum with about 95 per cent of the columbium used to make ferrocolumbium or ferrotantalum-columbium. These are in turn used in the manufacture of alloy steels, stainless steels, high temperature alloys and carbon steels. According to the U.S. Bureau of Mines Mineral Industry Surveys — *Columbium and Tantalum in 1965,* Dec. 20, 1965, consumption of ferrocolumbium and ferro-tantalum-columbium was about 2.2 million pounds of contained Cb and Ta. Consumption of tantalum metal and alloys was in the order of 60,000 pounds, an increase of 30 per cent from 1964.

Production of ferrocolumbium in Europe in 1965 is estimated to have exceeded 3 million pounds of contained Cb of which 1.5 million pounds were produced in Britain, 600,000 pounds in Germany, 600,000 pounds in France and 400,000 pounds in Sweden.

There are limited applications for columbium in chemical plants and in the electronic industry; tantalum is preferred because of its superior electrical properties. Columbium is resistant to most acids at room temperature, including aqua regia, although it is attacked by hydrofluoric acid. For use in electrolytic capacitors columbium may be anodized to produce an oxide film of good dielectric properties but by far the largest use of columbium is as a minor alloying addition to various grades of steel and superalloys. Columbium reacts with carbon in steels to form columbium carbide, which affects grain refinement and enhances creep properties. In high-chromium steels, columbium prevents chromium carbide formation in the grain boundaries and thus improves resistance to intergranular corrosion, an effect which also causes welded joints to fail. For these applications, purity is not of primary importance. The columbium is usually added as ferrocolumbium.

The future of columbium alloys depends on whether certain properties can be obtained economically. The alloys have sufficient high-temperature strength for use in advanced jet engines but the problem of protecting them from oxidation remains. Research is proceeding with coatings of precious and other metals and with other coatings of ceramics and glasses. Until the development of the Oka deposit by St. Lawrence Columbium and Metals Corporation the major potential problem facing the columbium industry was that of supply. The commencement of operations by St. Lawrence, followed by the development of the Araxa deposit in Brazil, has provided an impetus for the development of its uses by the ever-inventive United States steel industry.

In Canada, the need is for ferrocolumbium and ferrotantalum-columbium. In 1964, about 36 tons of contained columbium and tantalum in steel addition agents were consumed by the Canadian iron and steel industry. Indications are that consumption will increase with its wider application in carbon steels to which columbium additions provide higher strengths. This could be important in the fabrication of skelp and plate for use in oil- and gas-transmission piping. Macro Division of Kennametal Inc., Port Coquitlam, BC, manufactures high-purity tantalum carbide, tantalum-columbium carbide, tantalum-columbium-titanium carbide and tantalum-columbium-tungsten carbide. These materials are further processed as fully prepared powders for the hard metals industry and are also sold as intermediate crystals and powders for use by other carbide manufacturers.

Union Carbide Canada Limited, Metals and Carbon Division; Metallurgical Products Company Limited; Masterloy Products Limited; and Metallurg (Canada) Ltd. are the principal Canadian suppliers of ferrocolumbium.

The more important Canadian consumers of columbium and tantalum products are: Atlas Steels Division of Rio Algom Mines Limited, Welland; The Algoma Steel Corporation, Limited, Sault Ste. Marie; Black Clawson-Kennedy Ltd., Owen Sound; Dominion Foundries and Steel, Limited, Hamilton; Canadian Westinghouse Company Limited, Hamilton, all in Ontario; and Crucible Steel of Canada Ltd., Sorel, Quebec.

PRICES

The following quotations are from *E & M J Metal and Mineral Markets* of December 27, 1965.

Columbium metal, 99½%, per lb			
Roundels	$36		
Rough ingots	50		
Tantalum metal, f.o.b. shipping point, per lb			
Powder	30 – 49		
Sheet	47 – 60		
Rod	52 – 65		
Ferrocolumbium, 50 – 60% Cb, max. 0.4% C, max. 8% Si, ton lots, lump (2 inches), packed, delivered, per lb contained Cb ...	3.17		
Columbite ore, 65% Cb_2O_5 f.o.b. shipping point, per lb		Spot	Long Term
Ratio 10 to 1		$ 1.25 – $ 1.15	0.80 – 0.90
Ratio 8½ to 1		1.00 – 1.05	0.75 – 0.80

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Columbium and tantalum ores and concentrates ...	free	free	free
Ferrocolumbium, ferrotantalum, ferrotantalum-columbium	free	5	5
Columbium metal or tantalum metal in pure form, in lumps, powder, blocks, ingots	free	15	25
Columbium metal or tantalum metal if in alloy form, in rods, sheet or any semi-process form	15	20	25

United States	(%)
Columbium and tantalum ores and concentrates	free
Columbium metal	
Unwrought, other than alloys; waste and scrap*	10
Unwrought, alloys	15
Wrought	18
Tantalum	
Unwrought, waste and scrap*	10
Wrought	18
Unwrought, alloys	15
Ferrocolumbium and ferrotantalum	10

*Duty on scrap suspended to June 30, 1967.

Petroleum

D.W. RUTLEDGE*

The sustained growth of the Canadian petroleum industry continued in 1965. Despite a slowdown in some sectors, such as pipeline construction, new records were set in other segments of the industry. Production of crude oil and natural gas liquids averaged 937,000 barrels a day, an all-time high. Exploration increased, encouraged by important oil discoveries in northern Alberta. Geophysical methods have reached a degree of refinement that permitted a more accurate interpretation of subsurface conditions. Oil reserves were increased satisfactorily, mainly from new pressure maintenance and secondary recovery projects. Experimental schemes to permit economic extraction of heavy oil were in progress and construction of facilities to extract synthetic crude from the Athabasca bituminous sands by late 1967 was proceeding as planned. Canadian crude oil producers supplied 59.2 per cent of the crude oil used at Canadian refineries in 1965. Although imports of crude oil did not increase appreciably, imports of refined petroleum products did. Exports of Canadian crude oil to the United States continued to increase, but at a considerably slower rate than in 1964.

PRODUCTION

Output of liquid hydrocarbons – crude oil plus natural gas liquids – achieved a record in 1965. Total production was 342 million barrels, equal to an average daily production of 937,000 barrels, 9.2 per cent more than in 1964. Gross production of crude oil averaged 812,000 barrels a day. Field and gas-plant production of natural gas liquids reached 125,000 barrels a day, comprising 77,000 barrels of pentanes plus and condensate, and 48,000 barrels of propane and butane.

In Alberta, liquid hydrocarbon production increased 9.3 per cent, or at a slightly greater rate than in 1964. Sharply increasing yields of natural gas liquids because of the thriving demand for natural gas, combined with strong demand for specific natural gas liquids such as propane have contributed greatly to the sustained growth of Alberta production. Increases in liquid hydrocarbon production amounted to 7.7 per cent in Saskatchewan, 16 per cent in British Columbia, 12 per cent in Manitoba, and 2.6 per cent in Ontario.

Each province provided approximately the same proportions of total Canadian liquid hydrocarbon production in 1965 as in 1964. Alberta output accounted for 67.5 per cent of total production, Saskatchewan 26 per cent, British Columbia 4.5 per cent, Manitoba 1.4 per cent, and Ontario, the Northwest Territories, and New Brunswick, together, 0.6 per cent. All provinces except Alberta were producing crude oil at near-capacity rates.

*Mineral Resources Division

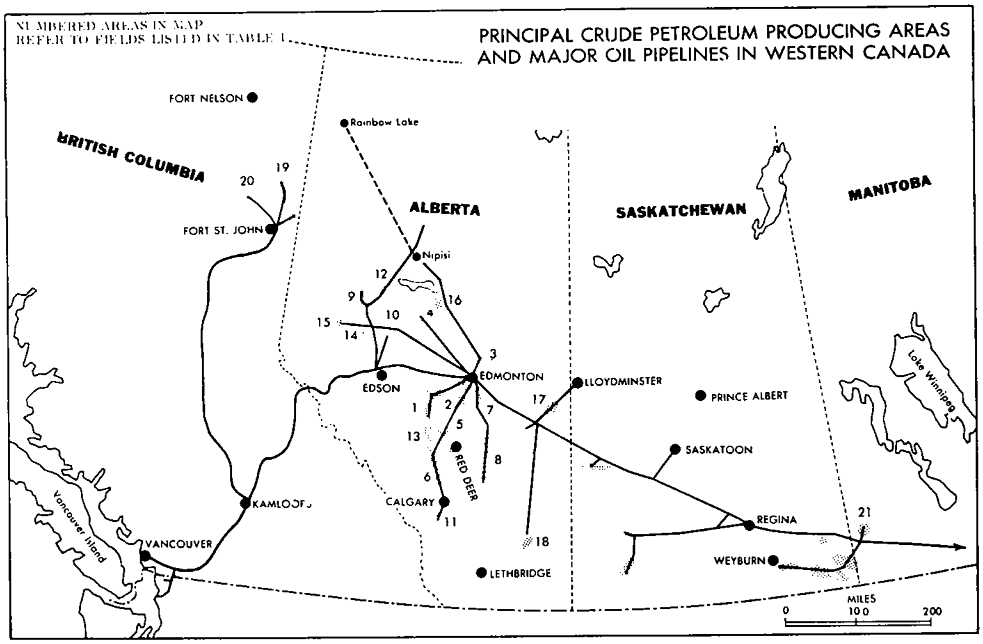


TABLE 1

Production of Crude Oil by Province and Field
(number in parentheses gives location of field on the accompanying map)

		1964		1965P	
		Barrels	Bbl/Day	Barrels	Bbl/Day
Alberta					
Pembina	(1)	40,607,165	110,949	38,714,572	106,067
Swan Hills[1]	(4)	16,056,458	43,870	17,575,549	48,152
Redwater	(3)	15,523,634	42,414	14,203,474	38,913
Leduc-Woodbend	(2)	11,530,595	31,504	9,365,185	25,658
Judy Creek	(4)	7,524,835	20,560	8,981,907	24,607
Golden Spike	(2)	3,074,138	8,399	8,226,887	22,539
Swan Hills South[1]	(4)	–	–	7,392,135	20,252
Bonnie Glen	(2)	6,752,175	18,449	6,320,983	17,317
Fenn-Big Valley	(8)	5,257,932	14,366	4,968,002	13,610
Virginia Hills	(4)	3,176,287	8,678	4,070,981	11,153
Wizard Lake	(2)	3,642,090	9,951	3,332,817	9,131
Sturgeon Lake South	(9)	2,812,349	7,684	3,065,919	8,399
Kaybob	(10)	2,712,038	7,410	2,972,566	8,144
Joarcam	(7)	2,899,322	7,921	2,737,142	7,499
Snipe Lake	(12)	1,872,210	5,115	2,539,781	6,958
Willesden Green	(1)	2,188,736	5,980	2,265,168	6,206
Joffre	(5)	3,613,941	9,874	2,215,808	6,070
Carson Creek North	(4)	1,383,894	3,781	2,207,218	6,047
Mitsue	(16)	34,744	95	2,200,386	6,028
Harmattan East	(6)	2,485,951	6,792	2,122,158	5,814
Acheson	(2)	2,207,308	6,031	2,061,706	5,648
Medicine River	(13)	1,543,689	4,218	1,810,697	4,960
Innisfail	(6)	2,706,995	7,397	1,766,305	4,839

Table 1 (cont.)

		1964		1965P	
		Barrels	Bbl/Day	Barrels	Bbl/Day
Alberta (cont.)					
Gilby	(5)	1,852,795	5,062	1,750,326	4,795
Kaybob South	(14)	1,405,266	3,840	1,705,216	4,672
Harmattan-Elkton	(6)	1,501,800	4,103	1,479,060	4,052
Garrington	(13)	1,504,495	4,111	1,455,723	3,988
Bantry	(18)	785,536	2,146	1,421,344	3,894
Westerose	(2)	1,481,448	4,048	1,396,429	3,826
Stettler	(8)	1,481,264	4,047	1,392,745	3,815
Wainwright	(17)	714,138	1,951	1,253,503	3,434
Crossfield	(6)	1,618,423	4,422	1,175,737	3,221
Turner Valley	(11)	1,195,970	3,268	1,078,982	2,956
Sundre	(6)	986,466	2,695	1,028,067	2,816
Simonette	(15)	892,235	2,438	1,004,008	2,750
Other fields and pools		20,415,267	5,578	21,039,535	5,764
Total		175,441,589	479,349	188,298,021	515,885
Total value		$450,186,921		$481,478,039	
Saskatchewan[2]					
Total unit and nonunit areas		81,404,430	222,416	87,775,205	240,480
Total value		$186,171,931		$200,741,894	
British Columbia					
Boundary Lake	(19)	5,911,797	16,152	5,335,522	14,618
Peejay	(19)	1,365,329	3,731	2,770,105	7,589
Milligan Creek	(19)	1,637,993	4,475	2,165,494	5,933
Blueberry	(20)	1,149,787	3,141	988,494	2,708
Other fields and pools		1,460,570	3,991	2,211,142	6,058
Total		11,525,476	31,490	13,470,757	36,906
Total value		$23,261,946		$27,126,064	
Manitoba					
North Virden-Scallion	(21)	1,583,226	4,326	2,056,552	5,634
Virden-Roselea	(21)	1,034,745	2,827	1,035,739	2,838
Other fields and pools		1,799,253	4,916	1,854,218	5,080
Total		4,417,224	12,069	4,946,509	13,552
Total value		$10,296,549		$11,530,312	
Ontario		1,246,682	3,406	1,279,321	3,505
Total value		$ 4,014,316		$ 4,119,413	
Northwest Territories		586,296[3]	1,602	644,998[3]	1,767
Total value		$ 438,549		$ 482,458	
New Brunswick		4,688	13	4,103	11
Total value		$ 6,516		$ 5,703	
Total, Canada		274,626,385	750,345	296,418,914	812,106
Total value		$674,376,728		$725,483,884	

Sources: Dominion Bureau of Statistics and provincial government reports.

[1]In 1965 the northern pool of Swan Hills and Deer Mountain were combined as Swan Hills field; the southern pool of Swan Hills was designated the Swan Hills South field. [2]Saskatchewan Government reports now list production by formations within unit and nonunit areas rather than by field. [3]Excludes base stock reinjected into the reservoir.

PPreliminary.

TABLE 2

Production of Natural Gas Liquids by Province

	1964		1965P	
	Barrels	Bbl/Day	Barrels	Bbl/Day
Alberta				
Propane	6,724,314	18,372	9,336,792	25,580
Butane	4,828,093	13,192	6,141,445	16,826
Pentanes plus	23,298,914	63,658	26,085,824	71,468
Condensate	742,169	2,028	546,418	1,497
Other natural gas liquids	—	—	344,333	943
Total	35,593,490	97,250	42,454,812	116,314
Saskatchewan				
Propane	646,003	1,765	675,688	1,851
Butane	367,036	1,003	338,398	927
Pentanes plus	285,624	780	252,736	692
Total	1,298,663	3,548	1,266,822	3,470
British Columbia				
Propane	244,804r	669	358,776	983
Butane	461,759r	1,262	477,990	1,310
Pentanes plus	922,211r	2,519	947,429	2,596
Condensate	26,367	72	31,782	87
Total	1,655,141r	4,522	1,815,977	4,976
Canada				
Propane	7,615,121r	20,806	10,371,256	28,414
Butane	5,656,888r	15,456	6,957,833	19,063
Pentanes plus	24,506,749r	66,958	27,285,989	74,756
Condensate	768,536	2,100	578,200	1,584
Other natural gas liquids	—	—	344,333	943
Total	38,547,294r	105,320	45,537,611	124,760
Returned to formation	1,227,332	3,353	577,307	1,581
Total net production	37,319,962r	101,967	44,960,304	123,179

Source: Provincial government reports.
pPreliminary; rRevised.

In Alberta, although crude oil production increased significantly output from many of the older fields decreased. In some cases this was because of declining capability but more commonly, the increasing number of new areas coming into production under provincial prorationing took more of the available market from existing fields. Crude oil production from the Pembina field, the largest producer, decreased from 111,000 to 106,000 barrels a day. Continued peripheral expansion of the Swan Hills field contributed to the production increase there. Water injection also aided in increasing production in some fields, especially in Saskatchewan.

The Alberta Oil and Gas Conservation Board estimated that the year-end daily crude-oil output capacity of the province was 1.35 million barrels, which means that only about 40 per cent of the capability was utilized during the year. The gradual implementation of the new proration plan is now transferring a greater share of production to pools with high reserves per acre. The new system will be especially beneficial to producers at the recently discovered Rainbow Lake oil pools where reserves per acre are extremely large.

TABLE 3

Value of Natural Gas Liquids by Province
($ thousands)

	1964	1965p
Alberta*	73,338	86,852
Saskatchewan	2,273	2,270
British Columbia	3,078	3,425
Total, Canada	78,689	92,547
Volume (thousand bbl)	35,876	43,862

Source: Dominion Bureau of Statistics.

*The Alberta Oil and Gas Conservation Board shows a breakdown of natural gas liquid sales for Alberta as follows:

	1964	1965p
	($ thousands)	
Propane	5,901	10,771
Butane	5,938	7,183
Pentanes plus	60,209	67,366

Because of the few plants in operation in British Columbia and Saskatchewan it is not possible to divulge the volumes of natural gas liquids entering marketing channels in these provinces. However, the value of production of condensates and pentanes plus and the value of sales of propane and butane is shown in Table 3 as totals of all natural gas liquids by province. The total volume is also shown.

pPreliminary.

RESERVES

At the end of 1965 Canada's recoverable reserves of liquid hydrocarbons amounted to 7.7 billion barrels, according to the estimates of the Canadian Petroleum Association. This represents a 22.6-year supply at the 1965 rate of production, and a 9-per-cent increase in reserves from 1964 year-end total. The growth of reserves would have been much greater had the new Rainbow Lake oil occurrences been taken into account. The relative sparseness of wells and the confidential nature of much of the drilling data permitted only relatively minor volumes of oil to be attributed to the Rainbow discoveries. In 1966, reserves of several hundred million barrels will likely be accorded the Rainbow Lake pools.

The Alberta Oil and Gas Conservation Board estimated the province's remaining recoverable reserves of crude oil at 6.08 billion barrels, and natural gas liquids at 1.26 billion barrels. The three largest oil fields are the same as in the previous year: Pembina, Swan Hills, and Redwater. Most of the province's increase in reserves was attributed to reserve appreciation in previously discovered pools, notably the Mitsue Gilwood, Fenn-Big

TABLE 4

Crude Oil – Production, Trade and Refinery Receipts, 1955–65
(barrels)

	Production[1]	Imports[2]	Exports[2]	Refinery Receipts[3] Domestic	Refinery Receipts[3] Imported[4]	Refinery Receipts[3] Total
1955	129,440,247	86,678,057	14,833,971	105,050,563	86,751,128	191,801,691
1956	171,981,413	106,469,685	42,908,086	125,592,074	106,305,532	231,897,606
1957	181,848,004	111,905,371	55,674,228	126,914,237	111,905,372	238,819,609
1958	165,496,196	104,038,800	31,679,429	134,513,998	107,444,741	241,958,739
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	199,456,553	143,946,481	343,403,034
1965p	296,418,914	144,184,281	108,010,297	208,838,613	144,000,656	352,839,269

Source: Dominion Bureau of Statistics.

[1]Crude Petroleum and Natural Gas Production (DBS). Alberta field condensate is excluded from the statistics for 1960, 1961 and 1962. [2]Trade of Canada (DBS). [3]Receipts at refineries are reported in Refined Petroleum Products (DBS). Refinery receipts include condensate and pentanes plus. [4]Imported includes some partly processed crude.

pPreliminary.

Valley D-2A, Golden Spike D-3A, and Snipe Lake Beaverhill Lake. Among 1965 discoveries, the Nipisi Gilwood pool contributed the largest addition to reserves. Enhanced recovery methods are not yet in use in the Mitsue and Nipisi fields and hence estimated recovery of oil in place is still a conservative 20 per cent. A 25-per-cent increase in recoverable reserves was assigned to Alberta's heavy-oil producing regions of Lloydminster-Wainwright and Bantry-Taber although reserves in these sectors constitute a comparatively minor portion of the over-all total. Oil in the Athabasca sands and other bituminous sands of northern Alberta are not included in published reserves, but in 1963 the Conservation Board estimated that 300 billion barrels of upgraded synthetic crude oil could eventually be recovered from the 700 billion barrels in place.

The Board's estimate of 1.26 billion barrels of recoverable reserves of natural gas liquids breaks down into 53.3 per cent pentanes plus, 28.2 per cent propane, and 18.5 per cent butane. Greatest reserves of natural gas liquids in presently producing fields are in the Harmattan, Westerose South, Pembina, and Swan Hills areas. The largest newly-discovered gas liquids reserves are in the Gold Creek Wabamun pool.

TABLE 5

Reserves of Crude Oil

Province or Region	At End of 1965 (thousand barrels)	Per Cent of Total 1964	Per Cent of Total 1965	Net Change Since 1964 (thousand barrels)
Alberta	5,719,683	85.4	85.2	+440,537
Saskatchewan	661,672	9.8	9.9	+ 59,320
British Columbia	231,822	3.3	3.5	+ 27,782
Northwest Territories	47,900	0.8	0.7	− 1,264
Manitoba	41,071	0.5	0.6	+ 7,434
Eastern Canada	9,089	0.2	0.1	− 218
Total	6,711,237	100.0	100.0	+533,591

Source: Canadian Petroleum Association.

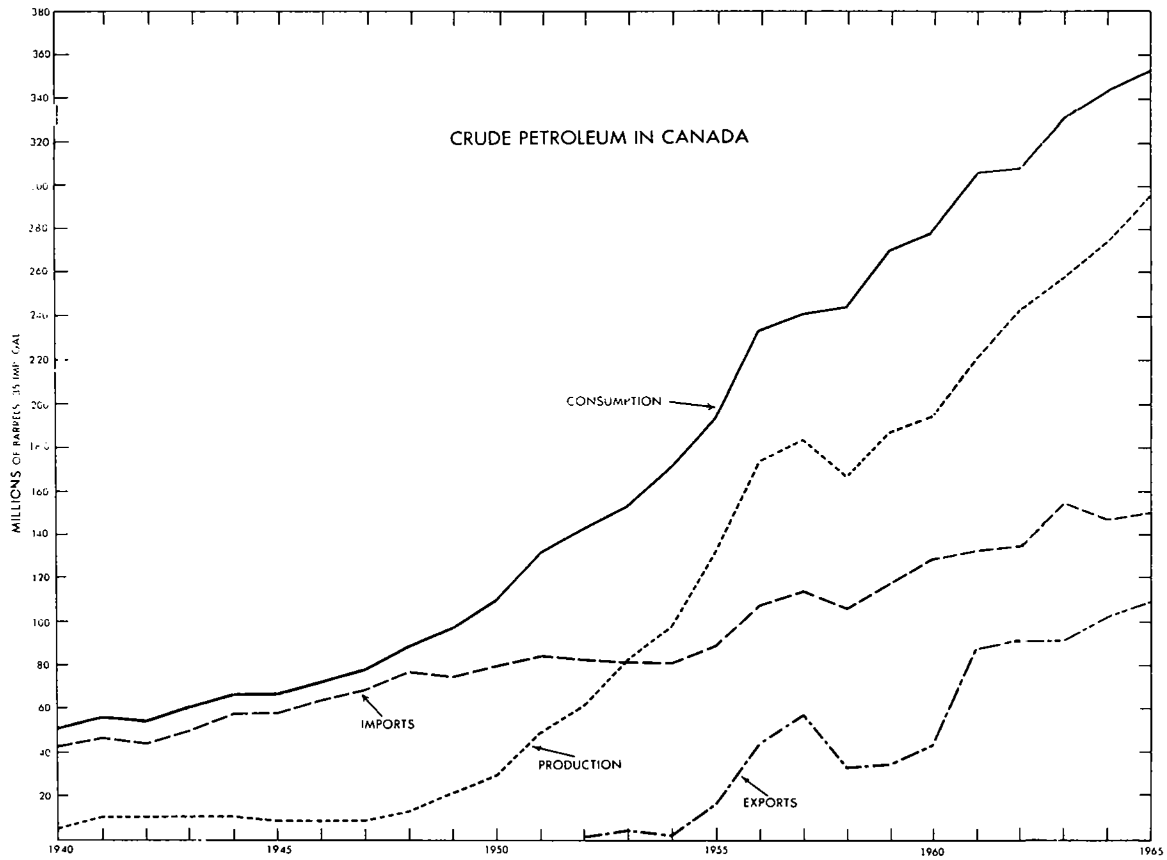
TABLE 6

Reserves of Liquid Hydrocarbons at End of 1965

	Natural Gas Liquids (thousand barrels)	Crude Oil Plus Natural Gas Liquids (thousand barrels)	Per Cent of Total
Alberta	952,204	6,671,887	86.5
Saskatchewan	8,124	669,796	8.7
British Columbia	38,511	270,333	3.5
Other areas	–	98,060	1.3
Total	998,839	7,710,076	100.0

Source: Canadian Petroleum Association.

– Nil.



EXPLORATION AND DEVELOPMENT

ALBERTA

A total of 10.2 million feet were drilled in Alberta in 1965, slightly less than the 10.3 million-foot record in 1964. The number of wells drilled increased from 1,831 to 1,956, indicating a shallower average depth of well. Exploration drilling increased substantially for the second consecutive year, and constituted 44 per cent of the total footage drilled compared with 37 per cent in 1964.

The discovery of oil in February at Rainbow Lake in the far northwestern corner of Alberta was the highlight of 1965 in the exploration sector of the Canadian oil industry. Subsequent drilling indicated that the Rainbow Lake area will rank in importance with the Leduc, Redwater, Pembina, and Swan Hills oil-producing regions. Banff Oil Ltd., Aquitaine Company of Canada Ltd. and Socony Mobil Oil of Canada, Ltd. were the participants in the discovery well, Banff Aquit Rainbow West 7-32-109-8W6. The productive capability of this well is around several thousand barrels a day. The main oil and gas reservoir, an exceptionally porous Middle Devonian (Keg River) dolomite reef, has a maximum thickness exceeding 600 feet. This pool is overlain by a much thinner but highly productive oil zone and two separate gas zones. Additional drilling has found at least six more oil discoveries and several gas discoveries within a 15-mile radius of the discovery well. Although individual Keg River pools appear to be of relatively limited areal extent, reserves per acre are the greatest ever found in Alberta. Thus the Rainbow discovery has come at a propitious time for participating companies, in view of the present conversion of the Alberta proration system to a plan that assigns much greater production than previously to pools with high reserves per unit of area.

In the Lesser Slave Lake region, the Devonian Gilwood sandstone 'play' which began with the Mitsue find in 1964 resulted in discovery of another important Gilwood oil reservoir in 1965, 40 miles northwest of Mitsue. The Nipisi field was found in January by three separate wells being drilled simultaneously: Hamilton Uno-Tex E Utikuma 8-13-79-8W5, Mobil Nipisi 7-6-79-7W5, and Texaco Texcan Nipisi 10-2-79-8W5. Despite its isolated location, the Nipisi field was connected to markets by two competitive oil pipelines within three months of discovery. The excellent productivity of the reservoir led oil companies to pay very large sums for oil rights. Rights of over a million dollars for land blocks were common, and nearly $40 million paid for petroleum rights at Nipisi in the year following the discovery. In the same period, some 40 Gilwood oil wells were completed in the Nipisi area.

Although there were no other oil discoveries in 1965 comparable in importance to the Rainbow Lake and Nipisi finds, several other areas of exploratory activity are of interest. One of the better oil discoveries in southern Alberta was Shell Cdn-Sup Olds 10-15-32-2W5. This well obtained oil production from the Devonian Wabamun formation immediately to the west of the Olds sour gas field, which also produces from the Wabamun. Several follow-up oil wells were completed.

Recent drilling in or near the Alberta Foothills has been more noteworthy for discoveries of wet gas, condensate, and sulphur (hydrogen sulphide) than for important oil discoveries. The large Devonian gas reserves indicated by four wells at Gold Creek, 25 miles southeast of Grande Prairie, carry important quantities of condensate—about 150 barrels per million cubic feet. Condensate discoveries also were made at Brazeau River, 26 miles southeast of the Edson gas field. HB Braz R 10-2-46-14W5 produced both gas and light oil from the Mississippian Shunda formation, and gas and condensate from the Elkton formation at a depth of about 10,400 feet. Fifty miles to the southeast, in the Crimson Lake region just north of the Ferrier oil field, a new area of Cardium and Viking oil production was established west of the main producing Cardium trend. Large sums of money were spent on land acquisition in the Crimson Lake area, but the importance of the new finds is not yet clear.

TABLE 7

Wells Drilled

	Oil		Gas		Dry		Service		Total	
	1964	1965	1964	1965	1964	1965	1964	1965	1964	1965
Alberta	912	877	243	220	667	856	9	3	1,831	1,956
Saskatchewan	628	697	27	57	529	519	11	11	1,195	1,284
British Columbia	42	113	35	41	61	93	2	2	140	249
Manitoba	72	26	—	—	34	38	1	—	107	64
Yukon and Northwest Territories	—	1	3	2	15	15	—	—	18	18
Total, Western Canada	1,654	1,714	308	320	1,306	1,521	23	16	3,291	3,571
Ontario	33	23	55	68	128	97	45	16	261	204
Quebec	—	—	—	—	10	2	—	—	10	2
Atlantic Provinces	—	1	—	—	1	2	—	—	1	3
Total, Eastern Canada	33	24	55	68	139	101	45	16	272	209
Total, Canada	1,687	1,738	363	388	1,445	1,622	68	32	3,563	3,780

Source: Canadian Petroleum Association.

TABLE 8

Oil Wells in Western Canada at End of Year

	Producing Wells		Wells Capable of Production	
	1964	1965	1964	1965
Alberta	9,613	8,736	12,114	12,771
Saskatchewan	4,837	5,384	5,640	6,192
Manitoba	745	748	892	889
British Columbia	310	412	401	497
Northwest Territories	31	31	60	60
Total	15,536	15,311	19,107	20,409

Sources: Provincial government reports and Department of Northern Affairs and National Resources.

Sharp reductions in tariffs on the Red Earth pipeline in 1965 encouraged exploration in the general region traversed by the pipeline. An oil discovery was made midway between the Red Earth and Utikuma Lake fields in Chevron Suptst Dome Loon S 4-16-85-9W5. This well is on production from an unspecified horizon, and other drilling is progressing in the same vicinity.

Oil exploration activity in northwestern Montana in the lower Cretaceous Moulton sand horizon extended into the Red Coulee district of southern Alberta. Production from some of the Montana wells was initially very prolific. Follow-up drilling in Alberta resulted in several oil wells adjacent to the eastern and western perimeters of the original Red Coulee pool.

Development drilling in Alberta made up 56 per cent of the total 10.2 million feet drilled in the province, but this was a substantial decline from the 63 per cent in 1964. A reduction in development was anticipated in view of the restricted output from developed fields. Except for the Nipisi field, the principal areas of development drilling were largely the same as in 1964. The Mitsue field was one of the two most actively developed fields. The completion of 139 oil wells increased the number of wells capable of production in the field to 153. Nearly a decade after its discovery, the Swan Hills field was still being enlarged. The productive tract was extended farther to the north and east, and the Deer Mountain field was incorporated into the Swan Hills field. Evidence of two reservoirs led to the separation of the Swan Hills field into two fields, Swan Hills and Swan Hills South. A total of 141 wells was added to these two fields. Expansion of the vast Pembina Cardium pool continued, but on a noticeably smaller scale. New Cardium wells were drilled mainly at the northwestern extremity of the field. More than half of the 93 wells added to the Pembina field were drilled in erratically distributed, but highly productive, Upper Cretaceous Belly River pools in the eastern sector.

Rapid development of the heavy-oil region in southeastern Alberta continued. Main development was in the Taber South and Taber fields where 50 oil wells were drilled. The Bantry and Jenner fields were also important centres of development in southeastern Alberta. Other main areas of oil field development were the Lloydminster, Clive, Medicine River and Utikuma Lake fields. The Alberta Oil and Gas Conservation Board designated a number of new or expanding producing areas as oil fields. These include Auburndale, Alderson East, Carrot Creek, Ethel, Jenner, Freeman, Giroux Lake, Leafland North, Lochend, Nipisi, Sunset, Three Hills, and Wintering Hills.

Installation of pressure maintenance or secondary recovery facilities played an important part in the development of new oil reserves. Few new projects were started, but expansion of established projects was continued. Forty-seven water injection wells were added in the Pembina Cardium pool to bring the total to 1,076. Waterflood facilities were increased in the Swan Hills, Crossfield Cardium, Willesden Green, Garrington, Joarcam, Leafland, Snipe Lake, and Turner Valley fields. Water injection programs were started in the Bigoray, Edson Cardium and Judy Creek South fields. Alberta had a total of 1,432 water injection wells and 119 gas and LPG injection wells at year's end.

Experimental oil recovery projects in the Lloydminster and Cold Lake heavy-oil regions were continued, and new test programs were initiated. At Lloydminster, Husky Oil Canada Ltd. carried out an experimental waterflood project utilizing water treated with a polymer to increase the viscosity of the water. The company continues to experiment with steam injection at Lloydminster, and Kodiak Petroleums Ltd. started steam injection tests in the same area. At Cold Lake, where there are hundreds of millions of barrels of viscous (10° API) crude, Triad Oil Co. Ltd. commenced a steam injection test project. Great Plains Development Company of Canada, Ltd. and associates started experimental steam stimulation and Imperial Oil Limited continued its Cold Lake steam recovery tests.

Installation of Great Canadian Oil Sands Limited's 45,000-barrel-a-day plant to extract synthetic crude from the Athabasca bituminous sands was proceeding on schedule. The estimated cost of the project is $230 million. Nearly 2,000 men were employed on construction, and commercial production is scheduled to begin in the fall of 1967. Several other companies continued testing various methods of recovering oil from the sands.

SASKATCHEWAN

Under the impetus of a continuing strong demand for Saskatchewan crude oil, drilling increased for the third successive year. A total of 4.56 million feet was drilled, an increase of 8.7 per cent from 1964. Of the total, 36 per cent was exploratory drilling. Despite the resurgence of exploratory activity, drilling failed to find any oil occurrences with sufficient promise to be classed as major. Several discoveries, however, located medium-sized oil pools with very satisfactory production rates. The Innes, Flat Lake, and Lake Alma oil discoveries in the southeastern sector are considered to be among the best finds of the year. The Innes pool was discovered in June, 2 miles north of the Midale field. Production comes from Mississippian Frobisher beds. The discovery well was drilled in LSD 1-36-7-11W2 by Michigan Wisconsin Pipe Line Company, United Canso Oil & Gas Ltd., and Tenneco Oil & Minerals, Ltd. Some 20 oil wells were completed by the end of the year, and further extension of the field is possible. Many of the wells are capable of producing 150 barrels daily at controlled flow rates.

The Flat Lake field, located on the International Boundary 30 miles southwest of the Weyburn field, was actually discovered in 1964 in neighbouring northeastern Montana. In 1965, the drilling of CDR-Scurry W Ratcliffe 4-4-1-16W2 extended the productive zone of the Mississippian Ratcliffe beds into Saskatchewan. Thirteen additional wells, all oil producers, were completed on the Canadian side of the boundary by the year's end. Net pay of from 15 to 25 feet can produce at daily rates of about 135 barrels per well. Central-Del Rio Oils Limited and Scurry-Rainbow Oil Limited, the main participants in the Flat Lake development, also discovered an oil pool of excellent productivity in LSD 2-29-1-17W2, seven miles northwest of Flat Lake. This Lake Alma pool, as it is known, lies in the deeper Oungre zone of the Ratcliffe beds. Three more oil wells and one dry hole were completed. Saskatchewan's only oil well producing from pre-Devonian formations lies midway between the Flat Lake and Lake Alma occurrences. Discovered in 1963, this Ordovician well was not particularly productive until recently when stimulation considerably increased the rate of output. Appreciable success in finding Devonian and Ordovician oil in adjacent states continues to enhance the possibilities of locating 'deep oil' in the Canadian part of the Williston Basin.

One significant oil discovery was made in southwestern Saskatchewan along the Fosterton-Dollard trend. Co-op Whitehall Illerbrun 9-6-12-17W3 intersected a new oil pool in Jurassic Upper Shaunavon sand 9 miles southeast of the Gull Lake field. Four more oil wells and several dry holes have partly delineated a reservoir which appears to be of relatively limited extent.

Development drilling in Saskatchewan consisted mainly of peripheral expansion of existing fields and extension of the aforementioned discoveries. Besides these discoveries, the principal development sectors in southeastern Saskatchewan were the Arcola pool 20 miles north of the Steelman field, and the Handsworth area 2 miles northeast of the Lost Horse Hills field. Development in southwestern Saskatchewan was mainly near the the north end of the productive trend, especially in the South Cantuar, Delta and Suffield pools. In the Coleville region, development consisted mainly of minor extensions at the east end of the Dodsland field. Near Lloydminster, considerable development drilling was carried out in the Aberfeldy and Lone Rock fields.

At the end of 1965, there were 48 waterflood projects in operation in Saskatchewan. These ranged from single-well injection pilot floods to the huge central-injection project in the Weyburn field. The Weyburn waterflood was expanded to encompass 634 wells of which nearly one-quarter were water injectors. In the Battrum heavy-oil field near Swift Current, Socony Mobil Oil of Canada, Ltd. began two types of thermal recovery experiments – steam injection and fireflood. Thermal recovery tests were also in progress in the Lloydminster district.

BRITISH COLUMBIA

Aggregate footage drilled in British Columbia was 1.08 million feet compared to 0.66 million feet in 1964. Exploratory drilling was confined mainly to two sectors: near the Triassic oil fields of Peejay and Wildmint, and northeast of Fort Nelson in the region of Devonian gas-bearing reefs. Results of drilling in the Triassic oil region were reasonably successful but no oil was discovered in the Fort Nelson region. The Nancy oil discovery of 1964 emphasized that profitable oil occurrences in the Triassic sands are not confined to the narrow chain of established fields of the Peejay-Beatton River trend. Excellent production was discovered in 1965 in the Weasel area several miles northwest of Nancy, and 3 miles west of the Wildmint field. High bids at land sales and rapid development of the new pool followed the discovery. Some 20 oil wells were drilled in the Weasel area during the year. A series of Triassic Halfway oil discoveries were made east and southeast of the Peejay field.

Development drilling centred mainly in the Peejay and Wildmint fields. The number of oil wells in the province capable of production was increased from 404 to 497. Waterflood projects were in operation in five British Columbia oil fields. Boundary Lake, Milligan Creek, Peejay, Beatton River and Beatton River West. Only the Boundary Lake operation was expanded appreciably in 1965. The number of water injection wells in that field was doubled to a total of 50.

Shell Canada Limited continued its marine seismic surveys offshore of mainland British Columbia preparatory to drilling in 1966, when a new semisubmersible drilling platform is to be delivered.

MANITOBA

The sharp revival in drilling activity that had occurred in 1963–64 came to an end and drilling declined substantially in 1965. Total exploratory and development drilling declined by 33 per cent to 164,500 feet, and the number of wells decreased by 40 per cent. However, there appears to be some revival of interest in Manitoba's oil potential since the discovery of oil at Rainbow Lake in northwestern Alberta. Middle Devonian Winnipegosis reefs of Manitoba and Saskatchewan represent a southeastward continuation of the Keg River reefs of the Rainbow Lake region. Previous exploration of the reef-bearing formation extending from the Northwest Territories to North Dakota has been relatively limited, but a reassessment of its petroleum possibilities is now in progress. One of the major factors that has restrained exploration in Manitoba is the complex land picture. A high proportion of freehold land and the closely checkerboarded division of petroleum rights inhibit exploration by making it difficult for oil companies to assemble acceptably large land blocks.

Several small new areas of commercial oil production were established during the year. One of these was discovered in Mississippian Alida beds 3 miles northeast of the Pierson field, the discovery well was KR et al. 13-17-3-28W1. Three successful follow-up wells were drilled. A new productive zone was outlined by eight wells drilled 2 miles west of the Daly field. In older fields, development drilling was confined mainly to the Routledge field.

YUKON AND NORTHWEST TERRITORIES

Drilling continued at about the same pace as in 1964. Footage totalled 119,600 feet, slightly more than in the previous year. Eighteen wells were drilled, the same number as in 1964. A well drilled in the Eagle Plains of the northern Yukon Territory by Socony Mobil Oil of Canada, Ltd., found oil in Permo-Pennsylvanian strata. Socony has now completed its costly, three-year exploration program in the northern Yukon during which 10 wells were drilled. Oil and gas were found, but not in sufficiently large quantities to encourage further work at the present time, particularly since the company's efforts have become directed towards its well-located land holdings at Rainbow Lake. On the Mackenzie River delta, the group of Shell Oil Limited, The British American Oil Company Limited, and Imperial Oil Limited drilled a well in which a showing of Upper Cretaceous gas was obtained. This is the most northerly well yet drilled on the mainland of the territories.

EASTERN CANADA

In Ontario, a sharp decrease of both exploratory and development drilling resulted in an over-all decrease from 1964 of 28 per cent in footage drilled. Aggregate footage was 350,900 feet. The 204 wells completed included 23 oil wells, only three of which were in the exploratory category. Two of these were Cambrian producers, and one was Silurian. One of the Cambrian wells, IOE et al. Dunwich 2-22 was an extension of the Willey pool discovered in 1964. Production, after treatment, was good, but further drilling is needed to assess the extent of reserves. In the development category, 10 oil wells were Silurian, seven were Cambrian, and three were Devonian.

Exploratory work continued in the Hudson Bay Lowlands and the adjoining offshore region. Oil company holdings remained essentially unchanged at 55.8 million acres. Richfield Oil Corporation held 50 million offshore acres under federal exploration permits. Magnetometer survey interpretations suggest as much as 5,000 feet of post-Precambrian sedimentary strata may exist near the central part of the bay, and hence the keen interest in petroleum possibilities. Industry and government surveys increased substantially in 1965. The work consisted of airborne magnetometer, and conventional marine seismic and gas exploder seismic surveys. Geological work included inspection of bottom sediments by divers.

Intensive exploration of the east
also carried out and land holdings were nearly doubled to 114 million acres. Much of the Gulf of St. Lawrence was taken up under new permits. Some companies hold both federal and provincial government exploratory permits in areas of disputed jurisdiction. On Pan American Petroleum Corporation's 31-million-acre block on the Grand Banks of Newfoundland, Pan Am and Imperial Oil jointly carried out marine seismic surveys, drilled 24 core-hole tests, and conducted gas detection tests of seawater. Socony Mobil Oil of Canada, Ltd. drilled five core holes near Sable Island.

In Quebec, two exploratory wells were drilled compared with 10 in 1964. Total footage of the two wells, both drilled on Anticosti Island, was just under 12,000 feet. Minor shows of gas were reported.

On the west coast of Newfoundland two dry wells totalling 4,917 feet were drilled on the Port au Port peninsula by Golden Eagle Oil and Gas Limited and British Newfoundland Exploration Limited. At Parsons Pond, where oil seeps have long been known, the Jubilee-NALCO group commenced drilling a well which was reported to have encountered several oil and gas shows in the first 2,500 feet.

In New Brunswick, an oil development well was drilled in the Stony Creek field.

TRANSPORTATION

New oil pipeline construction in 1965 was on a reduced scale compared with most years of the past decade. The laying of between 300 and 400 miles of new pipeline brought the operational mileage of oil pipelines within Canada to approximately 12,100 miles. The systems in Canada are predominantly crude oil lines, but some pipelines are for natural gas liquids or petroleum products.

TABLE 9

Mileage in Canada of Pipelines for Crude Oil, Natural Gas Liquids and Products

Year-end	Miles	Year-end	Miles
1954	4,656	1960	8,435
1955	5,079	1961	9,554
1956	6,051	1962	10,037
1957	6,873	1963	10,607
1958	7,148	1964	11,744
1959	7,945	1965P	12,084

Source: Dominion Bureau of Statistics.
PPreliminary.

TABLE 10

Deliveries of Crude Oil
(millions of barrels)

Company and Destination	1964	1965
Interprovincial Pipe Line		
Western Canada	33.1	38.7
United States	46.9	52.5
Ontario	104.5	112.5
Total	184.5	203.7
Trans Mountain Oil Pipe Line		
British Columbia	26.4	25.7
State of Washington	53.3	54.0
Total	79.7	79.7

Source: Company annual reports.

The two largest pipeline construction jobs were carried out by Interprovincial Pipe Line Company and Montreal Pipe Line Company Limited. Interprovincial's capital expenditures totalled $11 million. The company continued looping the main system by adding 49 miles of 34-inch line in Saskatchewan, and 23 miles in the U.S. section of the system. This brought the length of the third line between Regina, Sask. and Superior, Wisc. to 329 miles. Maximum rated daily capacity of the system is 575,000 barrels in the section between Cromer and Gretna, Manitoba. Montreal Pipe Line Company Limited completed a 24-inch loop beside the existing 18- and 12-inch crude oil lines between Montreal and Portland, Maine. Sixty-three miles of the new line were laid in Quebec. Present capacity of the expanded system is 356,000 barrels a day.

In Alberta, pipeline construction in 1965 consisted mainly of tying in important new northern oil fields. Mitsue Pipeline Ltd. completed laying its system from Redwater to Lesser Slave Lake. The 110-mile Mitsue line consists mainly of 10-inch pipe, but with 8-inch line through the Mitsue field. Nipisi Pipeline Ltd. laid 45 miles of 8-inch extension from the Mitsue line to the newly-discovered Nipisi field, at Utikuma Lake. A competitive 35-mile line of 8-inch diameter was constructed by Peace River Oil Pipe Line Co. Ltd. from the Red Earth-Snipe Lake system to the Nipisi field. Peace River also tied in the new fields of Sunset, Giroux Lake, and Calais with short laterals, and purchased the Windfall-Edson condensate line from Hudson's Bay Oil and Gas Company Limited. The capacity of Peace River's Fox Creek to Edmonton crude oil line is presently being expanded from 60,000 to 80,000 barrels a day.

TABLE 11

Crude Oil Refining Capacity By Regions

	1964		1965	
	Bbl/Day	%	Bbl/Day	%
Atlantic Provinces	125,500	11.9	125,500	11.6
Quebec	318,700	30.3	328,700	30.3
Ontario	306,900	29.2	322,400	29.8
Prairies and Northwest Territories	199,910	19.0	206,150	19.0
British Columbia	101,500	9.6	100,400	9.3
Total	1,052,510	100.0	1,083,150	100.0

Source: Department of Mines and Technical Surveys, *Petroleum Refineries in Canada* (Operators List 5) January 1966.

TABLE 12

Crude Oil Received at Canadian Refineries, 1965p
(barrels)

Location of Refineries	Country of Origin: Canada	Middle East	Trinidad	Venezuela	Total Received
Atlantic Provinces	4,335	15,091,676	—	22,678,228	37,774,239
Quebec	—	38,382,744	4,358,183	62,836,934	105,577,861
Ontario	109,356,595	—	—	652,891	110,009,486
Prairies	69,101,604	—	—	—	69,101,604
British Columbia	29,710,523	—	—	—	29,710,523
Northwest and Yukon Territories	665,556	—	—	—	665,556
Total	208,838,613	53,474,420	4,358,183	86,168,053	352,839,269

Source: Dominion Bureau of Statistics, *Refined Petroleum Products* monthly reports 1965.
pPreliminary; — Nil.

By the end of 1965, preliminary construction was in progress on the Rainbow Lake pipeline. This system will consist of 240 miles of 20-inch pipe extending northwestward from Utikuma Lake to the Rainbow Lake oil field. Construction also commenced on the 266-mile pipeline that will transport 'synthetic crude' from the Great Canadian Oil Sands Limited's Athabasca project to Edmonton. Fifty-seven miles at the southern end of the system was completed by December; completion of the pipeline is scheduled for the spring of 1966.

The looping of Husky Pipeline Ltd.'s Lloydminster to Hardisty system reflects the rapid growth of the market for Lloydminster heavy crude. The company laid 72 miles of 8-inch line beside the existing 6-inch pipe, thus eliminating the necessity of cyclical reversals of flow to transport condensate northward for blending with the heavy crude oil. In the Taber area of southeastern Alberta, Bow River Pipe Lines Ltd. laid a 13-mile lateral to the Chin Coulee field. Most other oil-pipeline construction in Alberta consisted of expansion of gathering systems. For example, Pembina Pipe Line Ltd. added 39 miles of crude oil gathering lines in the Pembina and Willesden Green fields. Federated Pipe Lines Ltd. added 13 miles of gathering lines in the Swan Hills area and laid 8 miles of 16-inch loop in the trunk line near Edmonton.

In southeastern Saskatchewan, Producers Pipelines Ltd. added 29 miles of gathering lines and laid 42 miles to new producing areas, including Flat Lake, Lake Alma West, Handsworth, Arcola, and Antler. In the Fosterton area of southwestern Saskatchewan, South Saskatchewan Pipe Line Company is increasing pumping facilities to allow delivery of 100,000 barrels a day by the spring of 1966. The company also added 20 miles of 12-inch loop from the expanding Delta pool to the Cantuar pump station.

Transportation charges on the Interprovincial Pipe Line Company and Trans Mountain Oil Pipe Line Company pipelines were unchanged: the Edmonton to Port Credit tariff remained at 51 cents a barrel; the tariff from Edmonton to Burnaby, near Vancouver, still stood at 40 cents. Pipeline tariffs to main terminals from several of the newer fields in Alberta and Saskatchewan were reduced. The most drastic reductions were in the Nipisi, Utikuma Lake, and Red Earth areas. Peace River Oil Pipe Line Co. Ltd. reduced the Red Earth to Edmonton tariff from $1 to 23 cents, and Utikuma to Edmonton from $1 to 20 cents. The benefits, as much as 80¢ a barrel, accrued to producers.

PETROLEUM REFINING

By the end of 1965, total crude oil refining capacity of Canada's 40 operating petroleum refineries reached 1,083,150 barrels a day, or three per cent more than the previous year's capacity. No new refineries were built in 1965 but modifications to several existing plants resulted in increased capacities. BP Refinery Canada Limited enlarged the Oakville refinery from 22,000 to 34,000 barrels a day. The capacity of Shell Canada Limited's Oakville refinery was increased slightly to 34,000 barrels daily. Small increases were effected in Imperial Oil Enterprises Ltd.'s Montreal, Edmonton and Calgary plants to 94,700, 30,000 and 17,500 barrels a day, respectively. Newfoundland's only oil refinery, owned and operated by Golden Eagle Refining Company of Canada, Limited, is being expanded from 8,500 to 15,000 barrels daily.

At least one new eastern refinery is scheduled for completion in the next two years. La Raffinerie Irving du Québec ltée plans to complete a 50,000-barrel-a-day plant near Quebec City by early 1968. This will be the only refinery in Quebec outside the Montreal area and, like the Montreal plants, it will use imported crude.

Imperial Oil Enterprises Ltd. remained the the largest refiner in Canada. The company's nine refineries comprise 34 per cent of Canadian refinery capacity. Shell Canada Limited's six plants constitute 16.5 per cent of the country's capacity. The British American Oil Company Ltd., third largest refiner, operates nine plants which account for 15.7 per cent of the total. British American will become the second largest refiner when the current 50-per-cent increase in its Montreal plant becomes effective in 1966.

MARKETING AND TRADE

Receipts of crude oil and equivalent at Canadian refineries in 1965 averaged 967,000 barrels a day, 3 per cent more than in 1964. Canadian crude petroleum producers benefitted from the increase to a greater extent than did foreign suppliers. Canadian petroleum constituted 59.2 per cent of refinery receipts compared with 58.2 per cent in 1964. This is consistent with the long-term trend of decreasing dependence on foreign crude oil. Refinery receipts of domestic crude increased 4.7 per cent. Two thirds of the increase went to Ontario refineries. Other provinces using domestic crude recorded small increases in refinery receipts, except British Columbia where consumption declined slightly.

Receipts of imported crude and equivalent at Canadian refineries in 1965 averaged 396,000 barrels a day representing an increase of less than one half of one per cent from 1964. The Atlantic provinces and Quebec use imported crude except for a minute quantity from New Brunswick. This marks the second consecutive year of static demand for foreign crude oil in Canada. Only 0.6 per cent of the crude oil used in Ontario refineries was imported. The flow of products from Montreal refineries into Ontario increased slightly in 1965, following the sharp cutback in such movements in

TABLE 13
Regional Consumption of Petroleum Products – Net Sales, 1965
(thousand barrels)

	Motor Gasoline	Kerosene, Stove Oil, Tractor Fuel	Diesel Fuel Oil	Light Fuel Oils No. 2 and 3	Heavy Fuel Oils No. 4, 5 and 6
Newfoundland	1,619	1,182	1,721	1,698	2,543
Maritimes	7,950	2,848	3,074	7,303	10,062
Quebec	30,072	6,349	7,226	25,834	32,427
Ontario	47,508	3,704	6,998	34,160	24,070
Manitoba	6,610	1,028	2,318	2,183	1,320
Saskatchewan	9,172	1,421	3,420	1,829	762
Alberta	12,971	433	5,015	1,177	468
British Columbia	12,337	1,740	5,540	4,767	7,670
Northwest and Yukon Territories	255	217	354	343	106
Total	128,494	18,922	35,666	79,294	79,428

Source: Dominion Bureau of Statistics, *Refined Petroleum Products* monthly reports, 1965.

TABLE 14

Imports of Refined Petroleum Products

(millions of barrels)

	1964	1965P
Heavy fuel oil	22.59	30.65
Light fuel oil	8.20	9.18
Stove oil	1.42	2.70
Motor gasoline	2.06	1.91
Aviation gasoline	0.26	0.16
Diesel fuel	3.39	6.49
Lubricating oil	1.36	1.72
Petroleum coke	2.09	1.73

Source: Dominion Bureau of Statistics

PPreliminary: 1965 figures are totals of monthly imports from *Refined Petroleum Products.*

1964. Although Venezuela remained the largest source of imported crude, the proportion supplied by that country dropped significantly in 1965 whereas the Middle East countries, particularly Saudi Arabia, provided correspondingly greater amounts. The other Middle East sources were Iran, Kuwait, Iraq, and Qatar. Nigeria, which has only recently become a large oil producer, started supplying crude oil to Canada in 1965.

Imports of refined petroleum products averaged 160,000 barrels a day, an increase of 40,000. This sharp expansion of product imports accounts for the virtual lack of growth of demand for crude oil in the Atlantic Provinces, Quebec and British Columbia. Large increases in product imports were recorded in all these major importing regions and to a lesser degree in Ontario. Light and heavy fuel oil and diesel fuel from Venezuela and the Netherlands Antilles and heavy fuel oil from United States comprised most of the product imports. A substantial increase in imports of products from Venezuela partly offset the decrease in that country's shipments of crude oil to Canada.

Early in 1965 the federal government assigned fixed duties on imported gasoline because of the disruptive price effects of importation of 'distress-price' European gasoline into the Toronto area in 1964. A significant decline in imports of gasoline from Europe occurred in 1965 but even in 1964 these imports made up a very small portion of the import trade.

Exports of crude oil and equivalent increased 6.7 per cent, slightly more than half the 1964 rate of increase. Average daily exports amounted to 297,000 barrels, nearly 100,000 barrels less than daily crude oil imports. All exported crude went to the United States. Fifty per cent of the exports was used at three coastal refineries in the State of Washington, and the remainder was exported to refineries east of the Rockies, mainly in the Great Lakes region. The Interprovincial pipeline supplied crude to 12 refineries in the States of Minnesota, Wisconsin, Michigan, Ohio, and New York.

TABLE 15

Supply and Demand of Oils, 1964–65

(thousand barrels)

	1964r	1965P
Supply		
Production		
Crude oil	274,626	296,419
Natural gas liquids	38,547	45,193
Gross production	313,173	341,612
Returned to field	1,227	5,266
Net production	311,946	336,346
Imports		
Crude oil	143,946	144,000
Products	43,786	60,002
Total imports	187,732	204,002
Change in stocks		
Crude and natural gas liquids	+161	−2,085
Refined oil products	+964	−2,571
Total change	+1,125	−4,656
Oils not accounted for	+788	−888
Total supply	501,591	534,804
Demand		
Exports		
Crude oil	101,667	107,696
Products	8,714	10,289
Total	110,381	117,985
Domestic sales		
Motor gasoline	121,288	128,543
Middle distillates	132,156	138,511
Heavy fuel oil	69,308	79,455
Other products	40,389	41,446
Total	363,141	387,955
Uses and losses		
Refinery	26,961	27,735
Field, plant and pipeline	1,108	1,473
Total	28,069	29,208
Total demand	501,591	535,148

Source: Dominion Bureau of Statistics provincial reports.

rRevised; PPreliminary.

The benefits gained by the 18,500 barrel-a-day increase in crude oil exports were partly offset by a 10,000 barrel-a-day decrease in exports of petroleum products. Exports of products averaged 14,000 barrels daily. The United States was by far the largest market for these products. The main commodities exported were butane, propane, heavy fuel oil and gasoline. An increase in shipments of propane and butane to Japan was evident.

There is no tariff on crude oil entering Canada. A United States import tax of 5¼ cents a barrel is levied on Canadian crude testing under 25° API gravity, and 10½ cents a barrel on oil testing at or above that gravity.

Geophysicist checks seismic 'logs' in recording vehicle.

Phosphate

C.M. BARTLEY*

Canada has not produced phosphatic raw material for many years. However, because of circumstances favourable to the processing of phosphate in Canada, steadily increasing amounts are being imported, and the manufacture, consumption and export of phosphatic fertilizers have risen consistently.

In 1965 phosphate rock imports increased for the tenth consecutive year to a new high of 1,695,000 short tons. Reported exports of phosphatic fertilizers increased substantially in value over 1964. Consumption of phosphate rock in Canada has increased almost 300 per cent over the past ten years to a high of 1,448,000 tons in 1964 and this figure will be exceeded in 1965.

The world-wide fertilizer industry is now undergoing rapid expansion. Canadian phosphate fertilizer activity is conforming to the trend as exploration for raw materials increases in western Canada and new production capacity is constructed and being planned in both western and eastern Canada.

PRODUCTION AND OCCURRENCES

Since the early eighteen-nineties, low-cost Florida sedimentary phosphate rock has been readily available and has displaced the domestic phosphate raw materials (apatite) previously produced in substantial quantities. A small but flourishing apatite-mining industry existed in the Buckingham area of Quebec and north of Kingston, Ontario, in the late eighteen hundreds. The deposits were generally small, irregular, coarse-grained occurrences of apatite with pink calcite and phlogopite mica, associated with pyroxenite.

Some of the alkaline rock complexes found in parts of Ontario and Quebec contain comparatively abundant apatite and are potential sources of phosphatic raw material. The Nemegos deposit near Chapleau, Ontario, controlled by Multi-Minerals Limited, is one on which considerable investigation has been done and a pilot plant test is being run to establish a commercial process for the separation and processing of apatite. The niobium-mineral deposits in the Oka area, near Montreal, contain small amounts of apatite which may be recoverable as a byproduct. Some ilmenite-magnetite deposits associated with anorthosite in eastern Quebec contain appreciable amounts of apatite which may be recoverable as a byproduct of any metallic operation.

The most promising source of phosphates raw material in Canada is undoubtedly the phosphate rock occurrences along the B.C. – Alberta boundary. Although high-grade occurrences have not been found, the extensive supplies of sulphur in British Columbia and Alberta and of potash in Saskatchewan have encouraged fertilizer development in western Canada. During 1965 there was a significant revival of interest in the phosphate occurrences on either side of the boundary. Large tracts of phosphate land rights have been acquired in both provinces and several companies have conducted aggressive field investigations to find phosphatic materials which could be processed to commercial fertilizer. The rising demand for fertilizers, and their increased price, may soon justify the use of these raw materials which previously were considered too low-grade.

*Mineral Processing Division, Mines Branch

TABLE I

Phosphate — Trade and Consumption

	1964		1965P	
	Short Tons	$	Short Tons	$
Imports				
Phosphate rock				
United States	1,368,768	11,144,630	1,689,133	13,733,955
Netherlands Antilles	1,923	86,925	6,163	257,435
Morocco	35,733	487,846	—	—
Total	1,406,424	11,719,401	1,695,296	13,991,390
Calcium Phosphates				
United States	16,950	1,619,686	16,718	1,582,300
Belgium and Luxembourg	1,353	75,541	1,470	84,453
Japan	843	57,026	1,410	92,563
Other countries	13	4,129	—	—
Total	19,159	1,756,382	19,598	1,759,316
Phosphate fertilizers				
Normal superphosphate				
United States	112,590	2,141,725	90,275	1,775,990
Triple superphosphate				
United States	63,258	3,685,283	52,919	2,878,935
Phosphate chemicals				
Potassium phosphates				
United States	1,793	573,794	1,919	603,649
Sodium phosphate, tribasic				
United States	823	141,495	708	119,232
Sodium phosphates, not elsewhere specified				
United States	3,522	861,851	6,289	1,187,713
West Germany	70	24,648	60	23,049
Total	3,592	886,499	6,349	1,210,762
Exports				
Nitrogen phosphate fertilizers				
United States		10,243,635		19,457,046
Cuba		12,052		—
Total		10,255,687		19,457,046
	1963		1964	
Consumption, phosphate rock, available data				
Fertilizers*	1,002,920		1,277,610	
Chemicals	163,561		169,562	
Other**	92		1,399	
Total	1,166,573		1,448,571	

Source: Dominion Bureau of Statistics.
*Includes small amount used for making animal feed supplements. **Pig iron, detergents and soaps, ceramics, etc.
PPreliminary; —Nil.

TABLE 2

Phosphate Rock – Imports and Consumption, 1956–65

(short tons)

	Imports	Consumption
1956	627,648	552,646
1957	723,220	772,715
1958	744,164	728,906
1959	797,063	786,044
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
1965p	1,695,296	

Source: Dominion Bureau of Statistics
p Preliminary

WORLD PRODUCTION

World production of phosphate in 1965 expanded substantially to more than 60 million metric tons, an increase of about 5 per cent over that of 1964. The United States provided most of the increase with an output of some 26.62 metric tons and there were important increases in the U.S.S.R. and North Africa.

Sources of phosphatic material are mainly sedimentary phosphate rock deposits which occur throughout the world. Apatite concentrates provide less than 20 per cent of total production and guano is a minor source. The sources of phosphate and production in 1964 and 1965 are shown in Table 3. Of these, U.S.S.R., North Viet Nam, Brazil and North Korea are the main sources of apatite. Production from Peru is in the form of guano. The Netherlands Antilles produces a naturally low-fluorine phosphate rock marketed mainly for use as additive to stock and poultry feeds.

TABLE 3

World Production of Phosphate

(thousand short tons)

	1964	1965
United States	25,715	29,170
U.S.S.R.	14,325e	..
Morocco	11,131	11,424
Tunisia	3,033	3,360
Nauru Island	2,038	1,620
North Viet Nam	1,152e	..
China	896	..
Senegal	879	896
Christmas Island	868	740
Togo	858	1,063
Other countries	3,964	..
Total	64,859	67,088

Sources : U.S. Bureau of Mines *Minerals Yearbook, 1964*, U.S. Bureau of Mines *Commodity Data Summaries*, January 1966, and others.
e Estimate; .. Not available.

CANADIAN DEVELOPMENTS

The Canadian phosphate fertilizer industry continued to expand strongly during 1965. Established companies have increased productive capacity and broadened the base of their operations, and several new producers have entered the industry. Most of the productive capacity in operation and under development is controlled by Canadian companies.

In western Canada the availability of sulphur, either as byproduct sulphuric acid from smelter gas as at The Consolidated Mining and Smelting Company of Canada Limited, (recently renamed Cominco Limited) or as elemental sulphur from Alberta, is a favourable factor in the domestic production of phosphate fertilizer. In addition, the demand for phosphatic fertilizers in western Canada has increased almost 370 per cent in the nine-year period 1957 to 1965. In eastern Canada, although tonnage consumed is somewhat greater, the increase in the same period was a more modest 67 per cent. Phosphate rock to manufacture these fertilizers is imported in ever increasing amounts, mainly from the United States.

During 1965 COMINCO completedconstruction of a 100,000-ton-per-year ammonium phosphate plant at Regina and to feed it, expanded phosphoric acid capacity at Kimberley by 75,000 tons per year.

Sherritt Gordon Mines, Limited at Fort Saskatchewan, Alberta, completed a plant capable of producing 125,000 tons of ammonium phosphate a year. Phosphate rock for this plant is obtained from International Minerals & Chemical Corporation in Florida and is transported to Vancouver by a large bulk carrier, S.S. *Achilleus*, under long-term charter. The ship carries IMC potash, produced at Esterhazy, Saskatchewan, on its return voyage to Florida and thus provides economical transportation by having full cargoes both ways.

Northwest Nitro-Chemicals Ltd. at Medicine Hat completed expansion of its ammonium phosphate plant in mid-1965. Western Co-operative Fertilizers Limited began operating a new plant with a capacity of about 200,000 tons of phosphatic fertilizers in October and, at the opening ceremonies, announced that rising demand for fertilizers would make it necessary to double capacity as soon as possible.

In eastern Canada, Brunswick Fertilizer Corporation Limited, owned jointly by Brunswick Mining and Smelting Corporation Limited and Albright & Wilson Limited, has announced a plant to produce 320,000 tons per year of diammonium phosphate at Belledune, near Bathurst, N.B. Sulphuric acid for this operation will be supplied from SO_2 generated in the pyrite-sulphur-iron and the lead-zinc smelters of Brunswick Mining and Smelting Corporation Limited at Belledune Point.

St. Lawrence Fertilizers Ltd., Valleyfield, Quebec, is building a plant to produce phosphatic fertilizers at the rate of more than 100,000 tons per year using byproduct sulphuric acid from the nearby smelter of Canadian Electrolytic Zinc Limited, and phosphate rock from Morocco and Florida. Production is expected in July 1966

Canadian Industries Limited is completing a large fertilizer complex near Sarnia to produce phosphoric acid and ammonium phosphate. The PhoSAI process, developed by Scottish Agricultural Industries Limited and new to North America, will be used to produce mono-ammonium phosphate.

In May, 1966, Electric Reduction Company of Canada, Ltd. announced construction of a \$40 million phosphorus manufacturing complex at Long Harbour, Newfoundland. Approximately 500,000 tons of imported phosphate rock will be consumed annually at full production.

Perhaps the most significant activity relating to phosphate during 1965 was the large and aggressive exploration programs under way for phosphate along the Alberta-B.C. boundary. Western Co-operative Fertilizers Limited holds a large block of claims in British Columbia and has conducted mapping, drilling and surface excavation towards the discovery and assessment of phosphate rock occurrences. Beneficiation studies of the material are planned. COMINCO explored the boundary area for phosphate many years ago.

In Alberta, phosphate prospecting permits covering more than 1.3 million acres were issued in 1965. Hudson's Bay Oil and Gas Company Limited in particular conducted a major reconnaissance exploration program.

TECHNOLOGY

Phosphorus is an essential constituent of life. To supply human, animal and plant requirements, sources of sedimentary phosphate rock, apatite and other materials have been brought into large-scale commercial operation. These raw materials are graded chemically in terms of the content of calcium phosphate, $Ca_3(PO_4)_2$, the important component (bone phosphate of lime or BPL) or of P_2O_5-1.0 BPL = 0.458 P_2O_5.

Phosphorus in minerals is relatively insoluble and only slightly available to plants. The function of the fertilizer industry is to convert the available raw material into forms from which the plant can readily assimilate phosphorus. The phosphorus in plants is then available to man and animals in the cereals and vegetables they consume.

Phosphate rock is converted to normal superphosphate containing 18 to 22 per cent available P_2O_5 by treatment with sulphuric acid. Triple superphosphate, containing 45 to 48 per cent available P_2O_5, is produced by treating phosphate rock with phosphoric acid. Phosphoric acid is made by treating phosphate rock with sulphuric acid. Generally these fertilizers are used in mixtures which also contain nitrogen and potassium, but they are also used singly. Phosphorus may appear in fertilizer as a mixture with one or more ingredients or in chemical combination with other ingredients. Ammonium phosphate, a chemical combination made by reacting ammonia with phosphoric acid, provides two essential ingredients for plant life, phosphorus and nitrogen. Diammonium phosphate, a more concentrated plant food, has about the same amount of available phosphorus as triple superphosphate plus 11 to 18 per cent nitrogen, and has become the most common variety of phosphate fertilizer.

The trend towards concentrated fertilizers to reduce transportation charges, and specialty fertilizers produced for specific crops or conditions, has brought about changes in processing, handling and marketing. Fertilizers move in bulk, in packages and as liquids. As the demand for fertilizers increases and the volume of material to be handled grows, changes are occurring in the structure of the industry. Companies are attempting to acquire sources of all the basic nutrients, and the organization of small local bulk-blending plants provides fertilizers designed for regional needs.

Phosphate rock generally contains 3 to 4 per cent fluorine, which is not harmful to plant life but must be reduced substantially when phosphorus is used as a supplement for stock and poultry feed. This is accomplished by calcining the rock, which drives off the fluorine, or by manufacturing wet process phosphoric acid and reacting this with limestone to produce dicalcium phosphate with less than 0.2 per cent fluorine.

Elemental phosphorus is manufactured by fusing a mixture of phosphate rock, silica and coke in an electric furnace. The phosphorus is then converted to high-purity phosphoric acid and numerous industrial chemicals.

USES AND SPECIFICATIONS

Phosphate rock is used mainly for fertilizer. Although a minor amount is fine-ground and applied directly to the soil, most is processed to make the phophorus more readily available. Smaller amounts of phosphate rock are used for making phosphorus and phosphorous chemicals, and feed supplements for livestock and poultry.

Phosphorous chemicals are consumed by a variety of industries. The main application is in the manufacture of soaps and detergents. The food-processing industry uses condiderable amounts as a leavening agent in baking powders, cake mixes, etc., and in food preservatives. They are also used in water-conditioning, metal treatment, plastic- and paper-manufacturing, the synthesis of organic phosphates, and the manufacture of chemical reagents and pharmaceutical preparations, as well as in paints, stock-feed supplements, munitions and fireworks and many other products.

For the manufacture of fertilizer, phosphate rock should contain at least 68 per cent BPL, but may contain as high as 77 per cent BPL, depending on the process. For electric furnace use, a lower BPL content is acceptable but the rocks must have no excess calcium, a maximum of 3 per cent Fe_2O_3 plus Al_2O_3, and be mostly coarser than 5 mesh.

PRICES AND TARIFFS

The rapidly growing demand for phosphate rock has resulted in price increases. The price of phosphate rock from several sources, including Florida and Morocco, increased during the year.

According to *Oil, Paint and Drug Reporter* of December 27, 1965, the following prices apply:

Phosphate rock, Florida land pebble, run of mine, washed, dried, unground, bulk carload, f.o.b. mines, per short ton

66-68% BPL	$6.25
68-70	7.23
70-72	7.90
74-75	8.96
76-77	9.95

Phosphate rock, Curaçao, bulk, f.o.b. Atlantic and Gulf ports, per ton – $46.75

Defluorinated phosphate, feed grade, various U.S. sources, 14-19% P, per ton – $54-73.35

Phosphate rock enters Canada duty free.

Platinum Metals

A.F. KILLIN *

Canada now produces all of the platinum group metals – platinum, palladium, rhodium, ruthenium, iridium and osmium. The International Nickel Company of Canada, Limited developed a process in 1965 for the recovery of osmium, the sixth and last of the platinum group metals, from the nickel-copper sulphide ores of Sudbury district. The platinum group metals are recovered in Canada as byproducts from the refining of nickel-copper ores and the volume of recovery varies with the production of these ores. In line with an increase in nickel production, Canadian production of platinum group metals in 1965 increased 75,825 ounces to 452,063 ounces valued at $35,678,078.

The major producing countries of the world are the U.S.S.R., Republic of South Africa, Canada and Colombia. The United States produces minor amounts of the platinum group metals. Because of the lack of statistical data it is not possible to accurately define the pattern of world production of platinum group metals. The United States Bureau of Mines estimated that the U.S.S.R. produces about 50 per cent of the world total followed by South Africa and Canada. World production in 1964 is estimated at 2,050,000 troy ounces of which the U.S.S.R. is estimated to have produced 1,000,000 ounces and South Africa about 600,000 ounces. World consumption figures are not available but consumption in the Free World is known to have exceeded production and the availability of supplies from the U.S.S.R. determined the degree of shortfall.

There were two prices quoted for platinum in 1965, the official price set by Engelhard Industries, Inc. and Johnson, Matthey & Co., Limited, and the free market price quoted by dealers and merchants. Most of the platinum and platinum group metals produced in the Free World were sold at the official price. Some reclaimed metal and the Russian metal were sold at the dealer's price. When the U.S.S.R. stopped selling platinum to the Free World in the latter part of the year the dealer's price rose from $140 to $160 an ounce.

The demand for platinum and platinum group metals is increasing. New oil refineries and fertilizer plants will require catalysts made of these metals and increased industrial use will add growth to the over-all consumption. The total Free World supply will be affected by sales from the U.S.S.R. but increased production in South Africa and Canada should lessen the West's dependence upon Russia.

Prices will be vulnerable to the marketing actions of the U.S.S.R. for some years to come.

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*Mineral Resources Division

TABLE 1

Platinum Metals — Production and Trade, 1964–65

	1964		1965P	
	Troy ounces	$	Troy ounces	$
Production[1]				
Platinum, palladium, rhodium, ruthenium, iridium	376,238	25,404,117	452,063	35,678,078
Exports				
Domestic origin				
Platinum metals in ores and concentrates				
Britain	383,315	19,314,889	471,238	26,245,128
Norway	19,962	1,295,599	16,823	1,358,065
United States	1,614	37,772	4,440	175,114
Total	404,891	20,648,260	492,501	27,778,307
Platinum metals				
United States	275	27,075	53,039	1,847,008
Japan	3,495	125,977	147	13,064
Other countries	131	11,202	264	24,787
Total	3,901	164,254	53,450	1,884,859
Foreign origin[2]				
Platinum metals, refined and semiprocessed	581,779	20,888,749	321,950	11,389,395
Imports				
Platinum lumps, ingots, powder and sponge				
Britain	125,000	12,110,789	47,605	4,914,710
United States	858	78,854	880	97,742
Norway	200	23,760	—	—
Total	126,058	12,213,403	48,485	5,012,452
Other platinum group metals in lumps, ingots, powder and sponge				
Britain	85,814	4,701,857	181,424	8,263,018
United States	9,685	454,031	3,694	186,076
Total	95,499	5,155,888	185,118	8,449,094
Total, platinum and platinum group metals				
Britain	210,814	16,812,646	229,029	13,177,728
United States	10,543	532,885	4,574	283,818
Other countries	200	23,760	—	—
Total	221,557	17,369,291	233,603	13,461,546
Platinum crucibles				
United States	30,747	2,788,810	19,923	1,867,699
Britain	2	249	38	3,785
Total	30,749	2,789,059	19,961	1,871,484
Platinum metals, fabricated material, not elsewhere specified				
United States	3,107	307,172	3,531	267,440
Britain	1,353	115,795	2,999	316,531
Total	4,460	422,967	6,530	583,971

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 change or alteration.

P Preliminary; — Nil.

TABLE 2

World Production of Platinum Metals
(troy ounces)

	1963	1964	1965e
U.S.S.R.	800,000	1,000,000	1,500,000
Republic of South Africa	305,500e	606,000e	750,000
Canada	357,651	376,238	452,063
United States	49,750	40,487	..
Colombia	29,453	23,345	25,000
Other countries	2,646	4,930	..
Total	1,545,000	2,051,000	2,732,000

Source: U.S. Bureau of Mines *Minerals Yearbook, 1964*, and U.S. Bureau of Mines *Commodity Data Summaries*, January, 1966.
e Estimate; .. Not available for publication.

PRODUCTION

CANADIAN

Platinum metals in Canada are recovered as byproducts from the treatment of nickel ores. These ores average about 0.025 ounce per ton of platinum metals. In the nickel smelting process the precious metals are collected in the nickel-copper sulphide matte. Nickel-copper matte anodes are purified by electrolysis at which time the precious metals are released and collected at the bottom of the electrolytic tanks as sludge. The sludge is purified, then shipped to refineries in Britain and United States for recovery of the individual metals.

Ontario, Manitoba, Quebec and British Columbia are the nickel-producing provinces in

TABLE 3

Platinum Metals — Production and Trade, 1956–65

	Production[1]			Exports		Imports[4]
	Platinum (troy oz)	Other Platinum Metals (troy oz)	Total (troy oz)	Domestic[2] ($)	Foreign[3] ($)	($)
1956	151,357	163,451	314,808	20,571,623	14,814,488	19,579,826
1957	199,565	216,582	416,147	17,638,093	10,081,412	15,430,931
1958	146,092	154,366	300,458	15,014,321	4,893,616	8,641,360
1959	150,382	177,713	328,095	12,497,221	8,676,998	6,466,280
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
1965p	..	..	452,063	29,663,166	11,389,395	13,461,546

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 in concentrates exported for treatment. [3]Exports of platinum metals refined and semiprocessed Re-exports of platinum metals from Britain considered exports of foreign produce [4]Imports mainly from Britain of refined and semiprocessed platinum metals derived from Canadian concentrates and residues

p Preliminary; .. Not available for publication.

Canada. Nickel-copper concentrates produced in British Columbia are exported as such to Japan and there is no recovery of platinum metals from these ores in Canada. Precious metal sludge from the nickel refinery of The International Nickel Company of Canada, Limited (INCO) at Thompson, Manitoba is sent to refineries in Britain and the United States. The greater part of the platinum metals produced in Canada is recovered from ores produced in the Sudbury area of Ontario. In this area, INCO operated the Creighton, Frood-Stobie, Garson, Levack, Murray, Crean Hill, Clarabelle and Maclennan mines, the Copper Cliff smelter and a nickel refinery at Port Colborne, Ontario. Sludges recovered at Port Colborne are shipped to Britain for refining of the platinum group metals. INCO has announced a major program of mine expansion and platinum metals production will increase with increased nickel production. Falconbridge Nickel Mines, Limited operated the Falconbridge, East, Onaping, Hardy, Fecunis and North mines in the Sudbury district, a nickel-copper smelter at Falconbridge, Ontario and a refinery at Kristiansand, Norway. From the smelter, matte containing nickel, copper and precious metals is shipped to Norway for refining. Falconbridge was developing the Strathcona mine for production at 6,000 tons of ore a day, scheduled for 1968. Increased nickel production will mean an increase in the output of platinum metals.

Metal Mines Limited at Gordon Lake, Ontario, Marbridge Mines Limited at Malartic, Quebec and Lorraine Mining Company Limited at Belleterre, Quebec shipped their nickel-copper concentrates to Sudbury for treatment by INCO and Falconbridge.

FOREIGN

South Africa

Rustenburg Platinum Mines Limited, the Free World's largest producer, continued expansion of its facilities. Production capacity in 1966, when the expansion is completed, is estimated at 900,000 ounces of platinum metals a year. Rustenburg has announced that it will operate its mines and plants beyond this capacity, if necessary, in order to stabilize the price of platinum metals. Such operation would reduce the amount of Russian platinoids required by the Free World.

The Brakspruit mine started production in 1965 under management of Rustenburg Platinum Mines. This mine is controlled by Rand Mines Ltd., Anglo American Corporation of South Africa Limited and General Mining and Finance Corporation Limited. Mining and treatment of the ore will be carried out by Rustenburg on a royalty basis over a period of 20 years. The matte produced will be refined by Engelhard Industries International Ltd. of the United States.

U.S.S.R.

No figures are reported by the U.S.S.R. but platinum production in 1965 is estimated at 1,500,000 ounces. The major portion of this output is thought to be derived from basic and ultrabasic rocks in the Norilsk region of Siberia. Minor amounts of placer platinum are still recovered in the U.S.S.R. Russia is believed to have excess productive capacity.

United States

Primary platinum production was obtained from placer platinum deposits in Alaska and as a byproduct of gold and copper refining.

Colombia

Placer deposits are the source of Colombia's production. The industry is relatively static and output ranges from 20,000 to 30,000 ounces a year.

Other

Small amounts of platinum metals are recovered as byproducts of base and precious metal refining or from placer deposits in Ethiopia, Japan, Australia and Sierra Leone.

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.

TABLE 4

Producing and Developing Mines, 1965

Company	Producing	Ore Produced 1964	Ore Produced 1965	Ore Reserves and Grade Dec. 31, 1965	Developing
The International Nickel Company of Canada, Limited	9	16,439,000	19,750,000	306,767,000 s.t. containing 9,274,000 s.t. of nickel and copper	Sudbury – Totten, Copper Cliff North, Kirkwood, Coleman and Little Stobie. Thompson – Birchtree and Soab
Falconbridge Nickel Mines, Limited	6	1,960,000	2,344,000	55,260,000 s.t. containing 1,162,000 s.t. of nickel and copper	Strathcona
Metal Mines Limited	1	192,874	..	..	–
Marbridge Mines Limited	1	..	125,313	180,450 s.t. averaging 2.71% Ni	–
Lorraine Mining Company Limited	1	–	162,533	335,300 s.t. averaging 0.64% Ni and 1.61% Cu	–
Giant Mascot Mines, Limited	1	324,635	330,954	760,000 s.t. averaging 0.81% Ni and 0.32% Cu	–

Source: Company reports.
.. Not available; —Nil.

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 electrodeposition. 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.

PRICES

Prices of platinum metals per troy ounce in the United States, according to *E & MJ Metal and Mineral Markets* on December 30, 1964, and on December 27, 1965 were:

	December 30, 1964	December 27, 1965
Platinum	$ 87–90	$ 97–100
Palladium	32–34	32–34
Osmium	190–200	300–350
Iridium	90–95	110–115
Rhodium	182–185	182–185
Ruthenium	55–60	55–60

The prices listed by *E & M J Metal and Mineral Markets* are official prices and not free market prices.

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Platinum wire and platinum bars, strips, sheets, plates; platinum, palladium, iridium, osmium, ruthenium and rhodium in lumps, ingots, powder, sponge or scrap	free	free	free
Platinum crucibles	free	free	free
Platinum retorts, pans, condensers, tubing and pipe, and preparations of platinum for use in manufacture of sulphuric acid	free	free	free
Platinum and black oxide of copper for use in manufacture of chlorates and colours	free	10%	10%

United States

Platinum, including gold- or silver-plated platinum but not rolled platinum

Unwrought	
Metals of the platinum group separately, native combinations of such metals and artificial combinations of such metals containing by weight not less than 90% of the metal platinum	free
Other, including alloys of platinum	40% ad val.
Semimanufactured	
Bars, plates and sheets, all not under 0.125 inch thick wholly of metals of the platinum groups separately, wholly of native combinations of metals of the platinum group, or wholly of artificial combinations thereof containing by weight not less than 90% of metal platinum	free
Other, including alloys of platinum	40% ad val.

Potash

C.M. BARTLEY*

POTASH MINERALS AND THEIR SOURCES

The term 'potash', applied to materials containing potassium in useful amounts, is derived from 'pot ashes'. In early days, solutions leached from wood ashes in iron pots were a source of potassium. Soluble potash minerals found in German salt deposits were recognized as valuable for fertilizer in 1857, and minerals have since been the source of potassium for fertilizer and for chemical use. The potassium content of the minerals has been stated in terms of K_2O because it was thought that potassium was effective as fertilizer only in this form. The present trend to high-analysis fertilizers makes this practice cumbersome because plant nutrient values sometimes total more than 100 per cent. Consideration is being given to stating nutrient values of potash and phosphate in terms of per cent potassium (K) and phosphorus (P), as is done with nitrogen, rather than as K_2O and P_2O_5.

The common and most useful potassium-bearing minerals, with chemical formulae and potassium content expressed as percentages of K_2O and K, are as follows:

Mineral	Formula	Percentages Equivalent K_2O	K
Sylvite	KCl	63.3	52
Carnallite	$KCl.MgCl_2 6H_2O$	17.0	14
Langbeinite	$K_2SO_4 2MgSO_4$	22.0	19
Kainite	$KCl.MgSO_4 3H_2O$	18.9	13
Nitre	KNO_3	46.5	39

Minerals valued for their potassium content occur almost entirely as bedded evaporite deposits associated with salt (NaCl) or as natural brines (as in the Dead Sea) where soluble salts are being concentrated by high rates of evaporation. The main sources of potash are evaporites that after deposition have been buried by overlying sediments and are thus protected from solution by surface water. Major deposits of potash minerals have been found in Germany, France, the U.S.S.R., Spain, the United States and, more recently, in Saskatchewan.

Potash is recovered from brines at Searles Lake in California. It is also recovered by Israel from brines drawn from the Dead Sea. Similar recovery is planned by Jordan at the Dead Sea. Brine occurrences in the Sechura desert of Peru have been investigated as a source of potash.

*Mineral Processing Division, Mines Branch

TABLE 1

Potash – Production and Imports, 1964-65

	1964		1965p	
	Short Tons	$	Short Tons	$
Production (shipments) K_2O content	858,351	31,161,954	1,430,000	54,400,000
Imports				
Potash fertilizers				
Potassium chloride				
United States	43,450	1,184,838	30,913	919,590
West Germany	7,850	245,783	16,347	510,720
France	9,126	284,405	6,553	190,179
U.S.S.R.	6,612	239,920	–	–
Total	67,038	1,954,946	53,813	1,620,489
Potassium sulphate				
United States	12,050	485,410	15,054	614,436
Italy	3,100	169,161	3,517	161,174
France	4,408	170,127	22	993
Total	19,558	824,698	18,593	776,603
Potash fertilizer, not elsewhere specified				
United States	6,203	105,522	9,051	154,472
Total, potash fertilizers	92,799	2,885,166	81,457	2,551,564
Potash chemicals				
Potassium carbonate	659	116,698	565	102,502
Potassium hydroxide	1,825	337,305	1,814	340,375
Potassium nitrates	884	133,272	1,465	196,977
Total, potash chemicals	3,368	587,275	3,844	639,854

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

TABLE 2

Potash Consumption*
(short tons)

	1963	1964	1965
Muriate of potash			
Fertilizers and chemicals	158,261	191,577	236,700e
Other	702	747	2
Total	158,963	192,324r	236,702e

Source: Dominion Bureau of Statistics.
* Available Data
rRevised; eEstimated.

POTASH – CANADA AND GENERAL

From the first attempt to recover potash in Saskatchewan, near Unity in 1951, interest and activity have fluctuated as problems have been encountered and solved and as fertilizer demand and output have varied from year to year. Initial production was achieved in 1958 at the Potash Company of America (PCA), Saskatoon project, but in 1959 the operation was closed to repair water leaks through the shaft wall. In 1962 International Minerals & Chemical Corporation (Canada) Limited (IMC) started to produce at Esterhazy. With subsequent expansions it now operates at a capacity of 2 million tons a year. The successful completion and operation of the Kalium Chemicals Limited solution mining plant at Belle Plaine, in 1964, and the resumption of production at Potash Company of America's Saskatoon area plant in early 1965 raised production capacity in Canada to 3.2 million tons a year.

IMC was completing a new mine and refinery near Esterhazy and projects were under development by five other companies in 1965. These projects will increase capacity to 6.7 million tons of product by the end of 1968 and to 10 million tons of product by 1970. In addition to this assured capacity several other projects are in various stages of planning, although plans for actual construction have not been announced. Two companies are believed to be close to decisions on projects which could add 2 million tons of productive capacity by 1970 and several other companies are known to be making plans for development in the period after 1970.

The rapid development of the potash industry in Canada can be attributed mainly to two factors. One is the urgent need to increase food supplies throughout the world as rapidly expanding populations, particularly in Asia, Africa and South America, make it increasingly difficult to maintain even minimum supplies of food. The other is the fact that major occurrences of high-grade potash ores are rare. The Saskatchewan deposits are both among the larger in volume and contain the highest concentrations of potash minerals of any known at the present time. The ability to produce by shaft, to depths of about 3,500 feet, as demonstrated by IMC and PCA, and by solution mining, as demonstrated by Kalium Chemicals Limited, in very large volume and at very attractive costs has clearly indicated that these projects are profitable. Several other factors have had a favourable influence on potash development. Canada is an attractive area for major investment because sound mining and taxation legislation are in force and power, transportation facilities, and experienced technical personnel are available. In addition, the world's largest present market for potash, the United States, is nearby and major future markets for potash, in Asia, South America, and Oceania, can be served more readily from Canada than from any other major source. For these reasons, the potash industry in Canada appears certain to enjoy a major role in the world potash industry.

PRODUCTION, TRADE AND CONSUMPTION

Production of potash increased in 1965 to 2.26 million tons of product, or 1.43 million tons of K_2O equivalent, worth more than $54 million. Output at IMC expanded as capacity was increased, PCA resumed production in mid-1965 after several years work rehabilitating its shaft and refinery, and Kalium Chemicals Limited operated for the full year compared to a few months in 1964.

The amount and value of potash fertilizer imports decreased in 1965 and total potash imports were lower although the amount and value of potash chemicals was somewhat higher.

TABLE 3

World Potash Production, Consumption and Trade by Continents
1963-64

	Production (%)	Consumption (%)	Exports (thousand metric tons K_2O equiv.)	Imports
Europe	58.2	52.2	3,195	2,686
U.S.S.R.	13.1	8.9	416	–
North and Central America	27.2	27.1	900	797
South America	0.3	1.3	13	129
Asia	1.2	8.0	137	845
Africa	–	1.2	–	110[e]
Oceania	–	1.3	–	128
Totals	100.0	100.0	4,661	4,695

Source: *Fertilizers, 1964. FAO of the United Nations,* Tables 2 and 4.

– Nil; [e]Estimated by author.

Exports of Canadian potash are not yet officially released because only two producers were active throughout 1965, but information on imports by foreign countries indicates that substantial amounts were shipped to the United States and Japan and a smaller but significant total to several other countries.

The consumption of potash in Canada has been increasing steadily and in 1965 reached an estimated high of 236,000 tons of product (KCl).

WESTERN CANADA DEPOSITS

In Saskatchewan, potash was first noted in the early nineteen-forties in cores from oil-well drilling. Subsequent discoveries indicating the extent and richness of the occurrences attracted wide interest in their development. Attempts to recover potash from these occurrences began in 1951 near Unity.

Potash is found in three or more fairly continuous and consistent layers in the upper part of the vast Prairie Evaporites Formation of Middle Devonian age. The formation has the shape of a huge platter underlying southern Saskatchewan and adjacent parts of Manitoba and Alberta. It is tilted slightly to the southwest, the shallow northern edge lying from 2,500 to 3,500 feet below the surface. Southward the depth increases to 5,000 feet at Regina and 7,000 feet at the International Boundary. The Blairmore formation, a layer of interbedded shales and water-bearing fine sands, is probably the best known of the stratigraphic series because its high water pressures present difficult problems in sinking shafts. The Prairie Evaporites consist largely of salt concentrated by the evaporation of an ancient sea; the potash zones are the result of final precipitation of the most soluble materials. Thus, the potash occurs with salt and is overlain by various sedimentary rocks ranging from glacial drift to limestone.

CANADIAN POTASH ACTIVITIES

SASKATCHEWAN

International Minerals & Chemical Corporation (Canada) Limited

The major producer of Canadian potash continued its program of aggressive development and expansion during 1965. Capacity of the K-1 plant at Yarbo was increased to 1.6 million tons of product per year in January and further expanded to 2 million tons at year's end. The shaft at the K-2 plant, 6 miles away at Cutarm, was well below the Blairmore formation and was expected to reach the potash bed by June 1966. Refinery buildings were under construction in the latter part of the year. The K-2 plant will have an initial capacity of 1.5 million tons of product annually but is designed for later expansion to 2.5 million tons.

The company also has moved to lower transportation costs and has increased the efficiency of potash shipments by inaugurating potash-phosphate backhaul shipments between Vancouver and Tampa, Florida. Large shipments of potash leave regularly from Vancouver, and potash storage has been built at Florida to reduce turn-around time for the large bulk carrier. The company is also constructing bulk storage facilities in Rotterdam, The Netherlands.

Kalium Chemicals Limited

In August 1965 the company completed the first full year of production at its potash solution mining plant near Belle Plaine, 30 miles west of Regina. The company was formed by Armour & Company and Pittsburg Plate Glass Company after several years of investigations on solution mining methods in Canada and the United States. A pilot plant, built in Saskatchewan in 1961, operated for about two years. The Belle Plaine commercial plant started to operate late in 1964 and has a reported capacity of at least 600,000 tons of product per year.

A carefully adjusted hot, weak brine is pumped into the potash formation some 5,200 feet below ground and a concentrated brine containing KCl and NaCl in solution is recovered. The pregnant solution is concentrated by evaporation, the salt is removed as a precipitated slurry and the potassium chloride is crystallized in three sizes. The concentrate is dried, screened and moved to storage or shipment. The creamy white potassium chloride crystals are somewhat higher in purity than the flotation product from shaft mining operations. The higher purity is not a significant advantage for agricultural fertilizer markets but may be preferred in certain other markets.

TABLE 4

Summary of Potash Projects in Saskatchewan, 1951-66

Company	Location	Start Construction	Approx. Capital Cost in $ million	Start Production (Scheduled)	Type of Mining	Production Capacity (million short tons K_2O/year)	Present Status
Western Potash Corp. Limited	Unity	1951	..		solution test	..	Test abandoned.
Potash Company of America	Saskatoon	1952	50	1965	shaft	0.36	In production.
Continental (formerly Western) Potash Corp.	Unity	1953	3		shaft to 1800	—	Inactive.
International Minerals & Chemical — K-1	Esterhazy	1957	65	1962	shaft	1.2	In production.
International Minerals & Chemical — K-2	Gerald	1963	60	(1967)	shaft	0.9	Shaft and refinery const. on schedule.
Kalium Chemicals Ltd.	Belle Plaine	1960	50	1964	solution mine	0.36	In production.
Imperial Oil Limited	Findlater	1962		..	solution test	—	Stopped 1964.
Southwest Potash Corp.	Boulder Lake	1963		..		..	Now considering shaft mine near Yorkton.
Alwinsal Potash of Canada	Lanigan	1964	60	(1968)	shaft	0.60	Shaft sinking.
Allan Potash Mines	Allan	1964	80	(1968)	2 shafts	0.90	Shaft sinking and refinery under const.
Consolidated Mining and Smelting	Vanscoy	1965	65	(1969)	2 shafts	0.72	Preparing to sink.
Noranda Mines Ltd. (Consolidated Morrison property)	Viscount	1965	73	(1969)	2 shafts	0.72	Preparing to sink.
Duval Corp.	Saskatoon	1965	63	(1969-70)	2 shafts	0.60	Preparing to sink.

Symbols: — Nil; .. Not available.

The successful development and operation of this potash solution mining project in Saskatchewan is immensely important. It permits the recovery of potash from depths beyond the reach of shaft mines. With operating experience, techniques and economics can be expected to improve.

Potash Company of America

After a shaft and refinery were completed in 1958, production was started and shipments continued into the latter part of 1959. However, a leakage of water through the shaft wall became worse, making it necessary to stop production and turn full attention to shaft repairs. Several years were required to rehabilitate the shaft and make changes in mining and refining equipment. Production was resumed early in 1965 and continues on a rising scale.

The plant, located about 14 miles east of Saskatoon, has a capacity of some 600,000 tons of product annually. Early in 1966 the company announced that a second shaft would be sunk at the Saskatoon property starting in 1967.

and total cost of the project has been estimated at $63 million. Production is expected in late 1969.

Southwest Potash Corporation

Southwest Potash Corporation, a subsidiary of American Metal Climax, Inc., has tested several permit areas and in 1965 was operating a solution test on a permit south of Lanigan. During the latter half of 1965 the company was interested in an area southeast of Yorkton and company officers have stated that a shaft mine was being considered, although no announcement has been made to date.

In addition to the companies mentioned, several others are believed to be close to decisions on active development. Tombill Mines Limited and Francana Oil & Gas Ltd. have jointly formed a new company, Sylvite of Canada Ltd., as an operating company for a potash mine on the property straddling the Saskatchewan-Manitoba boundary. Kerr-McGee Oil Industries, Inc., east of Lanigan, and Prairie Potash Mines Limited, located in Manitoba, are possible early developers.

Many other companies hold properties on which exploration has been done and several are known to be considering development although more work would be required before construction could be started.

Early in 1966 it was announced that solution mining would henceforth qualify for the three-year federal tax exemption available to shaft mines.

There has been continuing interest in two developments of potential value to Saskatchewan potash. The possibility of shafts with diameters of 5 to 10 feet being drilled using large-scale rotary drilling equipment has been proposed for Saskatchewan potash mines following test work in the United States. Immediate interest appears to be for ventilation purposes and as secondary or emergency access, but production through such shafts has been suggested. Lower costs and a saving in time, compared with excavated shafts, are claimed.

Investigation continues on methods of transporting potash by pipelines. Such a project requires careful laboratory and pilot-plant investigation because of its specialized application, and would demand long-term production and assured markets. When these conditions are met, it would offer substantial reductions in transportation costs.

ALBERTA

In 1965, for the first time, potash land holdings were recorded in Alberta. Four permits, located just south and west of Lloydminster, Sask., are shown on the map "Potash in Canada".

NOVA SCOTIA

Exploration work for potash, sponsored by the Nova Scotia Department of Mines and the Atlantic Development Board, has been under way in the Malagash area of Nova Scotia for the past year. Following control and geophysical surveys, shallow drilling is attempting to discover commercial deposits of the potash minerals which have been found associated with salt at Malagash and Pugwash. A program of deep drilling will start in 1966.

WORLD REVIEW

The world potash industry is rapidly expanding productive capacity. It is conducting exploration and development of established and new sources of raw material. The industry's structure is changing, initially as a result of, and now to further improve, transportation, marketing and distribution. The basic incentive for aggressive expansion in the potash industry, as in all the fertilizer material industries, is the growing imbalance between world population and world food supply. Population is increasing faster than food production, particularly in some of the less industrialized parts of the world. Agriculturists believe that catastrophic famines are inevitable in these areas in the near future unless major efforts are made immediately to increase food supplies.

Although agriculture is one of man's most ancient activities, the production of very large volumes of food for large and increasingly urban populations now demands scientific methods and powered equipment. Both are lacking in the less industrialized parts of the world and until they can be developed or acquired, immediate increases in food production can only be achieved by a crash program of fertilizer application to increase land productivity.

Expansion in nitrogen and phosphate fertilizer is taking place on a world wide basis and because raw materials are readily available can be continued until needs are satisfied. Sources of potash and sulphur are much less adequate at present and good sources of potash in particular are found in only a few places throughout the world. No major source of potash has yet been developed in the southern hemisphere or in eastern Asia, and it is in these areas – Asia, Africa and South America – that fertilizers are most needed. The gradual recognition of the imbalance between population and food supply as a serious threat to world peace and human well-being has resulted in aggressive efforts to increase fertilizer production. In Canada this can be seen in the spectacular growth in the potash industry in Saskatchewan.

In the United States, Kermac Potash Company was completing its 300,000-ton-per-year plant. The Texas Gulf Sulphur Company potash mine at Moab, Utah, had completed its first year of operations and although production (at 100,000 tons of product) was lower than planned, difficulties were being overcome and substantially higher production is expected in 1966. The United States Borax & Chemical potash property near Carlsbad, New Mexico, is being considered under an option-purchase agreement by a group of Carlsbad businessmen. United States Borax expects to obtain potash from Allan Potash Mines in Saskatchewan by 1968.

Two projects involving production of potash on a co-product basis are under investigation and development in Utah and in California. In Utah two groups have announced proposals for the recovery of potassium chloride, magnesium metal and several chemicals from Great Salt Lake brines, with production planned for 1969. In California potash and other chemicals, along with steam for generation of electric power, may be produced from deep geothermal brines in the Imperial Valley.

West European potash production increased during 1965, mainly in West Germany but also in France, Spain and Italy. Additional production was achieved by improvements in existing mines rather than increasing capacity. East German production expanded to 1.8 million metric tons. A new refinery using flotation recovery began operating at the Heinrich Rau Combine at Rossleben. Most German ores are processed by solution-crystallization methods. The long-term expansion of the East German industry continues steadily and since ore is of relatively good grade and the industry is aggressive and experienced there is considerable incentive to increase production.

The major expansion of potash production in U.S.S.R. involves several large mines some of which are now coming into production with others under development. It is reported that a new mine began operating at Soligorsk at the end of 1965 and that construction of a new mine at Berezhniki has been started. The discovery of a major potash deposit in Turkmenistan containing five potash-bearing zones has been announced. Agricultural requirements in the area are expected to encourage the development of this deposit.

Israeli production of potash increased substantially during 1965 to 230,000 metric tons as new facilities came into operation. Capacity is now reported as 600,000 tons per year and expansion to 1.0 million tons per year in a few years is planned.

Compagnie de Potasse du Congo is developing a mine in the Congo near Brazzaville. Production at the rate of about 550,000 tons of product per year is planned for 1968. American Potash and Chemical Corporation, which held a 42.5% interest, has withdrawn from the project.

The Ralph M. Parsons Company expected to attain production with a capacity of 300,000 tons of product per year in the Danakil Depression of Ethiopia in 1965 but no definite report of production has been seen.

The potash deposits in Yorkshire, England are under investigation by Armour Chemical Industries Ltd. A solution mining pilot plant is to be constructed near Whitby by Whitby Potash Ltd., a subsidiary of Armour Chemicals. Imperial Chemicals Limited, one of the earlier potash explorers in the area, is reported to be acquiring potash rights. A potash shale deposit in Scotland is under investigation.

TABLE 5

Estimated World Potash Resources and Production 1965

	Reserves (million metric tons)	% K_2O	Production 1965 (million metric tons K_2O)
United States	400		2.848
New Mexico	..	18	
Utah	..	25	
West Germany	20,000	12	2.400
U.S.S.R.	20,300	15	2.300
East Germany	9,000	20	1.900
France	400	17	1.879
Canada	50,000	25	1.297
Spain	500	16	.387
Italy	155	12	.210
Israel (and Jordan reserves)	2,000	3	.310
Chile (KNO_3)		1	.014
Ethiopia	50	25	–
Congo	40	20	–
Britain			
England	350	16	–
Scotland (shale)	100	10	–
Poland	165	8	–
Peru (brines)	..	3	–
Morocco	300	12	–
Libya	9	..	–
Brazil	11	15	–
Total	110,000	15	13.500

Sources: *Phosphorus and Potassium,* U.S. Bureau of Mines and others.

.. not available; – Nil.

The Moroccan deposits of sylvinite and carnallite have been explored and their economic potential has been studied but no decision on development has been announced.

Potash occurrences in Libya, Brazil, Peru and Jordan have been reported and varying amounts of exploration work have been carried out. At present these are regarded as potential sources.

OUTLOOK

The outlook for the potash industry in general and the Canadian industry in particular continues to be highly favourable. Current and planned developments in Canada, and other countries, clearly indicate that major companies are convinced that the needs are real and markets obtainable. Although some temporary surpluses of production over demand may occur if several large producers achieve operation at the same time these are expected to be minor and short lived.

The crisis in the race between population and food supply is near at hand but developments in the fertilizer industry in recent years now show signs of averting the threatened famines. The social and political consequences of widespread famine are beyond prediction and totally unacceptable. The successful solution of the food problem, on the other hand, offers rich rewards in decreased world tensions, rising demand for all materials and expanded world trade.

USES AND SPECIFICATIONS

Potash is one of the three basic ingredients in mixed chemical fertilizers, the others being phosphorus and nitrogen. The familiar grade notations on packaged fertilizers, such as 5-10-15, indicate the percentage content of nitrogen, phosphate and potash in that order. As fertilizer, potash contributes to healthy plant growth and assures the maximum of balanced development by regulating the intake of other fertilizer ingredients.

About 95 per cent of the potash produced is used as fertilizer, five per cent is used in the form of various chemicals of which potassium hydroxide has the widest application. Most fertilizer potash is used as concentrates of muriate (KCl) in various strengths, mixed with other ingredients. Smaller amounts are used as potassium sulphate for particular soils and crops.

PRICES

E & MJ Metal & Mineral Markets, December 13, 1965, reports Canadian prices f.o.b. Saskatchewan same as f.o.b. Carlsbad, New Mexico, will equalize to Carlsbad if it is cheaper.

The *Oil, Paint and Drug Reporter* of December 27, 1965, quoted the following U.S. prices:

	$
Potassium muriate, standard	
bulk, car lots, f.o.b. works, unit ton	0.40
bagged 60% min. K_2O, per s.t.	29.50
granular, bulk, car lots, unit ton	0.44
granular, bagged, 60% min. K_2O, s.t.	31.90
Potassium chloride, chemical	
99.95% KCl, bulk, car lots, per ton	33.00
" " bags, car lots, " "	38.50
Potassium sulphate, min. 50% K_2O,	
agricultural, bulk, car lots, unit ton	0.78

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Potash, muriate and sulphate of, crude; saltpetre or nitrate of potash	free	free	free
German potash salts and German mineral potash	free	free	free
Potassium chloride	free	free	25%
Potash, chlorate of, not further processed than ground	free	15%	20%

United States

Potassium chloride or muriate of potash	free
Potassium sulphate	free
Potassium nitrate or saltpetre, crude	free

Rare-Earth Elements

W.H. JACKSON*

Demand by the electronics industry has caused renewed interest in the rare earths, particularly for ores and concentrates high in the elements yttrium and europium. Most of the other rare earths are believed to be in adequate supply for available markets. An assessment of the rare-earth content of potential byproduct sources is desirable but there appears to be no urgency in prospecting for new occurrences. The Commission on Nomenclature of the International Union of Pure and Applied Chemistry recommended that the term rare-earth elements include scandium (element 21) and yttrium (element 39) as well as the rare earths proper which comprise elements 57 to 71, namely, lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium and lutetium.

SOURCES AND PROCESSING

Over 50 minerals contain rare earths and these have a wide distribution in nature, but workable deposits are uncommon. The main minerals containing rare earths are euxenite, brannerite, priorite, pyrochlore, bastnaesite, monazite, apatite and xenotime. In ores and concentrates, the rare-earth elements occur in widely variable proportions. Monazite, a phosphate containing rare earths and thorium, and bastnaesite, a rare-earth fluorocarbonate, are the principal commercial rare-earth ore minerals. The ceria group, elements 57 to 63, or the yttria group, elements 64 to 71 and including yttrium, tend to dominate a particular mineral and available ores have a preponderance of ceria group elements. The economic sources of monazite are usually placer and beach sand deposits that are mined primarily for their titanium and zirconium mineral content. Bastnaesite concentrate is another important source. Rare-earth recovery from Canadian uranium ore is a new source which complements existing ore sources, being high in the element yttrium. Potential additional sources of yttrium include byproduct recovery from wet process phosphoric acid plants treating phosphorites. In Finland, rare earths are recovered from apatite.

If demand for scandium should develop, it is likely that byproduct recovery from uranium mining or from wolframite processing would ensure adequate supply. Thorveitite is one of the few minerals containing this element.

CANADIAN INDUSTRY

Commercial production of rare-earth oxide (REO) concentrate, a new product of the Canadian mineral industry, commenced in 1965 as a byproduct of uranium and thorium recovery from ores containing uraninite, brannerite and monazite at mines in the Elliot Lake district of Ontario.

Rio Algom Mines Limited commenced rare-earth recovery in 1965 at the rate of about 100,000 pounds annually. The two other uranium producers in the Elliot Lake camp – Denison Mines Limited and Stanrock Uranium Mines Limited – will recover rare earths. The Stanrock

*Mineral Resources Division

operation began early in 1966; it is unusual in that uranium and the rare earths are derived by bacterial leaching of underground workings. Its rate of production is about 18,000 pounds of REO annually. Denison may recover rare earths from its circuit late in 1966.

The Elliot Lake ores contain, in per cent, about 0.11 uranium oxide (U_3O_8), 0.028 thorium oxide (ThO_2) and 0.057 rare-earth oxides. The distribution of rare earths is variable but approximates in per cent 20 to 40 yttrium oxide, 20 cerium oxide, and 10 to 20 neodymium oxide; other rare earths individually seldom exceed 5 per cent. Thorium and the rare earths can be recovered from the effluent solutions, formerly wasted, following uranium recovery. At the Nordic mine of Rio Algom, these solutions contain 0.13 gram per litre of thorium and 0.10 gram of rare earths. Quantities, values and grade of concentrate produced have not been published.

Production from Rio Algom will be shipped to Yttrium Corporation of America, a company jointly owned by The Rio Tinto-Zinc Corporation Limited and Molybdenum Corporation of America, which is constructing a plant at Louviers, Colorado, for the production of colour television phosphors. Stanrock production will be shipped to Michigan Chemical Corporation. There are no processors of rare-earth concentrates in Canada.

WORLD INDUSTRY

Monazite, recovered from beach sands, carbonatites, or pegmatites, is of variable composition containing 3 to 9 per cent thoria and 46 to 59 per cent REO. The main suppliers have been Australia, India, Brazil, United States, South Africa and the Malagasy Republic. Rare-earth recovery from monazite typically involves separation of thorium as a sludge after sulphuric acid treatment leaving rare earths in solution as sulphates. Fractional crystallization separates cerium products then didymium products, then lanthanum, praseodymium and neodymium products. Ion exchange and precipitation of other elements as oxalates is the next step and these are fired to oxides. Didymium is a trade term referring to a mixture of rare earths obtained after removing thorium and cerium from monazite ore.

Bastnaesite has been produced from the carbonatite type of deposit of Molybdenum Corporation of America at Mountain Pass, California, since 1952. Reserves are in excess of 5 million tons contained rare-earth oxides. The ore, mined by open pit, grades 10 per cent rare-earth oxides, with calcite, barite and silicates being the gangue minerals. After grinding and flotation the resultant concentrate averages 70 per cent rare-earth oxides. Concentrate is acid-leached at this point for sale to others. The distribution of rare-earth oxides in the concentrate, in per cent, is cerium 50, lanthanum 31, praseodymium 5, neodymium 12.9, samarium 0.62, europium 0.11, gadolinium 0.2 and yttrium 0.05. For europium recovery, concentrate is roasted, digested in concentrated hydrochloric acid, flocculated and cerium products are removed by filtration. Details of the subsequent solvent extraction steps have not been published. Products of bulk separation include lanthanum, neodymium and praseodymium. In another step, europium is separated from samarium, gadolinium and yttrium oxides. Phosphor-grade (99.9 per cent) europium oxide production began in July, 1965. The low content of yttrium in the ore is noteworthy, as is the relatively high content of europium in comparison to that of monazite which contains 0.04 per cent or less. In 1965, annual capacity of the mill at Mountain Pass was 10 million pounds of rare-earth oxides. A new mill that will raise capacity to 30 million pounds a year was scheduled for operation in mid-1966. Europium oxide capacity was to be doubled to 12,000 pounds. A coproduct containing praseodymium and neodymium was to be shipped to Louviers, Colorado.

World production of concentrate in 1965 was estimated at 11,000 tons. There is no information on production of the various rare-earth products from concentrate. The rare-earth production and processing industry is small but growing. Demand for the purer compounds has not developed in proportion to the distribution of the elements in the ores. For example, some are expensive because of rarity and lack of demand (e.g., lutetium) but expanding markets have lowered the cost of europium and yttrium; others, products of bulk separation, may be relatively low cost or in oversupply pending market development.

Separation of the individual rare earths of high purity from mixtures is accomplished by ion-exchange or solvent extraction techniques or by both if the object is to reduce the percentage of elements entering the ion-exchange columns for which no particular market exists. Details of processes used by individual companies are not published but, for the higher-purity compounds, the removal of non-rare-earth impurities is as important as achieving good separation of individual earths. A common method of producing individual rare-earth metals after fractioning is to reduce rare-earth fluoride with calcium above 1000°C. The process does not work for samarium, europium and ytterbium but oxides of these metals can be reduced with lanthanum. The U.S. Bureau of Mines is developing a fused salt electrolysis method.

Processors of rare earths include: in the United States, American Potash and Chemical Corporation, W.R. Grace and Co., Molybdenum Corporation of America, Michigan Chemical Corporation, Nuclear Corporation of America and Research Chemicals Limited; in Austria, Treibacher Chemische Werke Aktiengesellschaft; in France, Pechiney, Compagnie de Produits Chimiques et Electrométallurgiques; in Britain, New Metals and Chemicals Limited, London and Scandinavian Metallurgical Company, Johnson, Matthey and Co., Limited, and Thorium Limited; in Finland, Typpi Oy; in West Germany, Th. Goldschmidt A.G.; and in Japan, Santoku Metal Industry Company. The U.S.S.R., India and Brazil also have plants that process rare earths.

USES

Rare-earth oxides, products of chemical extraction, are mainly used as mixtures in about the same proportions as they occur in concentrate. Major outlets include glass-polishing compounds and the use of both oxides and fluorides of mixed rare earths in carbon arc lights. Mixed rare-earth metal (mischmetal), a product available for many years, is made by fused salt electrolysis of mixed rare-earth chloride, purified of phosphate and sulphate. Mischmetal is used for lighter flints, for nodular cast iron, and in magnesium alloys. A more refined product, mixed rare-earth chlorides of cerium, lanthanum, praseodymium, neodymium and samarium, the members of lower atomic weight, are ingredients of petroleum-cracking catalysts in place of silica-alumina. Didymium and cerium salts colour glass.

Of the higher-purity compounds, yttrium and europium oxides are currently in demand for the electronics industry. They are used in the approximate ratio of 19 to 1 as the red phosphor, europium-doped yttrium vanadate, in colour television tubes. Yttrium, neodymium and gadolinium have potential as components of glasses or artificial garnets for lasers. Lanthanum oxide is used in camera lens glass and praseodymium oxide in colouring ceramics yellow.

The pure separated rare earths are mainly used for research purposes. These can be very costly to produce and prices bear no relation whatever to the value of the raw minerals from which they are derived. Reflecting the interest in rare-earth research, an organization, the Rare-Earth Information Center, has been established at Ames Laboratory, Ames, Iowa.

PRICES

E & M J Metal and Mineral Markets for December 1965 quotes a nominal value for monazite, on a per pound total rare-earth content basis of 14 cents for massive material grading 55 per cent rare-earth oxides. For monazite sands containing 55 per cent rare earths, the price quoted was 8 cents a pound, for 60 per cent material it was 10 cents, and for 66 per cent material 12 cents. Monazite contains thorium and phosphate as impurities.

Mixed rare earths in the form of bastnaesite concentrates assaying 55 to 60 per cent rare-earth oxides sell for 30 cents a pound f.o.b. Nipton, California. Mixed rare-earth oxide assaying 88 to 92 per cent rare-earth oxide is worth 45 cents a pound.

In general, a mixed concentrate commands a relatively low price and prices are subject to negotiation between buyer and seller. Concentrates high in rare-earth elements in demand, mainly europium and yttrium, command higher prices.

Mischmetal sells for about $2.90 a pound; rare-earth oxides suitable for glass polishes for $.75 to $1.50 a pound. Representative quoted prices per pound for some oxides of 99.9 per cent purity include: $7.50 for cerium, $37.50 for neodymium, $50 for yttrium, $550 to $1,350 for europium. On large contracts prices may be lower. Metal prices, per pound, are quoted at $75 for cerium, $150 for neodymium, $180 for yttrium' and $1,200 to $5,000 for europium.

Roofing Granules

H. S. WILSON*

Consumption of roofing granules in 1965 amounted to 127,000 short tons, valued at about $3.4 million— a decrease of 9.8 per cent in volume and 11.5 per cent in value compared with 1964. These figures are similar to those for the years 1961 to 1963. Thus the increase achieved during 1964 was not sustained.

Table 1 shows consumption in 1964 and 1965 by kind and colour, and imports by kind. The colours are arranged in decreasing order of preference by volume in 1965. Table 2 shows the granule consumption for the period 1954 to 1965, the total values, the average price per ton for each year and the percentage of consumption produced in Canada. In all tables prices are f.o.b. consumer plants.

During 1965, consumption of Canadian produced naturally coloured granules increased over that of 1964. The consumption of imported naturally coloured, and domestic and imported artificially coloured granules decreased. Canadian-made granules continued to gain a greater share of the market. In 1965, this share was 76.9 per cent, compared with 73.9 per cent in 1964. Of the total naturally coloured granules consumed in 1965, 79.5 per cent was produced in Canada, whereas in 1964, 72.4 per cent was produced in Canada. The share of Canadian-made artificially coloured granules remained virtually unchanged from 1964 to 1965, changing from 75.0 per cent to 74.9 per cent. The percentage of slag granules made in Canada increased from 73.5 in 1964 to 76.6 in 1965. Table 3 shows the average prices of the naturally and artificially coloured granules, both domestic and imported, for 1964 and 1965.

CANADIAN PRODUCERS

Manufacturers of granules in Canada are located at Havelock, Ont., Montreal, Que., and Vancouver, BC.

Minnesota Minerals Limited at Havelock crushes a trap rock (basalt) for granules and operates a colouring plant, which produces a wide range of artificially coloured granules. This basalt is also crushed in sizes suitable for other uses, principally for road building and concrete aggregate applications.

Industrial Granules Ltd. of Montreal, the producer of the black-slag granule, obtains its raw material, a waste slag, from a steam-generating plant in Halifax, NS. Other sources of waste slag are constantly being investigated for their ability to granulate with a minimum of acicular-shaped fragments when quenched. The slag must be free from deleterious materials; its composition has much to do with the success of the granule product. A low iron content is necessary to assure freedom from staining of the granule surface when exposed to the weather.

G.W. Richmond of Vancouver, BC, produces slate granules.

*Mineral Processing Division, Mines Branch

TABLE 1

Consumption and Imports*

	1964		1965	
	Short Tons	$	Short Tons	$
Consumption				
By kind				
Naturally coloured	56,457	1,130,645	54,027	1,049,566
Artificially coloured	84,433	2,722,059	73,039	2,359,855
Total	140,890	3,852,704	127,066	3,409,421
By colour				
Black and grey-black	55,804	1,207,202	51,263	1,096,432
Grey	20,947	432,042	21,081	384,885
White	22,623	874,769	20,701	814,747
Green	18,829	619,640	16,972	567,120
Red	7,762	214,798	6,321	182,773
Brown and tan	6,914	197,233	6,153	179,592
Blue	3,703	154,611	2,778	114,399
Buff	1,514	56,182	688	25,577
Coral, cream and yellow	916	34,799	567	19,964
Turquoise	1,840	60,288	542	23,932
Not differentiated	38	1,140	–	–
Total	140,890	3,852,704	127,066	3,409,421
Imports, United States				
Naturally coloured	15,618	360,726	11,092	254,837
Artificially coloured	21,114	831,157	18,305	713,696
	36,732	1,191,883	29,397	968,533

* Value calculated from figures supplied directly by the consumers.
– Nil

TABLE 2

Consumption, 1954–65

	Total Tons	Total Dollars	Average Price/Ton	Canadian Percentage
1965	127,066	3,409,421	26.83	76.9
1964	140,890	3,852,704	27.35	73.9
1963	125,909	3,392,354	26.94	68.8
1962	125,463	3,476,875	27.71	59.5
1961	123,486	3,286,670	26.62	35.8
1960	113,826	2,962,363	26.03	44.7
1959	138,758	4,182,615	30.14	37.1
1958	134,565	4,509,638	31.82	29.8
1957	110,543	3,405,655	30.90	29.8
1956	133,691	3,884,961	29.20	25.0
1955	147,877	4,087,668	27.70	18.3
1954	133,917	3,563,578	26.61	19.0

ROOFING AND SIDING PLANTS

There are seven companies manufacturing roofing shingles and wall siding in 17 plants in Canada. These plants rely wholly on the manufactured granule for their production of shingles. The built-up roof, on the other hand, can be constructed with aggregate ranging in size from the smallest sand sizes for filler material, to gravel and rock fragments up to 8 inches long. Roofing granules used to make shingles and siding usually fall within the -8 +35 mesh range, mainly between the 10- and 20-mesh sizes.

The companies and plants manufacturing these products are:

Allied Chemical Canada, Ltd.
- Montreal, Que.
- Vancouver, BC
- St. Boniface, Man.

Building Products of Canada Limited
- Montreal, Que.
- Hamilton, Ont.
- Winnipeg, Man.
- Edmonton, Alta.

Canadian Gypsum Company, Limited
- Mount Dennis, Ont.

TABLE 3
Average Prices
($ per short ton)

	Imported		Canadian	
	1964	1965	1964	1965
Naturally coloured				
Rock	21.71	20.78	14.72	15.13
Slag	24.47	24.49	21.44	20.76
Slate	–	–	21.41	21.49
Artificially coloured				
Black and grey-black	32.86	34.65	22.90	21.13
Grey	30.08	30.22	28.16	28.89
White	41.69	41.25	37.15	38.38
Green	40.37	40.71	30.60	31.16
Red	34.86	35.28	24.89	26.00
Brown and tan	36.59	35.74	26.25	27.34
Blue	47.40	46.33	39.29	38.82
Buff	38.21	37.27	36.94	37.14
Coral, cream and yellow	45.51	44.73	28.07	28.71
Turquoise	51.21	48.75	26.32	42.35
Not differentiated	–	–	30.00	–
Average	39.37	39.49	29.86	31.99

TABLE 4
Residential Construction
(value × $000,000)

	1963	1964	1965[p]	1966[e]
New	1,713	2,028	2,133	2,216
Repair	544	577	619	656
Total	2,257	2,605	2,752	2,872

Source: Dominion Bureau of Statistics.
[p] Preliminary; [e] Estimated

(cont.)

Canadian Johns-Manville Company, Limited
Asbestos, Que.

Iko Asphalt Roofing Products Limited
Calgary, Alta.
Brampton, Ont.

Domtar Construction Materials Ltd.
Brantford, Ont.
Saint John, NB
Lachine, Que.
Lloydminster, Alta.
Burnaby, BC

The Philip Carey Company Ltd.
Lennoxville, Que.

TREND OF THE INDUSTRY

Total construction in Canada reached another new peak of $9.91 billion in 1965, compared with $8.63 billion in 1964, an increase of 14.9 per cent. In 1965, residential construction was valued at $2.75 billion, 27.8 per cent of total construction, compared with $2.60 billion, or 30.1 per cent of total construction in 1964.

Roofing granules, incorporated in roofing material, are used almost exclusively in house construction. Table 4 shows the values of residential construction in 1963 and 1964 (actual), 1965 (preliminary) and 1966 (intended).

In 1964, consumption of roofing granules had increased 11.9 per cent in volume over the previous year, while residential construction increased in value 15.5 per cent. In 1965, consumption of roofing granules decreased by 9.8 per cent. while residential construction increased 5.6 per cent. This anomaly might be explained by two related factors: the cost of construction continues to increase; and there is a trend in residential construction toward more multiple-family dwellings, such as high-rise apartments.

Salt

D.H. STONEHOUSE*

For the fourth consecutive year, salt production in Canada has shown a marked increase and record tonnages have been reported. Ten years ago rock salt production began to increase with the establishment of a new mine at Ojibway, Ontario. Production was accelerated further in 1959 when a mine was opened at Pugwash, Nova Scotia, and a second mine started in Ontario, at Goderich. Production of evaporated salt has increased over the years and has been assisted most recently by the completion in 1961 of new facilities at Pugwash, Nova Scotia. Salt output for 1965 was 4.3 million tons valued at $21.6 million, an increase of about 8 per cent over 1964 tonnage. Over 52 per cent of total reported production was mined rock salt, over 12 per cent was evaporated salt, over 35 per cent salt content of brines used or shipped, and the remainder was recovered in chemical operations. Total value has not increased in direct proportion to total tons because of greater output of relatively low-cost rock salt.

Principal sources of imported salt are the United States, Mexico and Spain. Total imports increased by 8 per cent to 441,601 tons valued at $1,949,852 for 1965.

Since 1959, the volume of exported salt has not been available for publication. The value of exports has risen by 38 per cent over the 1964 value to just under $5 million, of which exports to the United States account for 95 per cent.

Table 1 gives production, import and export data.

The chemical industry will continue to require salt as a basic raw material for the manufacture of a multitude of chemicals. The increasing demand for chlorine is expected to continue. The use of salt for removal of ice and snow from highways is likely to increase also, as is the application for water-softener regeneration. With the increase in population, greater amounts of salt will be used for food processing and for direct human consumption. Known reserves are ample and production facilities are capable of expansion when warranted.

*Mineral Processing Division, Mines Branch.

TABLE 1

Salt – Production and Trade 1964–65

	1964		1965p	
	Short tons	$	Short tons	$
Production (shipments)				
By type				
Fine vacuum salt	537,553	10,767,762	531,550	..
Mined rock salt	1,874,225	7,461,783	2,266,350	..
Salt recovered in chemical operations	13,303	79,035	24,212	..
Salt content of brines used or shipped	1,563,517	1,895,162	1,508,988	..
Total	3,988,598	20,203,742	4,331,100	21,564,734
By province				
Ontario	3,335,683	11,552,559	3,649,000	12,372,850
Nova Scotia	448,808	4,939,806	469,000	5,172,430
Alberta	101,411	1,593,430	105,400	1,794,475
Saskatchewan	74,952	1,487,277	77,000	1,527,168
Manitoba	27,744	630,670	30,700	697,811
Total	3,988,598	20,203,742	4,331,100	21,564,734
Imports				
Salt for sea or gulf fisheries				
Spain	34,449	163,641	44,949	188,999
Bahamas	10,516	58,815	2,942	11,774
Jamaica	350	1,512	2,079	8,947
United States	350	1,512	1,566	5,470
Netherlands			310	6,039
Total	45,665	225,480	51,846	221,229
Salt and brine, n.e.s.				
Bahamas			17,164	68,270
United States	199,595	1,500,542	182,456	1,406,500
Mexico	160,110	200,502	190,066	251,923
Britain	204	4,889	69	1,930
Total	359,909	1,705,933	389,755	1,728,623
By province				
Newfoundland	32,830	165,587		
Nova Scotia	12,688	66,112		
New Brunswick	–	–		
Quebec	95,500	637,154		
Ontario	68,888	585,109		
Manitoba	342	10,129		
Saskatchewan	3,392	42,656		
Alberta	296	12,252		
British Columbia	191,638	412,414		
Total	405,574	1,931,413		
Exports*				
United States		3,404,853		4,740,135
Trinidad –Tobago		56,750		40,495
Jamaica		56,521		100,290
British Guiana		35,894		41,260
Leeward and Windward Islands.		15,706		18,245
New Zealand		10,554		16,176
Other countries		38,291		39,908
Total		3,618,569		4,996,509

Source: Dominion Bureau of Statistics.

*Quantities not available.

p Preliminary; –Nil; ..Not available; n.e.s. Not elsewhere specified

TABLE 2

Salt – Production and Trade, 1956–65
(short tons)

	Production[1]	Imports	Exports[3]	
			Tons	$
1956	1,590,804	319,124	333,935	
1957	1,771,559	367,483	457,888	
1958	2,375,192	340,887	906,707[2]	
1959	3,289,976	369,967	1,274,077	4,639,522
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
1965p	4,331,100	441,601	..	4,996,509

Source: Dominion Bureau of Statistics.

[1]Producers' shipments. [2]Adjusted to include salt content of brine, estimated at 500,000 tons, exported to the United States during 1958. [3]Tonnages not available after 1959.

pPreliminary; ..Not available.

TABLE 3

World Production 1964
('000 short tons)

United States	31,628
China	12,100
U.S.S.R.	9,700
Britain	7,435
West Germany	6,389
India	5,122
France	4,073
Canada	3,989
Other countries	28,464
Total	108,900

Source: U.S. Bureau of Mines, *Minerals Yearbook, 1964.*

PRODUCERS

ONTARIO

Thick salt beds underlie the southwestern section of Ontario between Kincardine and Amherstburg at depths varying from 800 feet to 1,800 feet. Exploitation of this resource has kept Ontario the leading salt-producing province, accounting for over 84 per cent of the Canadian total.

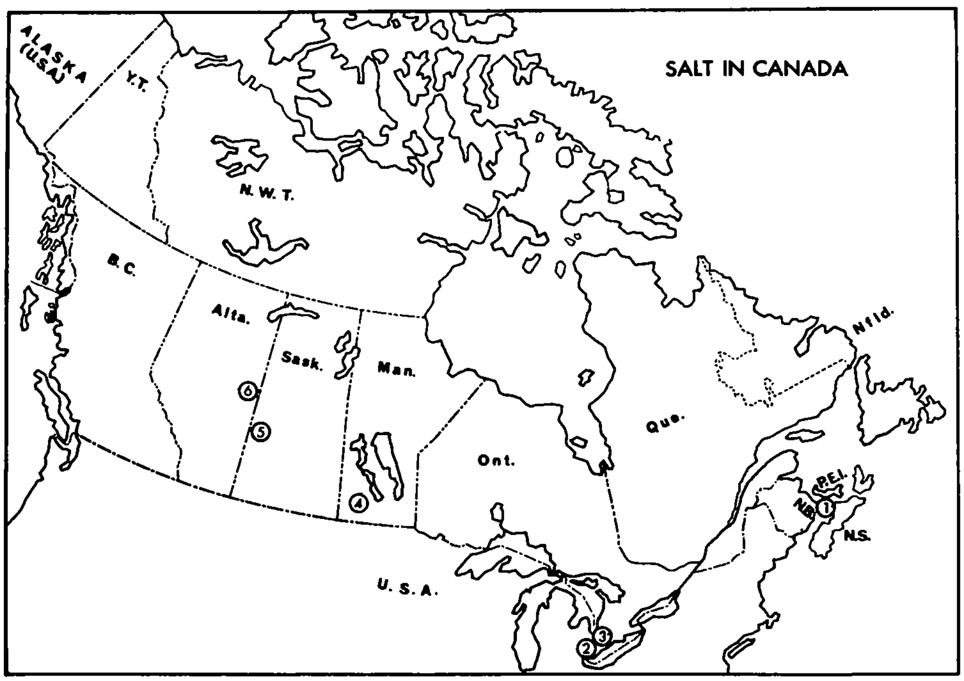
Rock salt is produced from two mines in Ontario, one at Ojibway, operated by The Canadian Rock Salt Company, Limited, the other at Goderich, operated by Sifto Salt Division of Domtar Chemicals Limited. Room and pillar, trackless mining methods are used in both mines. Ojibway works on the 980-foot horizon, taking an 18-foot section, and Goderich works at a depth of 1,760 feet, removing a 45-foot vertical section.

Salt is recovered from brining operations in four centres – Sandwich, a suburb of Windsor, Amherstburg, Sarnia and Goderich. The Canadian Salt Company Limited produces fine evaporated salt from brine at Sandwich and a subsidiary, Canadian Brine Limited, also at Sandwich, exports its production of brine via pipelines to a chemical plant in Detroit. Brunner Mond Canada, Limited produces industrial salt, soda-ash, calcium chloride and other chemicals at Amherstburg. Caustic soda and chlorine are produced by Dow Chemical of Canada, Limited at Sarnia from company-owned wells. At Goderich, Domtar Chemicals Limited operates brine wells from which fine evaporated salt is produced. Fused salt is made at the Sandwich plant of The Canadian Salt Company Limited.

NOVA SCOTIA

The Canadian Rock Salt Company Limited operates a rock salt mine at Pugwash where room and pillar mining methods are used. The dome-like body of salt is worked from the 630-foot horizon by rooms 20 to 25 feet in height. Some benching has been done to twice these heights. Brine, made on surface from mined rock salt, is used to produce fine evaporated salt through multiple stage, vacuum pan evaporation at the same plant site.

Fine evaporated salt is produced at Nappan by Sifto Salt Division of Domtar Chemicals Limited from natural brine which is recovered from depths of 1,100 to 1,800 feet.



EVAPORATOR PLANTS

(numbers refer to numbers on map)

1. Domtar Chemicals Limited, Sifto Salt Division, Nappan, N.S.
1. The Canadian Rock Salt Company Limited, Pugwash, N.S.
2. The Canadian Salt Company Limited, Sandwich, Ont.
2. Brunner Mond Canada, Limited, Amherstburg, Ont.
3. Domtar Chemicals Limited, Sifto Salt Division, Goderich, Ont.
4. The Canadian Salt Company Limited, Neepawa, Man.
5. Domtar Chemicals Limited, Sifto Salt Division, Unity, Sask.
6. The Canadian Salt Company Limited, Lindbergh, Alta.

FUSION PLANTS

2. The Canadian Salt Company Limited, Sandwich, Ont.
5. Domtar Chemicals Limited, Sifto Salt Division, Unity, Sask.
6. The Canadian Salt Company Limited, Lindbergh, Alta.

MINES

1. The Canadian Rock Salt Company Limited, Pugwash, N.S.
2. The Canadian Rock Salt Company Limited, Ojibway, Ont.
3. Domtar Chemicals Limited, Sifto Salt Division, Goderich, Ont.

PRAIRIE PROVINCES

The Canadian Salt Company Limited operates fine evaporated salt plants at Neepawa, Manitoba, and at Lindbergh, Alberta. Natural brine occurs at a 1,400-foot depth at Neepawa and at a 3,600-foot depth at Lindbergh. The plant of Domtar Chemicals Limited at Unity, Saskatchewan, uses natural brine from a 3,000-foot depth to produce fine salt. High-purity fused coarse salt is produced at both Unity and Lindbergh. Western Chemicals Ltd. of Calgary produces caustic soda, chlorine and hydrochloric acid at Duvernay, Alberta, using brine from company wells.

OTHER OCCURRENCES

In addition to the salt deposits that underlie the Nappan-Pugwash area of Nova Scotia, the western portion of southern Ontario and the Unity-Lindbergh area of Saskatchewan-Alberta, rock salt deposits occur at depth in the Mabou-Port Hood area of Cape Breton Island; near Antigonish in Antigonish County, Nova Scotia; under Hillsborough Bay, Prince Edward Island; in the area south of Moncton, New Brunswick; under large sections of southwestern Manitoba, central Saskatchewan and the northeastern portion of Alberta; in the area to the north of Great Slave Lake and in the vicinity of Norman Wells in the District of Mackenzie.

Although no definite evidence of rock salt deposits has yet been uncovered, brine springs, indicative of salt, are plentiful in the southwestern section of Newfoundland, north-central Nova Scotia, the Sussex area of New Brunswick, in southwestern Manitoba and northeastern Alberta, on Vancouver and Saltspring Islands in southwestern British Columbia and at Kwinitsa, east of Prince Rupert, British Columbia.

USES

The greatest consumer of salt is the chemical industry, and the largest users within this industry are the producers of chlorine and caustic soda. Much of the salt used in the manufacture of chemicals is used as brine.

The use of salt on highways to control ice and snow and to stabilize dirt roads has increased in recent years and is now the second largest market.

Considerable quantities of salt are used in food processing, meat packing, hide tanning, textile dyeing, soap making, pulp and paper manufacture, refrigeration, water softener regeneration, and as stock salt.

TABLE 4

Available Data on Consumption of Salt in Specified Canadian Industries, 1963*
(short tons)

Manufacturers of industrial chemicals	
Dry salt	405,476
Brine (salt content)	939,100
Snow and ice control	750,000[e]
Food preparation	50,098
Slaughtering and meat packing	55,622
Pulp and paper mills	61,025
Artificial ice	389
Leather tanneries	15,389
Soap and cleaning preparations	2,471
Dyeing and finishing textiles	1,570
Breweries	538
Fish processing	75,000[e]

Source: Dominion Bureau of Statistics.

*The latest year for which all data are available.

[e]Estimated.

TECHNOLOGY

Salt occurs either as a solid rock salt, or in solution as a brine. Under favourable conditions affording evaporation, soluble salts are crystallized and deposited from saturated solutions. Sodium chloride deposits several thousand feet thick have been formed from sea waters under lagoonal conditions. Calcium carbonate and sulphates are often associated with the sodium chloride, and where the evaporation was carried to completion, magnesium and potassium salts were formed.

Some deposits have been formed by evaporation of waters containing salts leached from surrounding material. These playa deposits can contain a considerable quantity of carbonate, sulphate and boron.

Salt has plastic qualities and under conditions of great pressure can be made to flow. Dome structures are the result of such deformation of deep deposits of salt.

In Canada salt production is realized from mining underground deposits and from brining such deposits. Mining operations involve room and pillar development and the use of heavy equipment to enable removal and processing of large tonnages of salt at low unit cost. The depth at which a mine is operated and conditions peculiar to specific mines influence room and pillar sizes. Rooms can vary from 30 to 60 feet in width and from 18 to 50 feet in height. Brining operations consist of circulating water through an underground cavity in a salt deposit and recovering the brine for evaporation on surface, usually in a vacuum pan installation. One Canadian producer utilizes the waste fines and scalp from the rock salt operation to produce a brine under controlled conditions. The brine is then put through a vacuum-pan evaporation cycle and fine evaporated salt is recovered.

Market requirements dictate whether rock salt or evaporated salt can be used and what quality and screen size would be acceptable. Rock salt is normally crushed, screened and shipped in bulk or in sacks. Rock salt fines can be compacted to yield a greater recovery of coarser sizes. Some fine evaporated salt is compressed into blocks, licks or briquettes, the latter being crushed and sized for specific applications. Various additives are included during processing as required, to provide iodine, cobalt and antiset material.

The association of gypsum, anhydrite and limestone with rock salt in varying degree in some deposits makes necessary some process of beneficiation. Taking advantage of the lesser friability of the impurities, it is common to scalp off coarser fractions after secondary crushing of coarse mine feed. Recent advances in the fields of electronic scanning and thermoadhesive separation have made the application of such devices practical for use in upgrading coarse rock salt output for certain markets requiring high purity.

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Fishery salt	free	free	free
Bulk salt	free	3¢ per 100 lb	5¢ per 100 lb
Salt in bags, barrels, etc	free	3.5¢ per 100 lb	7.5¢ per 100 lb
Table salt	5%	10%	15%
United States			
Bulk salt	1.7¢ per 100 lb		
Salt in bags, barrels, etc.	3.5¢ per 100 lb		
Salt in brine	10% ad val.		

Sand, Gravel and Crushed Stone

F.E. HANES*

The estimated** production of sand, gravel and crushed stone in 1965 was 245.5 million short tons valued at $193.1 million which is a 1.7 per cent increase in volume and 4.2 per cent increase in value compared with the 1964 revised statistics.

The estimated sand and gravel production for 1965 is 179.4 million short tons for an estimated value of $121.6 million, a slight gain in volume and a 3.6 per cent increase of value. The estimated production of crushed stone in 1965 amounted to 66.1 million short tons for a value of $71.5 million, increases of 5.1 and 5.2 per cent, respectively.

SAND AND GRAVEL

Following the procedure used in estimating the sand and gravel products in the 1964 review, volume production for 1965 will be calculated on 93 per cent of the total sand and gravel volume as shown by the Dominion Bureau of Statistics while the value of this product will be estimated at 94 per cent of the total 1965 value. This per cent share was sufficiently close in 1964 calculations to be acceptable as a method for estimating the principal 1965 construction materials included in the sand and gravel review. Materials used in the construction of roads and buildings in the form of concrete and fill materials, asphalt mixes, railroad ballast and mortar mixes, constitute this major category. Not included are such commodities as engine sand, molding sand, and other uses in non-construction applications. The estimated figures representing this commodity include both fine and coarse aggregates obtained from crushing natural gravels which for statistical purposes is not to be confused with crushed stone described below.

CRUSHED STONE

Estimates of total crushed stone figures shown in the 1964 review were obtained by adjusting the 1963 revised figures by a percentage amount equal to the increase reported for total structural materials in 1964 compared with 1963. The estimated figures involved in 1964 amounted to 60,150,000 short tons valued at $65,000,000 which proved to be quite conservative as shown by the adjusted 1964 figures in Table 1. In each case the values were roughly 4 per cent below the final adjusted figures.

Values for the 1965 production of crushed stone will probably be conservatively estimated, similarly, by increasing the 1964 values an amount equal to the increase of the 1965 total construction materials product over the 1964 product.

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* Mineral Processing Division, Mines Branch

** Values estimated by the author based on values for construction supplied by the Dominion Bureau of Statistics.

TABLE 1

Production of Sand, Gravel and Crushed Stone

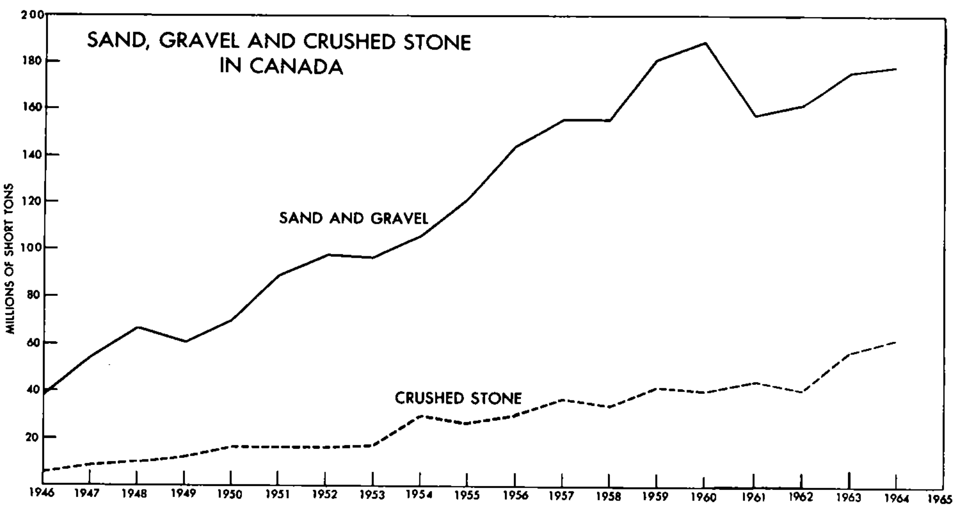
	1964		1965P	
	Short Tons	$	Short Tons	$
Production				
By Province				
Sand and gravel				
Newfoundland	4,431,349	3,370,310		
Prince Edward Island	608,923	481,283		
Nova Scotia	6,471,709	4,186,112		
New Brunswick	4,630,700	2,598,603		
Quebec	39,542,804	19,981,840		
Ontario	69,747,691	50,584,294		
Manitoba	9,453,260	6,793,687		
Saskatchewan	9,071,905	5,707,387		
Alberta	16,048,992	12,898,083		
British Columbia	18,457,949	10,795,465		
Total	178,465,282	117,397,064	179,378,400	121,570,200
Crushed stone				
Newfoundland	102,655	274,546		
Prince Edward Island	350,000	350,000		
Nova Scotia	318,250	477,425		
New Brunswick	2,954,130	2,538,614		
Quebec	35,582,483	37,587,412		
Ontario	21,475,168	24,617,291		
Manitoba	617,014	536,193		
Saskatchewan	–	–		
Alberta	112	520		
British Columbia	1,522,692	1,647,091		
Total	62,922,504	68,029,092	66,100,000	71,500,000
By Type				
Sand and gravel				
In roads (roadbed surface)	98,252,618	52,313,693		
Concrete aggregate	20,466,247	19,023,517		
Asphalt aggregate	5,576,891	5,291,028		
Railroad ballast	5,893,168	2,527,492		
Mortar sand	1,596,487	1,287,984		
Total	131,785,411	80,443,714		
Crushed gravel				
For roads (roadbed surface)	33,611,515	24,092,967		
Concrete aggregate	6,277,569	7,587,276		
Asphalt aggregate	2,947,496	2,378,125		
Railroad ballast	1,790,249	1,239,869		
Other uses	2,053,042	1,655,113		
Total	46,679,871	36,953,350		
Total sand, gravel and crushed gravel	178,465,282	117,397,064	179,378,400	121,570,200

Table 1 (cont.)

	1964		1965p	
	Short Tons	$	Short Tons	$
Crushed stone				
Concrete aggregate	19,300,500	21,869,957		
Railway ballast	2,612,650	2,398,781		
Road metal	34,300,682	35,993,846		
Rubble and riprap	1,359,265	1,484,109		
Terrazzo, stucco and artificial stone	87,749	1,068,354		
Other uses	5,261,658	5,214,045		
Total	62,922,504	68,029,092	66,100,000	71,500,000
Total sand, gravel, crushed gravel and crushed stone	241,387,786	185,426,156	245,478,400	193,070,200

Source: Dominion Bureau of Statistics.

pPreliminary estimates projected from available information by the author. Further information unavailable.



On the basis of 1965 preliminary figures, the per cent increase value for structural materials used for calculating the 1964 figures was 5.7 per cent. With the revised 1964 total construction material value of $403,058,324 the per cent increase in this category is actually 6.35.

The total preliminary value of all structural materials produced in 1965 amounted to $423.2 million, a 5 per cent increase over the revised 1964 value amounting to $403,058,324. Using this 5 per cent to estimate the 1965 crushed stone production, a conservative, but reasonably accurate, indication of the trend in this industry was obtained. As was true in 1964, only unreliable values would result by attempting to estimate the production for each province or for each type of material.

UTILIZATION BY TYPE

The magnitude of the aggregate industry is often overlooked and considered only as a low value per ton product. The average value per ton for sand and gravel based on revised 1964 statistics was 66 cents, and for crushed stone, $1.08 per ton. The average value for the total sand, gravel and crushed stone product was approximately 77 cents per ton. The total aggregate industry can be ranked, on the basis of its utilization as a construction material, high in the table of leading minerals exceeded only by two fuel minerals, natural gas and crude oil, and by four metallic minerals, nickel, iron ore, copper and zinc.

Natural and crushed aggregates are used in many ways and make up, in one form or another, the principal ingredient and often the secondary material in a varied number of applications. For example, its use in road building alone can be classified under numerous subheadings. In some cases, very specialized uses for certain aggregates such as top dressing mixes, antiskid uses and others, require selective quarrying, careful processing, and quality controls that call for specialized equipment and increased handling. The volume of this material, in size alone, requires a tremendous fleet of transportation equipment to move it first from the quarry, then to storage and finally to the job site where it often requires additional handling and moving. Because of the increasing importance for safety and durability as well as an occasional need to reach an aesthetic level, stiff specifications obtain for exploitation and processing for many aggregates.

Seventy-five per cent of the total sand and gravel product amounting to almost 100 million tons is used in road building and earth dam construction, 15.5 per cent, or 20.5 million tons, is used in concrete aggregate and most of the remainder is evenly distributed for use between railroad ballast and asphalt mixes.

Seventy-two per cent of the crushed gravel product is used for road metal, 13.4 per cent for concrete and about 13 per cent for asphalt and railroad ballast.

One twelfth of the crushed stone product is classified as 'other uses'; its value, approximately 99 cents per ton, does not identify its ultimate use. Almost 55 per cent of total crushed stone is used for road construction while 31 per cent is used in concrete. Railway ballast and rubble and riprap make up 4.2 and 2.2 per cent of the total products, respectively.

Aggregates for terrazzo, stucco and artificial stone use amounting to 87,749 short tons were produced in 1964. These various materials were valued at $1,068,354. An average value per ton calculated from these figures is misleading as it overvalues the artificial stone materials and undervalues the terrazzo chip and stucco dash products. The average price from this table gives a calculated value for these materials at $12.20 per ton; terrazzo chips often command $30 and more per ton. The Dominion Bureau of Statistics reports the production of terrazzo chips, stucco dash and artificial stone products separately amounting to 22,806, 23,563 and 41,380 short tons, respectively, for values of $376,966, $469,925 and $221,463. The average prices from these values are $16.53, $19.94 and $5.35 per ton.

UTILIZATION BY PROVINCE

Ontario is the largest producer of sand and gravel with 39 per cent of the total production. Quebec is second with 22 per cent. However, Quebec only values its sand aggregate at 51 cents per ton (average) while Ontario values its products at 73 cents per ton. Ontario therefore has a larger share of the total value of sand and gravel, 43 per cent, while Quebec has only 17 per cent. The product is either in readily available amounts or of a quality where less processing is required. Another possibility may be a difference in marketing and economics between the two provinces.

A similar relationship exists between British Columbia and Alberta. The former has 18.5 million short tons of sand and gravel production, or 10.3 per cent of the total, while the latter has 16.05 million short tons or 9.3 per cent of the product. Alberta, however, values this product at an average price of 80 cents per ton while British Columbia's value is 58.5 cents per ton. The higher average price for this commodity in Alberta may be due to a different economic structure between the two provinces or it might be a difference based on the availability of suitable deposits.

In the crushed stone field, Quebec accounts for more than half of the total product, by volume 56.5 per cent, and by value, 55 per cent. Ontario shares only 34 per cent of the total product by volume and 36 per cent of the total value. Quebec's average price at $1.06 per ton is about 10 cents lower than Ontario's $1.15 per ton value.

New Brunswick with 2.95 million short tons and British Columbia with 1.52 million short tons make up 7 per cent of the remaining 9.5 per cent.

IMPORTS AND EXPORTS

A 25.4 per cent increase in volume and 13.6 per cent increase in value was reported for the total imported sand, gravel and crushed stone products in 1965 compared with 1964. About 4 per cent less sand and gravel was imported this year compared with 1964 and, based on average prices per ton, only $1.20 was paid per ton in 1965 compared with $1.25 per ton for the 1964 product. There was 42 per cent more crushed stone imported in 1965 compared with 1964. Less was paid per ton for the product which was valued at an average price of $2.34 per ton for the 1965 material compared with $2.78 paid the previous year.

Thirty per cent more stone materials were exported in 1965 compared with 1964 for an increased value amounting to 29.4 per cent. A greater volume of sand (almost 50 per cent) was exported at an increase of 48 per cent in value compared with 1964. The selling price of sand was $1.48 per ton. Seventy per cent more gravel was exported but at a decreased value (12 per cent) in 1965 compared with 1964.

TABLE 2

Imports and Exports – Sand, Gravel and Crushed Stone

	1964		1965p	
	Short Tons	$	Short Tons	$
Imports				
Sand and gravel	593,455	741,466	570,977	682,701
Crushed stone, incl. stone refuse	1,052,468	2,934,275	1,493,439	3,493,404
Total	1,645,923	3,675,741	2,064,416	4,176,105
Exports				
Sand	432,564	574,029	637,058	849,045
Gravel	28,900	30,051	50,883	26,448
Crushed limestone and refuse	910,869	1,290,911	1,098,073	1,576,949
Total	1,372,333	1,894,991	1,786,014	2,452,442

pPreliminary

Selenium and Tellurium

A.F. KILLIN*

Selenium

Selenium is recovered as a byproduct from the treatment of tank muds produced in the electrolytic refining of copper. It is a greyish semimetal with electrical properties characteristic of the semiconductor group of metalloid elements. Selenium recovery plants were in operation at each of Canada's two copper refineries and production in 1965 totalled 504,109 pounds valued at $2,435,704. This was 38,363 pounds and $176,836 more than in 1964.

Canadian Copper Refiners Limited at Montreal East, Quebec, operates Canada's largest selenium recovery plant. The company's refinery treats copper anodes from the Noranda, Quebec, smelter of Noranda Mines Limited and the Gaspé Copper Mines, Limited, smelter at Murdochville, 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 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 slimes from the company's electrolytic copper refinery at Copper Cliff and its nickel refinery at Port Colborne, Ontario. The marketable product produced is a minus 200 mesh, 99.7 per cent selenium powder.

CONSUMPTION AND USES

Since World War II the principal use of selenium has been in the manufacture of dry-plate rectifiers for the electronics industry. Prior to this, selenium was used in the glass, rubber, chemical and steel industries. Selenium is produced as a byproduct of copper refining and for this reason the supply of selenium is dependent upon the rate of copper production. In the early nineteen-fifties, when the growing use of selenium in electronics was competing with more conventional uses, a shortage developed and the price rose very sharply to over $15 a pound. The high price and short supply encouraged the search for substitutes in all applications and demand for selenium declined. Stable prices over the last three

*Mineral Resources Division

TABLE 1

Selenium — Production, Exports and Consumption, 1964-65

	1964		1965P	
	Pounds	$	Pounds	$
Production				
All forms[1]				
Quebec	279,834	1,357,195	280,000	1,350,000
Ontario	104,905	508,789	122,425	592,537
Manitoba	36,178	175,463	51,596	250,240
Saskatchewan	44,829	217,421	50,088	242,927
Total	465,746	2,258,868	504,109	2,435,704
Refined[2]	462,795		514,595	
Exports (metal)				
Britain	199,800	1,081,810	218,600	1,151,521
United States	174,200	990,811	196,500	1,137,675
Argentina	4,900	23,982	9,300	42,928
Australia	4,400	18,044	7,400	29,480
India	3,200	19,541	4,800	23,274
Republic of South Africa	2,800	13,306	4,800	23,015
Other countries	12,000	58,590	9,800	46,816
Total	401,300	2,206,084	451,200	2,454,709
Consumption[3] (selenium content)	13,968		15,888	

Source: Dominion Bureau of Statistics.

[1]Recoverable selenium content of blister copper treated at domestic refineries, plus refined selenium from domestic primary materials. [2]Includes production from scrap. [3]As reported by consumers.

P Preliminary.

TABLE 2

Selenium — Production, Exports and Consumption, 1956-65
(pounds)

	Production		Exports[4]	Consumption[3]
	All Forms[1]	Refined[2]	Metals and Salts	
1956	330,389	355,024	409,729	31,669
1957	321,392	332,011	228,051	15,572
1958	306,990	342,141	250,351	16,600
1959	368,107	372,410	325,712	22,156
1960	521,638	524,659	404,410	14,461
1961	430,612	422,955	345,800	13,160
1962	487,066	466,629	325,600	12,587
1963	468,772	462,400	445,700	12,424
1964	465,746	462,795	401,300	13,968
1965P	504,109	514,595	451,200	15,888

Source: Dominion Bureau of Statistics.

[1]Recoverable selenium content of blister copper treated at domestic refineries, plus refined selenium from domestic primary material. [2]Includes production from scrap. [3]To 1958 inclusive, producers' domestic shipments of selenium produced at domestic refineries, for 1959 and years following, consumption (selenium content) as reported by consumers. [4]From 1956 to 1960, exports of selenium metal and compounds; from 1961, exports of metal, metal powder shot, etc.

P Preliminary.

TABLE 3

Free World Production of Selenium, 1963-65

(pounds)

	1963	1964	1965^{e}
United States	928,000	929,000	561,000
Canada	468,772	465,746	504,109
Japan	313,494	330,335	300,000
Sweden	198,400^{e}	198,400^{e}	200,000
Belgium and Luxembourg (exports)	54,013	94,100^{e}	50,000
Zambia	62,891	57,631	..
Other countries	45,430	43,788	..
Total	2,071,000	2,119,000	..

Source: U.S. Bureau of Mines *Minerals Yearbook, 1964* and U.S. Pureau of Mines *Commodity Data Summaries*, January 1966.
^{e}Estimate; .. Not available.

TABLE 4

Canadian Industrial Use of Selenium, 1963-64

(pounds of contained selenium)

	1963	1964
By end-use		
Glass	6,189	6,498
Other*	6,235	7,470
Total	12,424	13,968

Source: Consumers' reports to Dominion Bureau of Statistics.

*Electronics, rubber, steel, pharmaceuticals.

years and the efforts of the Selenium and Tellurium Development Association have gradually built up new markets and recaptured lost markets. Sales and consumption of selenium have increased and a steady growth of demand in line with increased production is forecast.

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, selenium 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. The ceramics and paint industries use selenium as a pigment to obtain colours from orange to dark maroon and in the colouring of inks for printing on glass containers.

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.

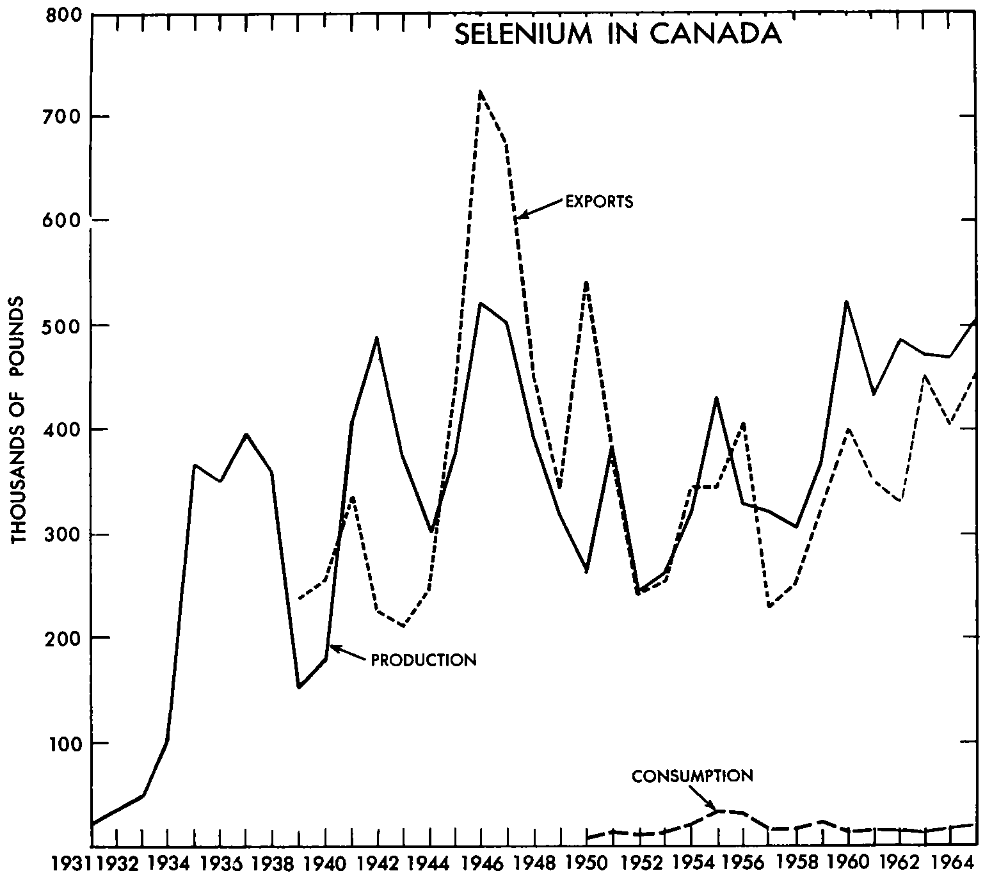
Selenium, in proportions from 0.20 to 0.35 per cent, improves the porosity of stainless steel castings. Ferroselenium (55 to 57% Se) is added to stainless and lead-recarburized steels to improve their machinability and other properties.

Canadian consumption of selenium in 1965 was 15,888 pounds, 1,920 pounds more than was used in 1964. Approximately half the domestic use was in the manufacture of glass; the rest was consumed by the rubber, electronics, steel and pharmaceutical industries.

PRICES

Throughout 1965 selenium prices per pound of selenium in the United States, as quoted by *E & MJ Metal and Mineral Markets*, were:

Commercial grade powder – $4.50
High purity selenium – 6.00



TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
In pure form as lumps, powder, ingot, blocks if of a class not produced in Canada	free	15	25
Above forms if produced in Canada	15	20	25
Alloys, rod, sheet, or processed form	15	20	25

United States

Selenium metal, selenium dioxide, selenium salts free
Other selenium compounds 9% ad val.

Tellurium

The tellurium recovered in Canada is obtained by the same companies that recover selenium from tankhouse slimes of the two electrolytic copper refineries and the nickel refinery. Total production in 1965 from the two plants as reported by The International Nickel Company of Canada, Limited, and Canadian Copper Refiners Limited was 86,264 pounds valued at $554,793. This was 8,482 pounds and $49,210 more in production and value than in 1964. Refined production in 1965 was 69,930 pounds. The excess over refined production was stockpiled as telluriferous refinery muds.

TABLE 5

Tellurium – Production and Consumption, 1964-65

	1964		1965P	
	Pounds	$	Pounds	$
Production				
All forms[1]				
Quebec	64,063	416,409	64,000	415,000
Ontario	7,900	51,350	9,115	54,325
Manitoba	2,599	16,894	6,672	43,368
Saskatchewan	3,220	20,930	6,477	42,100
Total	77,782	505,583	86,264	554,793
Refined[2]	80,255		69,930	
Consumption (refined)[3]	1,473		1,870	

Source: Dominion Bureau of Statistics.
[1]Includes the recoverable tellurium content of blister copper treated, plus refined tellurium from domestic primary material. [2]Refinery output from all sources. [3]Reported by consumers.
P Preliminary.

CONSUMPTION AND USES

Tellurium is recovered from the same sources as selenium and its rate of production and growth of consumption are governed by the same factors. 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. Low production and the odour and toxicity of tellurium continue to inhibit its use in industry.

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.

TABLE 6

Production of Tellurium, 1956-65

(pounds)

	All Forms*	Refined**
1956	7,867	15,915
1957	31,524	34,895
1958	38,250	42,337
1959	13,023	8,900
1960	44,682	41,756
1961	77,609	81,050
1962	58,725	57,630
1963	76,842	79,570
1964	77,782	80,255
1965P	86,264	69,930

Source: Dominion Bureau of Statistics.
*Includes recoverable tellurium content of blister copper, not necessarily recovered in year designated, plus refined tellurium from domestic primary material.
**Refinery production from all sources.
P Preliminary.

TABLE 7

Free World Production of Tellurium, 1963-65

(pounds)

	1963	1964	1965^{e}
United States	201,000	145,000	140,000
Canada	76,842	77,782	86,264
Peru	26,634	46,757	35,000
Japan	13,256	7,573	10,000
Total	317,732	277,112	271,264

Source: U.S. Bureau of Mines *Minerals Yearbook* and U.S. Bureau of Mines *Commodity Data Summaries*, January 1966.
^{e}Estimate.

TABLE 8

Refined Tellurium Used in Canada, 1963-64

(pounds of contained tellurium)

	1963	1964
By end-use		
Metal alloys	811	576
Other*	1,042	897
Total	1,853	1,473

Source: Consumers' reports to Dominion Bureau of Statistics.
*Rubber, electronics.

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, has good hot-working properties and high thermal and electric conductivity. Up to 0.1 per cent tellurium in lead forms a corrosion-resistant alloy used to sheath marine cables and to line tanks subject to chemical corrosion.

Consumption of tellurium in Canada was 1,870 pounds, 397 pounds more than in 1964. Consumption was almost evenly divided between the metal alloy industry and the rubber and electronics industries.

PRICES

The United States price of tellurium in 100-pound lots for 1965, as quoted by *E & MJ Metal and Mineral Markets*, was $6 for both powder and slab.

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
In lumps, powder, ingots, etc.*	free	15%	25%
In alloys, rod, sheet, or processed form	15%	20%	25%

United States	
Tellurium metal	8% ad val.
Tellurium salts and compounds	10% ad val.

*This tariff applies if material is determined to be of a class or kind not produced in Canada, otherwise tariff quoted immediately below applies.

Silica

R.K. COLLINGS*

Silica (silicon dioxide) commonly occurs as quartz in the form of sand, sandstone, quartzite and vein quartz. Deposits are widespread in Canada; however, only those of high purity are of commercial interest. Current production is confined largely to five provinces – Ontario, Quebec, Manitoba, Saskatchewan and British Columbia. The chief production is lump quartzite and sandstone, and sand for use as metallurgical flux. Silica for flux represented 73 per cent of production in 1964; the remainder consisted of lump silica for ferrosilicon manufacture, and sand for glass and silicon carbide production, and for use by the foundry industry, as sand-blast sand, etc. Total silica production increased 12.5 per cent in 1965, to 2.4 million tons. Value, at $4.9 million, was almost 10 per cent greater than that of 1964.

Imports of silica (including silica brick) rose 8.5 per cent in value to $5.4 million in 1965. Imports of silica sand were up 8 per cent, to 834,780 tons at $3.5 million, in spite of increased domestic production. However, silica brick imports dropped over 30 per cent, reflecting the trend towards increased use of basic refractories in open-hearth steel-making operations.

Exports of silica amounted to 111,533 tons valued at $369,310. The bulk was comprised of lump silica for ferrosilicon production and crushed silica for artificial abrasives manufacture, and was exported to the United States from Ontario and British Columbia.

Canada has always been heavily dependent on imported silica sand, chiefly from northeastern U.S., for the bulk of its requirements. The chief consumers, glass and silicon carbide manufacturers and steel foundries, are located principally in southeastern Quebec and southern Ontario where there are no naturally occurring high-quality sand deposits. However, two domestic producers are assuming an increasingly important role in providing high-quality sand for the Quebec market – Industrial Minerals of Canada Limited, operating a deposit of Potsdam sandstone at St. Canut, Two Mountains County, Que., and Dominion Industrial Mineral Corporation, operating a deposit of friable quartzite at St. Donat, Montcalm County, Que. Unfortunately, these two producers are presently unable to effectively compete with imported sand in the Ontario market because of higher processing costs and freight rates.

Interest in the development of domestic resources of silica continues at a high level. Several companies, including Leeds Metals Company Ltd., and En-Ola Explorations Limited, Montreal, are actively investigating silica deposits in Quebec, the former a deposit near St. Urban de Charlevoix, the latter a deposit near Ste. Clothilde de Chateauguay – as possible sources of silica sand.

* Mineral Processing Division, Mines Branch

TABLE 1

Silica — Production and Trade, 1964-65

	1964		1965p	
	Short Tons	$	Short Tons	$
Production, quartz and silica sand*				
By province				
Ontario	1,127,425	836,937	1,247,000	915,500
Quebec	459,195	2,692,249	493,042	2,688,368
Manitoba	301,472	644,157	389,601	737,485
Saskatchewan	187,179	169,977	168,339	134,671
British Columbia	42,002	162,718	83,573	467,615
Total	2,117,273	4,506,038	2,381,555	4,943,639
By use				
Flux	1,538,461	1,223,768		
Ferrosilicon	236,321	900,202		
Silicon carbide	83,975	561,004		
Glass	123,791	819,008		
Foundry	39,571	319,960		
Other uses	95,154	682,096		
Total	2,117,273	4,506,038	2,381,555	4,943,639
Imports				
Silica sand				
United States	765,686	2,877,472	826,139	3,221,479
Norway	3,617	37,350	4,542	45,560
Australia	2,015	124,705	3,522	154,447
Other countries	582	20,143	577	30,942
Total	771,900	3,059,670	834,780	3,452,428
Silex and crystallized quartz				
United States	5,168	282,182	5,014	330,930
Other countries	8	45,123	90	64,179
Total	5,176	327,305	5,104	395,109
	(Thousands)		(Thousands)	
Firebrick and similar shapes, silica				
United States	3,170	1,557,420	2,062	1,533,554
Other countries	23	6,796	24	6,336
Total	3,193	1,564,216	2,086	1,539,890
	(Short Tons)		(Short Tons)	
Exports, quartzite				
United States	146,206	425,371	111,533	369,310

Source: Dominion Bureau of Statistics.
* Producers' shipments, including crude and crushed quartz, crushed sandstone and quartzite, and natural silica sands.
p Preliminary.

In Ontario, Algoma Central Railways currently is exploring the mineral possibilities of an 88-square-mile area northeast of Hearst. By agreement with the Provincial Government, the railway has exclusive rights to search for clays, silica sand, gypsum, marl and iron. Exploration is being concentrated along both sides of the Missinaibi River in McBrien, Amery and Habel townships.

PRINCIPAL PRODUCERS

QUEBEC

Union Carbide Exploration Ltd. quarries quartzitic sandstone at Melocheville, Beauharnois County, for use in ferrosilicon manufacture at Beauharnois. Fines from this operation are used in foundry work, in cement manufacture and as metallurgical flux.

TABLE 2

Silica — Production and Trade, 1956-65
(short tons)

	Production		Imports				
	Quartz and Silica Sand	Silica Brick* (thousand bricks)	Silica Sand	Silex or Crystallized Quartz	Flint and Ground Flint Stones	Ganister**	Exports of Quartzite
1956	2,142,234	5,799	840,374	26,892	616	562	181,196
1957	2,139,246	4,308	744,867	13,718	528	667	232,299
1958	1,453,656	2,815	603,343	12,024	542	..	17,074
1959	2,163,546	1,926	792,129	13,815	786	..	147,412
1960	2,260,766	..	720,826	10,521	1,232	..	13,057
1961	2,194,054	..	693,210	10,327	1,339	..	26,774
1962	2,085,620	..	765,431	8,960	1,193	..	156,205
1963	1,836,612	..	787,157	11,887	1,812	..	47,437
1964	2,117,273	..	771,900	5,176	..	..	146,206
1965P	2,381,555	..	834,780	5,104	..	..	111,533

Source: Dominion Bureau of Statistics.
* Not available after 1959. Beginning 1960, silica to make silica brick included in production of quartz and silica. ** Included with miscellaneous stone imports from January 1, 1958.
P Preliminary; .. Not available.

E. Montpetit et Fils Ltée also quarries sandstone in the Melocheville area. This sandstone is used by Chromium Mining & Smelting Corporation, Limited, for ferrosilicon production at Beauharnois.

Dominion Industrial Mineral Corporation, Montreal, produces silica sand and flour from a quartzite deposit at St. Donat de Montcalm. The silica flour is produced and distributed from a plant at Lachine. Most of the production of sand is sold for glass and silicon carbide manufacture. A site for a new mill has been purchased near Ste. Agathe; however, plans for construction of this mill have not been completed as yet.

Industrial Minerals of Canada Limited, Toronto, produces silica sand and flour at St. Canut, Two Mountains County, from Potsdam sandstone. The sand is used for glass and silicon carbide manufacture, and for foundry purposes. The flour is used by steel foundries, as a filler in asbestos-cement products, and in various cleaners. During the year, sandstone from Ste. Scholastique, 10 miles distant, was processed at St. Canut in a full-scale plant trial. A high-purity sand product resulted. Although not currently mined, the Ste. Scholastique sandstone will serve as a future source of silica for the St. Canut plant.

Baskatong Quartz Products, Montreal, produces lump and crushed quartz from a deposit on the southwestern shore of Lake Baskatong. This material is used, in lump form, in silicon metal manufacture and, to a limited extent, as grinding pebble. The crushed quartz is sold for use as exposed aggregate in decorative concrete.

ONTARIO

Union Carbide Canada Limited operates a quarry at Killarney in the Lorraine quartzite formation that extends along the northern end of Georgian Bay. Most of the production is exported to company-owned plants in the U.S. for ferrosilicon production. The balance is used in Canada for the same purpose.

MANITOBA

The Winnipeg Supply and Fuel Company, Limited, Winnipeg, operates a sand deposit on Black Island, Lake Winnipeg. Sand from this deposit is shipped to Selkirk where it is washed, sized, and sold for glass manufacture, foundry purposes and for other uses.

BRITISH COLUMBIA

Pacific Silica Limited quarries quartz near Oliver. This quartz is crushed, sized and sold as stucco-dash, roofing rock and poultry grit. Part of the production is exported to the U.S. for the manufacture of silicon carbide and ferro-silicon.

OTHER AREAS

Metallurgical silica is quarried near Howick, Quebec, for use in elemental phosphorus production at Varennes; near Sudbury, Ontario, and Thompson, Manitoba, for use in smelting nickel-copper ores; and west of Flin Flon, in Saskatchewan, for use in smelting copper-zinc ore.

SPECIFICATIONS AND USES

LUMP SILICA

Silica Flux

Quartz, quartzite, sandstone and sand are used as fluxes in smelting low-silica, base-metal ores. A high silica content is required. Impurities such as iron and alumina are not objectionable in small amounts. Lump silica used as flux is generally minus one, plus 5/16 inch in size.

Silicon Alloys

Lump quartz, quartzite and well-cemented sandstone are used in the manufacture of silicon, ferrosilicon and other alloys of silicon. The silica content should be 98 per cent, the iron, expressed as Fe_2O_3, and alumina should be less than 1 per cent each, and the total iron and alumina less than 1½ per cent. Lime and magnesia should each be less than 0.2 per cent. Phosphorus and arsenic are objectionable. Size is generally minus 6, plus 1 inch.

Silica Brick

Quartz and quartzite, crushed to minus 8 mesh, are used in the manufacture of silica brick for high-temperature refractory furnaces. The iron and alumina should be less than 1 per cent each and other impurities, such as lime and magnesia, should be low.

Aggregate

Crushed and sized quartz and quartzite are finding new markets as exposed aggregate in precast concrete building panels, slabs, sidewalks and decorative landscape units, in addition to their traditional use in stucco applications. Colour and texture are important. Some architects prefer a white, opaque quartz, while others prefer the shiny, translucent variety.

Other Uses

Lump quartz and quartzite are used as lining in ball and tube mills and as lining and packing for acid towers. Naturally occurring flint pebbles and rounded pebbles produced from lump quartz or quartzite are used as grinding media for the reduction of various nonmetallic ores.

TABLE 3
Available Statistics on Consumption of Silica by Specified Industries, 1964

Industry	Short Tons
Smelter flux*	1,538,461
Glass manufacturing (including glass fibre)	347,531
Foundry sand	235,340
Artificial abrasives	131,993
Ferrosilicon	144,820
Fertilizer, stock and poultry feed	15,526
Chemicals	18,309
Ceramic	12,187
Asbestos products	24,168
Paints	1,450
Soaps, cleansers and detergents	1,088
Other	20,723
Total	2,491,596

Source: Dominion Bureau of Statistics.
* Production of quartz and silica for flux purposes.

SILICA SAND

Glass Manufacture

Naturally occurring sand and sand produced by crushing quartzite or sandstone are used in the manufacture of glass and fused silicaware. The silica content should be more than 99 per cent; that of iron should be uniform and less than 0.02 per cent. Other impurities such as alumina, lime and magnesia should be low. Uniformity of grain size is important, all sand preferably should be between 20 and 100 mesh.

Silicon Carbide

Sand used for silicon-carbide manufacture should have a silica content of 99 per cent. Iron and alumina should be less than 0.1 per cent each. Lime, magnesia and phosphorus are objectionable. A coarse-grained sand is preferred for silicon-carbide manufacture but finer sands are sometimes used. All sand should be plus 100 mesh, with the bulk of it plus 35 mesh.

Hydraulic Fracturing

Sand used in the hydraulic fracturing of oil-bearing formations must be clean and dry, have a high compressive strength and a high silica content, and be free of all acid-consuming constituents. The grain size should be between 20 and 35 mesh. Grains should be well rounded to facilitate placement and to provide maximum permeability.

Foundry Use

Naturally occurring sand and sand produced by the reduction of sandstone are used extensively in the foundry industry for moulding. Sands for this purpose vary greatly in screen size and chemical composition. Grain size varies between 20 and 200 mesh in closely sized ranges. A rounded grain is preferred.

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. All sand should be between 20 and 100 mesh.

Other Uses

Coarsely ground, closely sized quartz, quartzite, sandstone and sand are used as abrasive grit in sandblasting operations and for the manufacture of sandpaper. Various grades of sand are used in water-treatment plants as filtering media. Silica is also used in portland cement manufacture.

SILICA FLOUR

Silica flour, formed by finely grinding quartz, quartzite, sandstone or sand, is used in the ceramic industry for enamel frits and pottery flint. It is also used as an inert filler in rubber and asbestos-cement products, as an extender in paint and as an abrasive ingredient in soaps and scouring powders. Silica flour is finding increasing application in concrete used in the fabrication of autoclave-cured products such as building blocks and panels.

QUARTZ CRYSTALS

Quartz crystals with desirable piezoelectric properties are used in radio-frequency control apparatus, radar and other electronic devices. Crystals 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, in part, by excellent quality synthetic crystal grown in the laboratory from quartz 'seed'.

There is little demand for quartz crystal in Canada and virtually no production, domestic requirements being met by imports chiefly from Brazil and the United States. In 1963, the last year for which import statistics are separately available, 6 tons valued at $286,000, were imported. Quartz Crystals Mines Limited, Toronto, occasionally produces minor tonnages from its mine near Lyndhurst, Ontario, for sale to museums, rock collectors, etc.

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

Canada	
Sand and ganister	free
Silex, or crystallized quartz, ground or unground	free
United States	
Sand containing by weight 95% or more silica and not more than 0.6% oxide of iron, per long ton	50¢
Quartzite, whether or not manufactured .	free
Silica, not specially provided for	free

Silver

J.G. GEORGE*

In 1965, Canadian mine production of silver was 32,964,299 ounces, slightly more than 3 million ounces greater than in 1964. Output declined in the Yukon Territory, British Columbia and Nova Scotia but was more than offset by increases in the Northwest Territories and the other provinces. The province with the highest increase was again New Brunswick mainly because of the substantial output at the base-metal property of Brunswick Mining and Smelting Corporation Limited, which completed its first full year of operation. Output in the Northwest Territories reached an all-time high as a result of the substantially increased production by Echo Bay Mines Ltd. from its silver-copper property near Port Radium. Ontario was again the leading silver-producing province and output was considerably higher than in 1964. Most of the increase was attributed to higher production in the Cobalt-Gowganda area. The drop in production in the Yukon Territory resulted mainly from reduced output at United Keno Hill Mines Limited.

Base-metal ores continued to be the main source of Canada's mine output of silver, accounting for 80 per cent of total production. Almost 19 per cent came from silver-cobalt ores mined in northern Ontario and the remainder was by-product recovery from lode and placer gold ores.

The principal Canadian silver producers are listed in Table 4; the map shows their approximate locations. The four largest producers in 1965 in declining order of output were United Keno Hill Mines Limited in the Yukon Territory, The Consolidated Mining and Smelting Company of Canada Limited (COMINCO) in southeastern B.C., Brunswick Mining and Smelting Corporation Limited near Bathurst, N.B., and Noranda Mines Limited (Geco Division) in Ontario. Base-metal ores mined by these four producers accounted for about 38 per cent of Canada's total silver production. Some 6.1 million ounces of silver, amounting to 18.6 per cent of total production, were derived from silver-cobalt ores mined in the Cobalt and Gowganda areas of Ontario; the largest producer was Silverfields Mining Corporation Limited at 1,114,853 ounces.

Canadian producers of refined silver included: Canadian Copper Refiners Limited at Montreal East, Que., which recovered 9.6 million ounces from the treatment of anode and blister copper; COMINCO, at its refinery at Trail, B.C., which recovered 6.4 million ounces in the processing of lead and zinc ores and concentrates; Cobalt Refinery Limited, which produced 2.8

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*Mineral Resources Division

TABLE 1

Silver – Production, Trade and Consumption, 1964–65

	1964		1965p	
	Troy Ounces	$	Troy Ounces	$
Production*				
By provinces and territories				
Ontario	9,929,858	13,901,801	11,203,506	15,673,705
Quebec	4,564,559	6,390,383	5,315,163	7,435,913
British Columbia	5,280,129	7,392,180	4,851,193	6,786,819
Yukon	5,638,712	7,894,196	4,495,121	6,288,674
New Brunswick	1,469,192	2,056,869	2,914,600	4,077,525
Northwest Territories	65,223	91,312	1,274,200	1,782,606
Newfoundland	1,089,748	1,525,647	1,127,980	1,578,044
Manitoba and Saskatchewan.	1,320,962	1,849,347	1,382,519	1,934,144
Nova Scotia	544,224	761,914	400,000	559,600
Alberta	4	6	17	24
Total	29,902,611	41,863,655	32,964,299	46,117,054
By sources				
Base-metal ores	24,027,983		26,359,492	
Gold ores	548,513		471,810	
Silver-cobalt and silver ores	5,314,294		6,122,844	
Placer gold ores	11,821		10,153	
Total	29,902,611	41,863,655	32,964,299	46,117,054
Refined silver	20,744,682		20,630,190	
Exports				
In ores and concentrates				
United States	6,263,418	7,064,589	6,834,846	7,842,965
Belgium and Luxembourg	1,448,549	1,723,320	2,950,666	3,766,196
West Germany	630,729	591,411	746,827	806,809
Japan	364,907	457,771	525,959	669,146
Italy	–	–	369,000	487,000
Britain	263,102	320,334	337,787	352,149
Sweden	272,134	371,235	205,501	285,658
Mexico	78,291	57,818	176,092	135,555
Other countries	157,187	173,052	99,199	117,362
Total	9,478,317	10,759,530	12,245,877	14,462,840
Refined metal				
United States	10,535,443	14,651,856	11,239,541	15,637,397
Venezuela	16,379	24,938	16,845	25,762
Trinidad and Tobago	335	492	11,047	16,273
Other countries	31,282	45,725	677	3,086
Total	10,583,439	14,723,011	11,268,110	15,682,518
Imports, refined metal				
United States	5,195,559	7,268,139	13,412,838	18,738,707
Britain	2,205	3,339	596	1,133
Total	5,197,764	7,271,478	13,413,434	18,739,840
Consumption, by use				
Coinage	13,726,413		24,427,576	
Silverware	1,456,945		1,552,115	
Photography	384,541r		505,672	
Wire and rod	13,251		16,753	
Silver alloys	348,718		447,298	
Miscellaneous**	2,845,439r		3,220,683	
Total	18,775,307		30,170,097	

Source: Dominion Bureau of Statistics.

*Computed as follows: recoverable silver in ores, concentrates and matte exported; silver in crude gold bullion produced; silver in blister and anode copper made at Canadian smelters; silver in base bullion produced from domestic ores by COMINCO; silver bullion produced from treatment of domestic cobalt-silver ores by Cobalt Refinery Limited at Cobalt, Ont. **Includes sheet, anodes for electroplating and silver used in the manufacture of electrical equipment and jewelry.

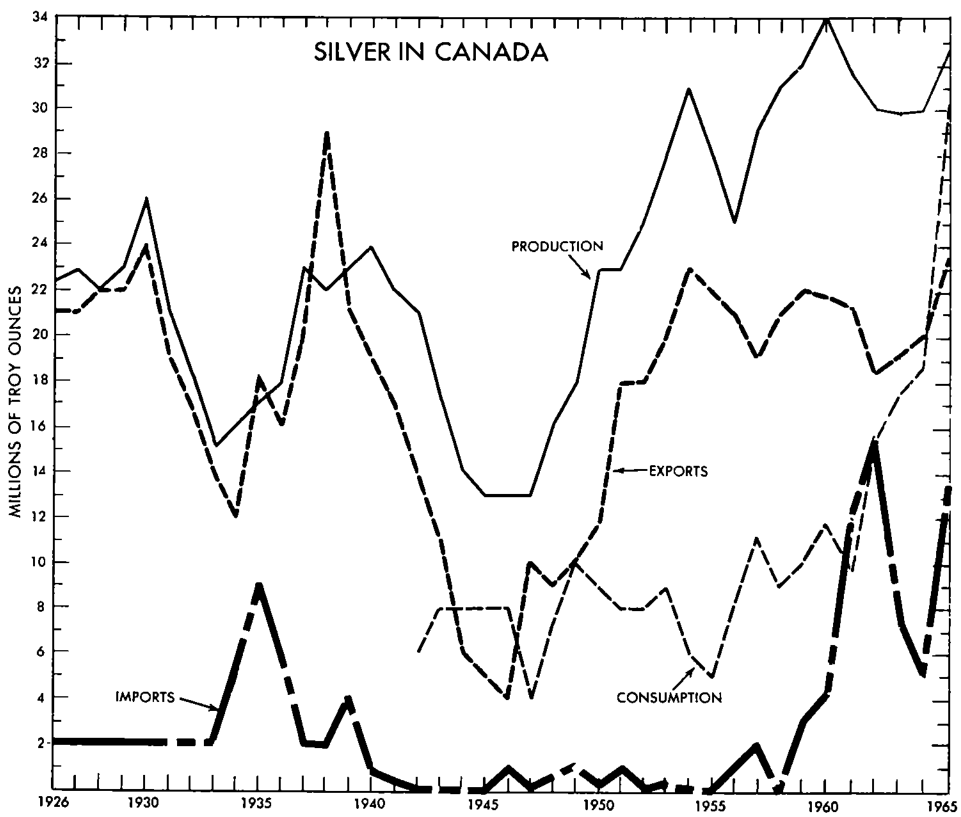
p Preliminary; – Nil; r Revised.

TABLE 2

Silver — Production, Trade and Consumption, 1956–65
(troy ounces)

	Production		Exports			Imports Unmanu- factured	Consumption**
	All Forms*	Refined Silver	In Ores and Concentrates	In Bullion	Total		
1956	28,431,847	22,109,419	6,924,414	14,341,753	21,266,167	1,010,180	7,710,925
1957	28,823,298	20,533,053	5,979,459	12,799,990	18,779,449	1,859,131	10,730,255
1958	31,163,470	25,430,204	5,098,788	16,026,550	21,125,338	2,701	9,299,809
1959	31,923,969	22,362,533	6,814,865	15,140,830	21,955,695	2,807,774	10,202,769
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	29,932,003r	19,772,408	8,286,756	10,834,629	19,121,385	7,950,972	17,574,628
1964	29,902,611r	20,744,682	9,478,317	10,583,439	20,061,756	5,197,764	18,775,307
1965p	32,964,299	20,630,190	12,245,877	11,268,110	23,513,987	13,413,434	30,170,097

Source: Dominion Bureau of Statistics.
*Recoverable silver in ores, concentrates and matte shipped for export; in crude and gold bullion produced; in blister and anode copper made at Canadian smelters; in base bullion made by COMINCO at Trail, B.C.; bullion produced from the treatment of cobalt-silver ores. **Includes consumption for coinage.
p Preliminary; r Revised.



million ounces in the processing of silver-cobalt ores and concentrates at its plant at Cobalt, Ont.; and The International Nickel Company of Canada, Limited (INCO) at Copper Cliff, Ont., which recovered refined silver in the treatment of nickel-copper concentrates. INCO delivered almost 1.6 million ounces of silver to markets in 1965. Other producers were the Royal Canadian Mint at Ottawa, Ont. (from gold bullion), and Hollinger Consolidated Gold Mines, Limited at Timmins, Ont. (from gold precipitates).

Although little change took place in Canada's silver export pattern the total quantity of silver exported in ores and concentrates and as refined metal increased from 20,061,756 ounces in 1964 to 23,513,987 ounces in 1965. The United States continued to be our major customer, importing more than 18 million ounces or about 77 per cent of Canada's total exports. Imports of refined silver in 1965 at 13,413,434 ounces were more than double those of the previous year and reflected increasing requirements of silver by the Royal Canadian Mint for coinage. All of the imports, excepting 596 ounces, came from the United States.

Reported consumption of silver in Canada in 1965 reached a record high of 30,170,097 ounces mainly because of the vastly increased amount used in coinage, which was almost double that in 1964.

WORLD PRODUCTION AND CONSUMPTION

Free World silver production during the past five years has shown only a slightly increasing trend. It rose from 203.3 million troy ounces in 1961 to an estimated 221.5 million ounces in 1965. During the same period, Free World consumption for both industrial and coinage uses, excluding requirements for U.S. coinage which are supplied from Treasury stocks, rose from 320.7 million ounces to an estimated 388 million ounces. The gap between production and consumption, not including U.S. coinage requirements, widened considerably during that five-year period and was more than 166 million ounces in 1965.

Consumption of silver for coinage in the Free World, excluding the United States, amounted to 54.4 million ounces in 1965 compared with 61.5 million ounces in 1964. A sharp drop in Japan's consumption was the main reason for the decline. In 1966 world industrial demand is expected at least to maintain its 1965 level. The trend toward using nonsilver coins, or ones of lower silver content will, of course, result in reduced demand for this purpose.

On a mine-production basis, Canada continued to be the world's fourth largest silver producer. Mexico led the world for the forty-seventh consecutive year with output in 1965 estimated at 43 million ounces. It was followed by the United States and Peru.

TABLE 3

World Production of Silver 1964–65

(troy ounces)

	1964p	1965e
Mexico	41,943,247	43,000,000
United States	37,000,000	38,500,000
Peru	37,043,217	37,600,000
Canada	30,316,486	31,000,000
Russia	27,000,000e	
Australia	18,275,000	
Japan	8,625,337	
Spain	4,955,201[1]	
Bolivia	4,822,611	
East Germany	4,800,000e	
Yugoslavia	4,036,879	
Honduras	3,220,371	
Sweden	3,060,751	
Chile	3,047,679	
Other countries	21,313,606e	107,100,000[2]
Total	249,500,000[3]	257,000,000[3]

Source: 1964 statistics from U.S. Bureau of Mines *Minerals Yearbook, 1964*. 1965 statistics from U.S. Bureau of Mines, *Commodity Data Summaries*, January 1966.

[1]1963 data. [2]Combined quantity including other Free World countries and Communist countries (except Yugoslavia). [3]Data do not add exactly to totals shown because of rounding where estimated figures are included in the detail.

p Preliminary; e Estimate

During the past five years United States production of silver has trended slightly upwards, to about 38,500,000 ounces in 1965. Handy and Harman* have estimated its consumption in industrial uses and coinage in 1965 at 140 million and 320.3 million ounces, respectively. The huge deficit in requirements was

**The Silver Market in 1965*, compiled by Handy and Harman.

met by imports and withdrawals from U.S. Treasury stocks. The Treasury continued to offer silver for industrial or nonmonetary uses at the statutory price of $1.2929 a troy ounce, under the terms of legislation enacted June 4, 1963, which repealed all then-outstanding silver purchase acts. At the beginning of 1965 Treasury reserves were about 1.21 billion ounces; by year's end they had been reduced to approximately 800,000,000 ounces.

In July 1965 the U.S. Government passed the Coinage Act of 1965 eliminating silver from U.S. dimes and quarters, which formerly contained 90 per cent silver. It also reduced the silver content of half dollars from 90 to 40 per cent. The new dimes and quarters are cupronickel-cladded on a copper core. This is the first major change in U.S. subsidiary coins since 1792. The Treasury began to issue the new quarters on November 1 and later that month it began minting new dimes and half dollars. In 1964 and 1965 requirements for U.S. coinage were about 203 and 320.3 million ounces of silver, respectively. These requirements are expected to be greatly reduced in the next few years.

As a result of the silver shortage, a strategic stock-pile for U.S. national defence apparently will be created, which would almost certainly be filled from Treasury stocks. The U.S. Office of Emergency Planning has established a stockpile objective of 165 million ounces.

DEVELOPMENTS

YUKON TERRITORY

Extensive mining development and exploration was conducted in all four mining districts of the Territory in 1965. United Keno Hill Mines Limited carried out a program of surface and underground development on its various holdings in the Galena Hill and Keno Hill areas in the Mayo district. The critical labour shortage, however, caused reduced ore output, and silver production was some 1 million ounces less than in 1964. The company's Silver King mine was closed down as ore reserves were exhausted, and operations were temporarily suspended at its No Cash, Galkeno and Onek mines because of the manpower shortage.

Dynasty Explorations Limited, and Cyprus Mines Corporation of Los Angeles, California, formed Anvil Mining Corporation Limited to continue exploration at their lead-zinc-silver deposit in the Vangorda Creek area. Diamond drilling results to the end of the year indicated a potentially large zinc-lead-silver deposit of several million tons. Mount Nansen Mines Limited, controlled by Peso Silver Mines Limited, continued underground development work by drifting and diamond drilling at its gold-silver properties near Carmacks. Casino Silver Mines Ltd. began an underground drifting program at its Casino Creek property near the Yukon River in the Whitehorse mining district. In the Watson Lake area, Logjam Silver Mines Limited explored its silver-lead-zinc property.

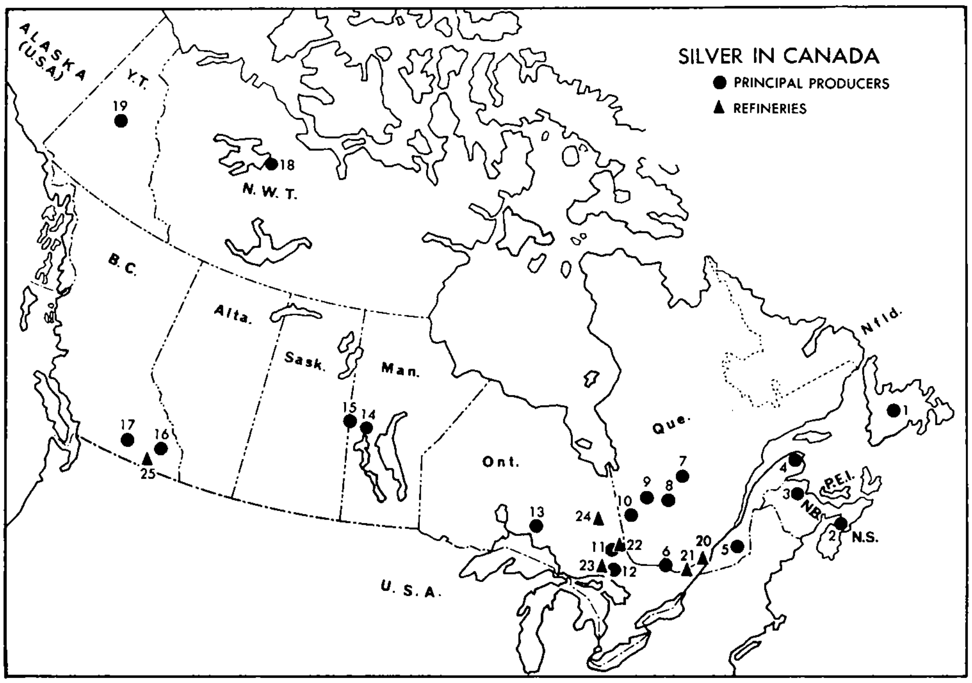
BRITISH COLUMBIA

Increased exploration and development activity was reported in many sections of the province because of higher sustained lead and zinc prices and the favourable outlook for silver. In the latter part of 1965 construction began on a 750-ton-a-day concentrator at the zinc-copper-lead property of Western Mines Limited at Buttle Lake, Vancouver Island. Production was scheduled for mid-1966. Ore reserves at September 30, 1965, totalled almost 2 million tons containing about 2.58 ounces of silver a ton. Giant Mascot Mines, Limited prepared to bring into production, on a 100-ton-a-day basis, the Estella lead-zinc mine, near Cranbrook. Ore reserves contain approximately 2.9 ounces of silver a ton.

Sirmac Mines Limited explored its silver holdings near Alice Arm. Antoine Silver Mines Ltd., Arlington Silver Mines Ltd., Reco Silver Mines Limited and Slocan Ottawa Mines Ltd. continued exploration and development at their silver-base-metal properties in the Slocan district.

MANITOBA-SASKATCHEWAN

In Manitoba and Saskatchewan all but a small portion of the silver output again came from the five base-metal mines near Flin Flon and Snow Lake, Man., operated by Hudson Bay Mining and Smelting Co., Limited. Production at one of them, the Coronation mine, ceased in August 1965 upon depletion of ore reserves. The company also continued development of two new mines scheduled for production in 1966 – its Osborne Lake mine near Snow Lake and the Flexar mine of Flexar Mines Limited



PRINCIPAL PRODUCERS
(numbers refer to numbers on the map)

1. American Smelting and Refining Company (Buchans unit)
2. Magnet Cove Barium Corporation
3. Brunswick Mining and Smelting Corporation Limited
   Heath Steele Mines Limited
4. Gaspé Copper Mines, Limited
5. Cupra Mines Ltd.
   Solbec Copper Mines, Ltd.
6. New Calumet Mines Limited
7. Opemiska Copper Mines (Quebec) Limited
8. The Coniagas Mines, Limited
9. Mattagami Lake Mines Limited
10. Lake Dufault Mines, Limited
    Manitou-Barvue Mines Limited
    Noranda Mines Limited (Horne mine)
    Normetal Mining Corporation, Limited
    Quemont Mining Corporation, Limited
11. Agnico Mines Limited
    Canadian Keeley Mines Limited
    Deer Horn Mines Limited
    Glen Lake Silver Mines Limited
    Hiho Silver Mines Limited
    Langis Silver & Cobalt Mining Company Limited
    Rusty Lake Mining Corporation
    Silverfields Mining Corporation Limited
    Siscoe Metals of Ontario Limited
12. The International Nickel Company of Canada, Limited
13. Noranda Mines Limited (Geco Division)
    Willecho Mines Limited
    Willroy Mines Limited
14. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake mine, Stall Lake mine).
15. Hudson Bay Mining and Smelting Co., Limited (Flin Flon mine, Schist Lake mine).
16. The Consolidated Mining and Smelting Company of Canada Limited (Bluebell mine, Sullivan mine)
17. Mastodon-Highland Bell Mines Limited
18. Echo Bay Mines Ltd.
19. United Keno Hill Mines Limited

REFINERIES

20. Canadian Copper Refiners Limited
21. Royal Canadian Mint
22. Cobalt Refinery Limited
23. The International Nickel Company of Canada, Limited
24. Hollinger Consolidated Gold Mines, Limited
25. The Consolidated Mining and Smelting Company of Canada Limited

(80 per cent owned by Hudson Bay), 8½ miles southwest of Flin Flon.

ONTARIO

Active exploration and development continued in the Cobalt and Gowganda areas and silver production in the district was higher than in 1964. Two mines that began production in 1964 – Hiho Silver Mines Limited and Silverfields Mining Corporation Limited – completed their first full year's operation. Three former producers that ceased operations in 1964 – Silver Summit Mines Limited, Silver Town Mines Limited, and McIntyre-Porcupine Mines, Limited (Castle Division) at Gowganda – remained idle in 1965. McIntyre, however, continued extensive underground exploration and development at its property. Rix-Athabasca Uranium Mines Limited, which produced 219,580 ounces of silver in 1964 from a leased property, dropped its lease in December of that year. Rusty Lake Mining Corporation continued mining operations and development work at its property in the Gowganda district. Since early in 1964 the company has been producing and shipping high-grade ore, with shipments in 1965 containing almost 28,000 ounces of silver. Canadian Keeley Mines Limited explored its property near Cobalt and some old mill tailings and development ore were processed in the concentrator.

Development continued at the silver-gold-lead-zinc prospect of Golsil Mines Limited in the Favourable Lake area, about 100 miles north of Red Lake. Surface diamond drilling in 1965 outlined some 600,000 tons of base-metal ore containing 7.81 ounces of silver a ton. Ontario's silver output will increase considerably when the large base-metal deposit of Texas Gulf Sulphur Company, about 15 miles north of Timmins, is brought into production. Ore reserves have been estimated at 55 million tons grading 7.08 per cent zinc, 1.33 per cent copper and 4.85 ounces of silver a ton. Development is well advanced for the open-pit mine, concentrator and related facilities. Productive capacity of the project is being increased from 2 million to 3 million tons of ore a year. Silver will be recovered mainly from the lead and copper concentrates, and in smaller amounts from the zinc concentrates. Initial production is scheduled for the latter part of 1966. At productive capacity, this mine will be the world's largest single source of silver.

QUEBEC

Quebec's silver production, derived almost entirely from gold and base-metal ores, was about 750,000 ounces higher than in 1964 mainly because of the greater output by Lake Dufault Mines, Limited, near Noranda, which completed its first full year's operation at the end of 1965. Cupra Mines Ltd. became the province's only new producer of substantial amounts of silver when it commenced production of copper-zinc-lead-silver ore late in the year at its mine near Stratford Place in the Eastern Townships.

NEW BRUNSWICK

Brunswick Mining and Smelting Corporation Limited, which in 1965 completed its first full year's operation, became Canada's third largest silver producer. Production from the main No. 12 orebody at its zinc-lead-copper-silver property near Bathurst was treated at the company's 4,500-ton-a-day mill; byproduct silver was contained in the lead and zinc concentrates produced. Construction continued on a new 2,250-ton-a-day concentrator at the No. 12 mine-site, which will treat ore from the nearby No. 6 mine. Approximately 14.8 million tons of base-metal ore, containing about 1.91 ounces of silver a ton, are available for open-pit mining at the No. 6 orebody. Heath Steele Mines Limited is sinking a new shaft on B orebody at its base-metal property about 40 miles northwest of Newcastle.

Exploration and underground development work continued at the property of Key Anacon Mines Limited about 2½ miles southeast of the No. 12 mine of Brunswick Mining and Smelting Corporation Limited. Proven base-metal ore reserves were approximately 1.8 million tons containing 2.67 ounces of silver a ton. Nigadoo River Mines Limited, a subsidiary of the Sullivan group of companies, continued development of its silver-lead-zinc-copper property 15 miles northwest of Bathurst.

TABLE 4

Principal Silver Producers in Canada, 1964–65

Company and Location	Mill Capacity (short tons/day)	Type of Ore Milled	Silver Content 1965 (1964) (oz/ton)	Ore Produced 1965 (1964) (short tons)	Contained Silver Produced 1965 (1964) (troy ounces)
British Columbia					
The Consolidated Mining and Smelting Company of Canada Limited					
Sullivan mine, Kimberly	10,000	Pb, Zn, Ag	.. (..)	2,301,071 (2,710,832)	2,839,161[1] (2,897,791)
Bluebell mine, Riondel	700	Pb, Zn, Ag	.. (..)	256,332 (257,871)	351,378 (324,174)
Mastodon-Highland Bell Mines Limited, Beaverdell	100	Ag, Pb, Zn	27.92 (32.28)	23,213 (25,090)	656,571 (809,819)
Yukon Territory–Northwest Territories					
Echo Bay Mines Ltd. Port Radium	100	Ag, Cu	52.6 (..)	30,730 (..)	1,455,522 (..)
United Keno Hill Mines Limited (Hector-Calumet, Elsa, Keno and Silver King mines), Mayo district	500	Ag, Pb, Zn	33.25 (33.37)	146,850 (181,849)	4,701,820 (5,724,070)
Manitoba and Saskatchewan					
Hudson Bay Mining and Smelting Co., Limited	6,000 (treated at central mill at Flin Flon)	Cu,Zn,Pb,Ag	0.86 (0.94)	1,640,328 (1,585,394)	1,288,624 (1,262,725)
Flin Flon mine, Flin Flon		Cu, Zn, Ag	0.90	873,934 (789,918)	
Chisel Lake mine, Snow Lake		Zn,Cu,Pb,Ag	1.27	293,221 (267,630)	
Stall Lake mine, Snow Lake		Cu, Zn	0.34	284,392 (264,645)	
Schist Lake mine, Flin Flon		Cu, Zn, Ag	1.22	109,010 (72,438)	
Coronation mine, Flin Flon		Cu, Zn	0.24	82,491 (185,069)	
Ontario					
Noranda Mines Limited (Geco Division), Manitouwadge	3,300	Cu,Zn,Ag,Pb	2.17 (2.48)	1,326,400 (1,299,300)	2,214,600 (2,468,813)
Willecho Mines Limited,[2] Lun-Echo mine, Manitouwadge	Ore custom milled	Zn,Cu,Ag,Pb	1.73 (–)	283,259 (–)	318,890 (–)
Willroy Mines Limited, Manitouwadge	1,500	Zn,Cu,Ag,Pb	1.84 (1.38)	293,989 (530,151)	365,575 (512,804)

Table 4 (cont.)

Company and Location	Mill Capacity (short tons/day)	Type of Ore Milled	Silver Content 1965 (1964) (oz/ton)	Ore Produced 1965 (1964) (short tons)	Contained Silver Produced 1965 (1964) (troy ounces)
The International Nickel Company of Canada, Limited, Sudbury, Ont., and Thompson, Man.	[3]	Ni, Cu	.. (..)	19,750,000[4] (16,439,000)[4]	1,581,000[5] (1,493,000)[5]
Agnico Mines Limited, Nipissing 407, Christopher and O'Brien mines, Cobalt district	400	Ag, Co	16.40 (11.18)	70,975 (71,489)	1,101,932 (730,709)
Canadian Keeley Mines Limited, Keeley-Frontier Mine, Cobalt district	200	Ag, Co	.. (..)	.. (..)	128,000[e] (..)
Deer Horn Mines Limited, Cross Lake O'Brien mine, Cobalt district	100	Ag, Co	12.7 (15.7)	25,092 (27,690)	319,533 (423,974)
Glen Lake Silver Mines Limited, Bailey mine, Cobalt district	100	Ag, Co	39.72 (26.76)	7,641 (23,889)	292,053 (693,253)
Hiho Silver Mines Limited, Hiho mine, Cobalt district	Ore custom milled	Ag, Co	36.54 (63.12)	23,562 (6,316)	860,876 (398,754)
Langis Silver & Cobalt Mining Company Limited, Langis mine, Cobalt district	175	Ag, Co	12.98 (18.95)	34,992 (36,762)	437,190 (713,593)
Rusty Lake Mining Corporation, Gowganda district	[6]	Ag, Co	.. (..)	1,426 (1,022)	47,766 (55,095)
Silverfields Mining Corporation Limited, Cobalt district	Ore custom milled[7]	Ag, Co	29.44 (..)	68,795 (..)	1,114,853 (650,166)[8]
Siscoe Metals of Ontario Limited, Miller-Lake O'Brien mine, Gowganda district	275	Ag, Co	18.77 (21.73)	58,049 (64,019)	1,103,785 (1,399,522)
Quebec					
The Coniagas Mines, Limited, Coniagas mine, Bachelor Lake	500	Zn, Ag, Pb	3.14 (3.68)	123,059 (114,459)	330,189 (333,591)
Cupra Mines Ltd.,[9] Cupra mine, Stratford Place	Ore custom milled	Cu,Zn,Pb,Ag	1.34 (–)	82,427 (–)	85,437 (–)
Gaspé Copper Mines, Limited, Gaspé mine, Murdochville	7,000	Cu	.. (..)	2,602,900 (2,725,300)	524,500 (521,000)
Lake Dufault Mines, Limited, Noranda	1,300	Cu, Zn, Ag	.. (2.37)	475,007 (112,117)	921,663 (192,704)

Table 4 (cont.)

Company and Location	Mill Capacity (short tons/day)	Type of Ore Milled	Silver Content 1965 (1964) (oz/ton)	Ore Produced 1965 (1964) (short tons)	Contained Silver Produced 1965 (1964) (troy ounces)
Manitou-Barvue Mines Limited, Golden Manitou mine, Val d'Or	1,300	Zn,Cu,Ag,Pb	2.85 (3.68)	168,895[10] (142,925)[10]	393,221 (409,992)
Mattagami Lake Mines Limited, Mattagami Lake mine, Matagami	3,850	Zn, Cu, Ag	1.07 (1.15)	1,406,154 (1,282,072)	350,674 (346,600)
New Calumet Mines Limited, Grand Calumet	800	Zn, Pb, Ag	3.58 (3.55)	97,586[11] (94,823)[11]	283,674[11] (289,071)[11]
Noranda Mines Limited, Home mine, Noranda	3,200	Cu, Au	. . (. .)	771,400 (897,341)	. . (. .)
Normetal Mining Corporation, Limited, Normetal mine, Normetal	1,000	Zn, Cu, Ag	1.59 (1.75)	350,693 (348,924)	382,472 (429,818)
Opemiska Copper Mines (Quebec) Limited, Chapais	2,000	Cu	0.45 (0.46)	745,976 (748,990)	281,088 (281,797)
Quemont Mining Corporation, Limited, Noranda	2,300	Cu, Zn	0.86 (0.70)	657,307 (752,691)	343,754 (358,589)
Solbec Copper Mines, Ltd., Stratford Place	1,500	Cu,Zn,Pb,Ag	1.23 (1.28)	403,869 (424,127)	295,078 (279,452)
New Brunswick					
Brunswick Mining and Smelting Corporation Limited, No. 12 mine, Bathurst	4,500	Zn,Pb,Cu,Ag	2.76 (2.60)	1,657,519 (777,902)	. . (. .)
Heath Steele Mines Limited, Newcastle	1,500[12]	Zn,Cu,Pb,Ag	2.61 (2.6)	. . (290,000)	433,621 (506,000)
Nova Scotia					
Magnet Cove Barium Corporation, Walton....	125	Ag,Pb,Cu,Zn	12.5 (12.7)	48,594 (48,927)	548,800 (524,200)
Newfoundland					
American Smelting and Refining Company (Buchans unit), Buchans	1,250	Zn,Pb,Cu,Ag	4.24 (4.07)	366,000 (383,000)	1,401,721 (1,337,825)

[1] COMINCO's total silver production, including that from purchased ores and concentrates, was 6,415,230 ounces. [2] Mine brought into production early in 1965. [3] INCO operates eight nickel-copper mines in Sudbury district and Thompson nickel-copper mine in northern Manitoba. Ores from Sudbury district mines are treated in three mills having combined daily capacity of 48,000 tons. Thompson mill has daily capacity of 6,000 tons. [4] Ore production includes output of Thompson mine in Manitoba. [5] Silver delivered to markets. [6] Produces and ships high-grade ore. [7] Company purchased 200-ton-a-day mill in August 1965 and commenced milling its own ore in December 1965. [8] Shipments via Temiskaming Testing Laboratory. [9] Mine brought into production at the end of September 1965. [10] Production does not include copper ore milled in separate circuit. In 1965, 283,875 tons of copper ore were milled. [11] Production for fiscal years ending September 30. [12] Part of Heath Steele's mill capacity used to treat copper ore from nearby Wedge mine operated by COMINCO.

[e] Estimated; – Nil; . . Not available.

USES

Although industrial uses for silver have increased and industrial consumption has grown, the metal's greatest single use continues to be in the manufacture of coinage. This is because it strongly resists corrosion, has good alloying properties, and has an attractive appearance and intrinsic value. According to Handy and Harman*, Free World consumption of silver for coinage in 1965 was 374.7 million troy ounces or 53 per cent of total consumption. The photographic industry, in which the use of silver is based on the light sensitivity and ease of reduction of certain silver compounds, is still the largest industrial outlet for the metal. Silver is well known in jewelry, silverware and silverplate manufacture for the same properties that make it popular as a coinage metal as well as for its high malleability, ductility and ability to take a fine finish.

TABLE 5

United States Silver Consumption by End Use — 1960, 1963 and 1964*
(thousands of troy ounces)

End Use	1960	1963	1964
Batteries	3,500	6,200	9,000
Brazing alloys and solders	10,500	13,000	15,750
Dental and medical	4,800	5,100	5,200
Electrical contacts and other electrical uses, electronic components	19,500	26,000	30,275
Mirrors	3,000	3,100	3,100
Missiles		200	1,000
Photographic film, plates and sensitized photographic paper	31,700	33,300	40,300
Silverware and jewelry	29,000	12,000	22,500
Miscellaneous		1,100	
Total industrial use	102,000	110,000**	127,125
Coinage	46,000	111,500	203,000

Source: *United States Congressional Record*, Senate, April 23, 1965, p. 8069.

*Total U.S. industrial and coinage uses in 1965 were forecast in the source reference at 135,325,000 and 235,000,000 ounces, respectively. **Figures in column total 100,000.

The rapid expansion of the electronics industry has caused increased demand for silver contacts, conductors, and other silver-bearing components in manufacturing electrical and electronic equipment. Silver is important as a constituent of brazing and soldering alloys, mainly 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 nearly all nonferrous metals and alloys as well as iron and silver. These solders are widely used in the manufacture of refrigeration, air-conditioning and automotive equipment, and electrical appliances. The use of silver in storage batteries has tripled in recent years. Coupled with zinc or cadmium, these batteries have a high output and long life in relation to size and weight, and are rechargeable. They are preferred where weight and dependability are critical factors as in jet aircraft, missiles, satellites, space capsules, and portable tools and appliances.

Among the more recently developed outlets for silver are the silver alloy contacts in electrical relays to control circuits in computers and tabulators. Another application is the development of photochromic glass containing silver halide for protection from solar light.

PRICES

At the beginning of the year the Canadian price was $1.3940 per troy ounce and at the end of December it was $1.3950. Throughout the year it fluctuated between a low of $1.3930, which prevailed from January 18 to 29, and a high of $1.4080 from July 9 to 14. The New York price for silver remained unchanged at $1.293 a troy ounce.

The Silver Market in 1965, compiled by Handy and Harman.

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Silver ores and concentrates	free	free	free
Silver anodes	5	7½	10
Silver in ingots, blocks, bars, drops, sheets or plates, unmanufactured; silver sweepings, silver scrap	free	free	free
Silver leaf	12½	25	30
Manufactures of silver, not otherwise provided for	17½	27½	45
Wire or strip, silver, silver-filled, nickel-silver for manufacture of jewelry	free	12½	25

United States	
Silver ores and concentrates	free
Silver bullion and silver doré	free
Silver unwrought	
Platinum-plated	32.5%
Gold-plated	50%
Other	21%
Rolled silver	21%
Silver scrap, waste, sweepings	free

Sodium Sulphate

C.M. BARTLEY*

Canadian production of sodium sulphate (salt cake) increased in 1965 to 346,000 tons from 333,000 tons in 1964 to establish a new high. Heavy demands for sodium sulphate from the kraft paper industry in Canada and the United States were mainly responsible for increased shipments. Imports were slightly lower and exports increased about 8 per cent to a new high of 116,000 tons. For the first time in many years a small amount of sodium sulphate was exported to overseas consumers.

Demand for sodium sulphate has increased steadily since 1957 and has now reached a level taxing the productive capacities of present plants. At the same time substantial expansion of kraft paper production capacity is under way and further additions to capacity are planned. To meet these near and long-term needs, three new projects were announced in 1965. These are expected to be producing in 1967. Total new capacity is about 300,000 tons per year or nearly double current output.

PRODUCTION AND TRADE

Sodium sulphate was produced by four companies from natural alkali lake deposits at five plants in Saskatchewan in 1965. A smaller amount was produced as a byproduct of a manufacturing process in a plant at Cornwall, Ontario. Production from Saskatchewan serves western and central Canadian markets and provides the major part of Canadian exports. Some Saskatchewan material is marketed in eastern Canada but the long freight haul makes it difficult to compete in this market against European and United States imports, which have lower transportation charges.

Exports of Canadian sodium sulphate have been almost entirely to the United States and have increased about 100 per cent since 1960 and almost 200 per cent since 1957. Generally about two thirds of Canadian production is consumed in Canada and one third is exported to the United States. In 1965, for the first time in many years, a small shipment of sodium sulphate was made to offshore markets in the Caribbean.

Expansion of production from its present levels will require consideration of some new factors in arriving at economic feasibility. Current producers operate where large sodium sulphate deposits of satisfactory quality were found in the most favourable geographical locations. New producers must find the best

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*Mineral Processing Division, Mines Branch

TABLE 1

Sodium Sulphate — Production, Trade and Consumption, 1964–65

	1964		1965p	
	Short Tons	$	Short Tons	$
Production (shipments)	333,263	5.222,313	346,000	5,590,312
Imports				
Total crude salt cake and Glauber's salt				
United States	21,510	399,320	16,312	313,423
Britain	8,861	187,153	12,535	209,777
West Germany	371	10,375	478	13,211
Other countries	91	2,595	22	598
Total	30,833	599,443	29,347	537,009
Exports				
Crude sodium sulphate				
United States	107,318	1,776,186	116,340	1,927,048
Other countries	—	—	5	203
Total	107,318	1,776,186	116,345	1,927,251
	1963		1964	
	Short Tons		Short Tons	
Consumption				
Pulp and paper	221,107r		236,432	
Glass, including glasswool	2,866		3,224	
Soaps	4,172		4,088	
Other products	10,176		848	
Total	238,321r		244,592	

Source: Dominion Bureau of Statistics.

p Preliminary; r Revised.

TABLE 2

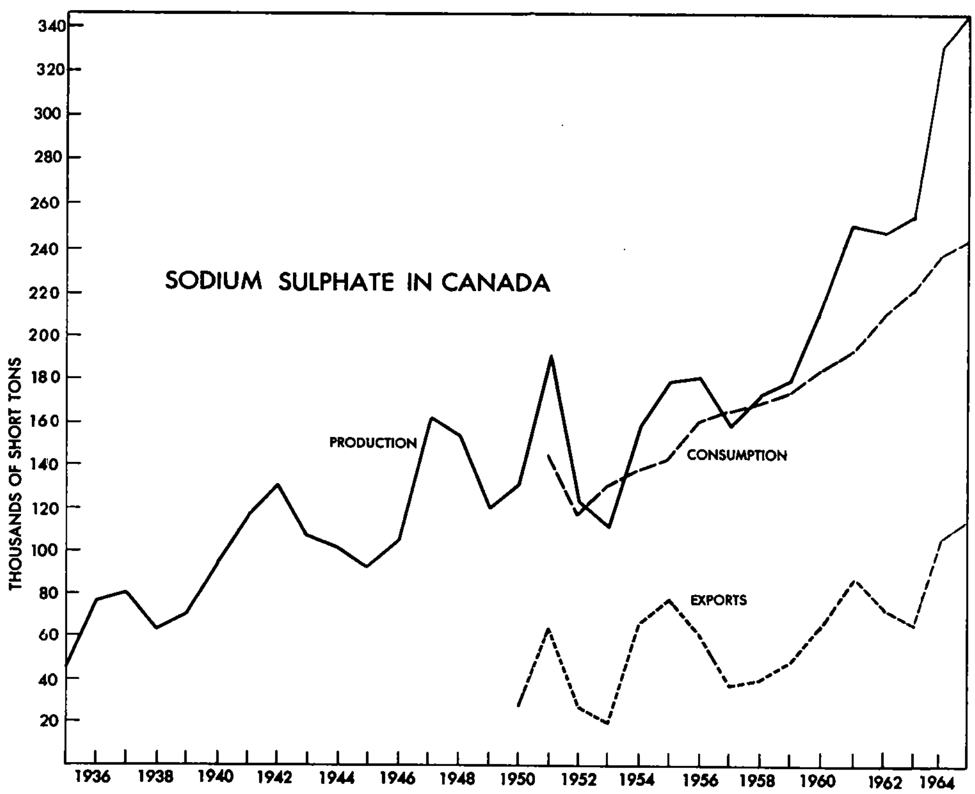
Sodium Sulphate — Production, Trade and Consumption, 1956–65
(short tons)

	Production*	Imports			Exports	Consumption
		Salt Cake	Glauber's Salt	Total		
1956	181,053	30,319	2,768	33,087	60,579	161,273
1957	157,800	28,088	1,512	29,600	37,023	163,743
1958	173,217	25,813	1,217	27,030	39,763	168,067
1959	179,535	27,157	966	28,123	47,922	171,634
1960	214,208	24,706	1,151	25,857	63,831	183,062
1961	250,996	32,310	899	33,209	87,048	200,096
1962	246,672	31,347	426	31,773	74,049	210,691
1963	256,914	19,002	495	19,497	65,348	238,321r
1964	333,263	..	..	30,833	107,318	244,592
1965	346,000p	..	..	29,347	116,345	..

Source: Dominion Bureau of Statistics.

*Producers' shipments of crude sodium sulphate.

p Preliminary; .. Not available.



remaining deposits. To obtain a deposit with large reserves it may be necessary to accept one that contains more insoluble material than that contained in presently operating deposits. Some variations in processing would be required but once the process has been decided and a suitable plant built these resources can be utilized to produce a standard commercial product. Various companies and the Saskatchewan Research Council have been active in this development research in recent years and processes are now available for deposits which formerly were difficult to treat.

PRODUCING AND DEVELOPING COMPANIES

Table 3 lists four producing companies that operate five plants in Saskatchewan with a combined annual capacity of about 400,000 tons, and three new projects with a total productive capacity of about 300,000 tons per year. Total plant and development costs for these latter three plants will amount to about $4 million. Construction will start during the summer of 1966 and all the plants are expected to be producing in 1967. The new plants are located in the southwest part of the province. Alsask is on the Saskatchewan-Alberta boundary about 90 miles north of Maple Creek and the other two plants are located northeast of Maple Creek and northwest of Swift Current.

Courtaulds (Canada) Limited, at Cornwall, Ontario, produces a few thousand tons of byproduct salt cake annually.

TABLE 3

Sodium Sulphate – Producers and Prospective Producers

Company	Plant Location	Source Lake	Reported Annual Capacity	Remarks
Midwest Chemicals Limited	Palo	Whiteshore	100,000	Operating
Ormiston Mining and Smelting Co. Ltd.	Ormiston	Horse Shoe	75,000	Operating
Sybouts Sodium Sulphate Co., Ltd.	Gladmar	East Coteau	30,000	Operating
Saskatchewan Minerals Sodium Sulphate Division	Chaplin	Chaplin	150,000	Operating
" " "	Bishopric	Fredrick	50,000	Operating
" " "	Fox Valley	Ingebright	150,000	Production planned early 1967
Sodium Sulphate (Saskatchewan) Ltd.	Alsask	Alsask	50,000	Production planned 1967
Tombill Mines Limited	Cabri	Snake·Hole	100,000	Production planned mid-1967

DEPOSITS

Sodium sulphate is found in many lakes and ponds of southern Saskatchewan in the form of permanent or intermittent crystal beds and in the brines which cover them. Sulphates in the soil are dissolved by the water from rain and snow and the solutions accumulate in closed drainage basins. Summer evaporation reduces the water content of the brine and the solution becomes more concentrated. In the fall and winter the brine chills to the point of crystallization, and a bed of crystals is deposited at the bottom of the lake. The seasonal repetition of this cycle over a long period of time has accumulated thick beds of sodium sulphate crystals in numerous lakes.

Sodium sulphate occurs in nature as Glauber's salt or mirabilite (Na_2SO_4, $10H_2O$) and occasionally as thenardite (Na_2SO_4) or anhydrous sodium sulphate. Both minerals are soluble in water and solubility increases as the temperature rises. The fact that solubility varies with temperatures is used advantageously in Saskatchewan to recover a relatively pure product from the natural occurrences.

Reserves in Saskatchewan lakes have been estimated at more than 200 million tons. Fifteen deposits have been estimated to contain at least 1 million tons each. Similar though smaller deposits occur in Alberta and British Columbia.

RECOVERY AND PROCESSING

The first recovery of sodium sulphate from Saskatchewan lakes, some 15 tons in 1919, was obtained by harvesting raw crystal from dried and frozen lake beds in the winter. Refinements of this method are still used but most of the production is now obtained by pumping concentrated lake brine to prepared reservoirs in the late summer and recovering the crystal which is deposited when cold weather chills the brine in the fall. These operations are carefully timed and controlled so that brine is pumped from the lake at its highest estimated concentration for that particular season. Just before precipitation is complete the remaining liquid, which now contains a small amount of sodium sulphate and a concentration of some undesirable elements, is pumped back to the lake. This procedure concentrates the sodium sulphate in a clean-floored enclosure and removes much of the unwanted elements present in the natural brine, to provide a relatively high-grade product. The crystal bed is later removed to the plant by scrapers, shovels and draglines. One company, Ormiston Mining and Smelting Co. Ltd., uses a floating dredge to excavate crystal from the lake bottom and to pump it in brine through a 10-inch pipeline directly to the plant.

Processing consists essentially of removing water and dehydrating the natural crystal to an anhydrous powder using equipment such as submerged combustion units, evaporators and rotary kilns. In recent years rotary kilns have been used mostly for final drying of the product rather than for bulk dehydration. The end product is usually marketed as a bulk product grading about 97 per cent Na_2SO_4.

The availability of natural gas in Saskatchewan has had a favourable effect on efficiency and economics at several plants, mainly as savings on storage, maintenance and corrosion costs, which were appreciable when fuels such as low-grade coal or heavy oils were used.

INDUSTRY ACTIVITIES AND OUTLOOK

A comprehensive investigation of Saskatchewan sodium sulphate occurrences by L.H. Cole of Mines Branch, Ottawa, from 1921 to 1924 provided the basic information for present operations. This general exploration and technical study was followed by detailed exploration and process development at various locations. The industry has been aware of the increasing use of kraft pulp. Recently, various industry and government organizations have conducted exploration on unworked deposits and sponsored research directed to the more efficient operation of present processes and the development of new ones to suit particular occurrences.

Production of sodium sulphate in 1965 appears to be close to the nominal capacity of present plants. The effect that unfavourable weather might have on the harvest of crystals in any one year has been considered and all companies maintain considerable stockpiles of raw crystals to insure some supply. However, any extended period of unfavourable weather when demand is increasing might restrict output from some plants. For these reasons exploration and process development have been carried out in preparation for industry expansion. At some lakes, reserves and brine conditions are such that additional processing capacity at present plants would assure increased production. At other deposits, one or more dry years might reduce the brine volume and seriously restrict the output of the plant. To maintain and expand production under such circumstances it has been necessary to develop some of the untapped deposits and construct new processing plants.

The decision to expand sodium sulphate production capacity has been complicated by the announcement of a pulping process which eliminates the need for sodium sulphate. The Rapson process, developed by Dr. Howard Rapson of the University of Toronto and Electric Reduction Company of Canada, Ltd., uses sulphur, salt and limestone to produce the chemicals, including sodium sulphate, required for the process. The process reportedly permits significant cost savings and closer control of processing efficiency but it is too early to judge its acceptance by the pulp industry.

In Alberta, Western Minerals Ltd. has investigated the potential of the Metiskow sodium sulphate deposit but no decision regarding development has been announced.

In general the outlook for the Canadian sodium sulphate industry is favourable. Demands for kraft paper are increasing in Canada and the United States and production of sodium sulphate will have to be increased to satisfy requirements. Other consumer markets, though presently minor, show some increase.

The possibility has been considered of combining sodium sulphate in the form of brine or solid with potassium chloride, which is now in large-scale production in Saskatchewan, to produce potassium sulphate fertilizer. Several methods have been investigated and production of this type of fertilizer based on a process developed by the Saskatchewan Research Council, is reported to be under consideration by Tombill Mines Limited.

USES AND SPECIFICATIONS

More than 95 per cent of sodium sulphate consumed goes into kraft paper, to which it adds strength and toughness. Some is used in the manufacture of newsprint, where an increase in wet strength permits the operation of production machinery at higher speed. Sodium sulphate is also consumed in the manufacture of glass, detergents, mineral-feed supplements, in base-metal smelting, in chemical and medicinal products and as a soil conditioner.

The physical and chemical specifications for sodium sulphate vary. Material of 95 per cent Na_2SO_4 content has been used for kraft paper but higher grades are desirable. Glass, detergent and chemicals require grades of about 98 per cent. Fine chemicals and medicinal products call for grades above 99 per cent. For detergents a high degree of whiteness is desired.

Uniform grain size, consistent quality and free-flowing characteristics are important in handling and use.

PRICES

The Canadian price of sodium sulphate (salt cake) bulk, carload, f.o.b. works as reported by *Canadian Chemical Processing* in October 1965 was $16.50 a ton.

According to the *Oil, Paint and Drug Reporter* of December 27, 1965, United States prices of sodium sulphate were:

	(per short ton)
Detergent, rayon-grade, car lots:	
bags	$38
f.o.b. works, bulk	34
Crude (salt cake), 100% Na_2SO_4, domestic, bulk, f.o.b. works	28

TARIFFS

Canada	
Crude (salt cake), per lb	
British Preferential	1/5¢
Most Favoured Nation	1/5
General	3/5
United States	
Crude, or crude salt cake	free
Anhydrous, per long ton	$0.50
Crystallized, or Glauber's salt, per long ton	1.00

Stone, Building and Ornamental

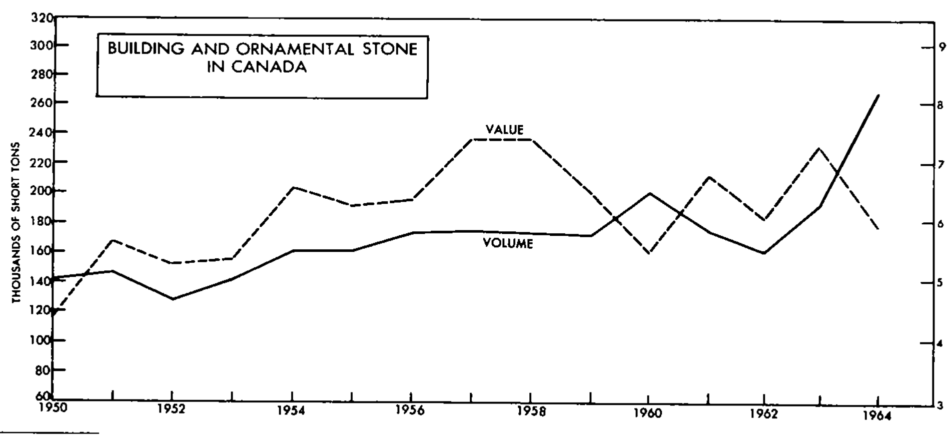
F.E. HANES*

There is no estimate for the 1965 production of building and ornamental stone due to the lack of specific statistical information.

To estimate a value for building and ornamental stone production in Canada for any year is extremely difficult due to the complexity of the statistical reports of the commodities. Statistics for individual rock types are not immediately available. Also, a comparison between 1964 and 1963 figures shows, by their extreme fluctuations in both volume and value for the commodities, the danger of direct interpolation. Since average values for stone materials are widely variable for different types, difficulty is encountered when comparing estimated annual values.

Statistics in reports from some of the provinces, where detail has been given, show increases in production for 1965 for some of the stone commodities. Also the trend shown in building materials, structural materials and the total mineral production in Canada all indicate marked increases in 1965 compared with the 1964 values. These trends should be considered, coupled with firsthand knowledge of the industry's growth, when attempting to evaluate the potential wealth of the industry.

British Columbia, for example, showed increased value in building stone production of $118,975 for 1965 compared with $25,522 in 1964. Cement, lime and limestone, rubble, riprap and crushed stone, and sand and gravel production all show increases in value of from 12 to 50 per cent for the same period. Note the increased value in production of building stone amounting to 366 per cent; an anomalous situation such as this makes estimating very difficult. Total structural materials in British



*Mineral Processing Division, Mines Branch

Columbia increased from $26.4 to $32.3 million from 1964 to 1965 according to preliminary figures by the province. The value for total structural materials after recent adjustments by the Dominion Bureau of Statistics is $37.4 million for this figure.

The Province of Nova Scotia, using a different tabulation, shows total production for granite, building and ornamental stone to be 517 net tons in 1963, 460 in 1964 and 525 in 1965. This is an increase in granite production for 1965 of 14 per cent. Sandstone production in 1965 of ornamental and building stone remained at the 10,000 ton volume it had attained in 1964. Only 9,000 tons were produced in 1963. The production of a quartzite building material in Nova Scotia decreased from 3,458 tons to 2,050 tons (1964 to 1965) but was still almost double the 1963 volume of 1,216 tons. Total structural materials produced in 1965 amounting to $8.7 million was an increase over 1964 of greater than 24 per cent.

Both Quebec and Ontario show increases in production of total structural materials and total mineral production. Total structural gains are slight, being less than 1 per cent for Quebec and 3 to 4 per cent for Ontario. The total mineral production for Quebec is less than a 2.5 per cent increase, while Ontario has a 9.4 per cent increase in the same category.

Increased production in 1965 over 1964 for Manitoba building stones is reported, while production of stone during 1966 continues to increase.

Statistics of New Brunswick's total structural materials and total mineral production show that the former dropped in value from $9.36 million to $9 million while the latter increased by about 73 per cent from $48.7 to $83.9 million from 1964 to 1965.

The total value of construction in Canada increased almost 15 per cent from its 1964 value of $8.63 billion to $9.91 billion in 1965. Building construction makes up almost 60 per cent of this total, or $5.88 billion, which showed an increase of 13.5 per cent over the 1964 value of $5.18 billion.

The total value (preliminary) for all structural materials produced in 1965 amounted to $423.2 million, a 5 per cent increase over the 1964 value (revised statistic) of $403,058,324. When compared with the $379,011,116 value for 1963 (6.3 per cent increase in 1964) the period from prior to 1963 to the present shows a definite trend of increased production of structural materials.

The total mineral production for Canada, amounting to $3.05, $3.39 and $3.74 billion for the years 1963, 1964 and 1965, respectively, shows consistent increases of 11.2 and 11.5 per cent for 1964 and 1965, respectively.

Building and ornamental stones share this increased productivity of structural material, and the more the architect, consumer and public are made aware of the aesthetic and durable qualities of our natural stone resources, the greater will be this share.

TABLE 1

Canadian Production of Building and Ornamental Stone, 1964[r]

	1964	
	Short Tons	$
By type		
Granite	158,733	3,632,507
Limestone	67,635	1,357,844
Marble	1,797	78,209
Sandstone	41,017	813,819
Total	269,182	5,882,379
By areas		
Atlantic provinces	4,943	395,949
Quebec	168,149	3,662,799
Ontario	82,647	1,438,091
Western provinces	13,443	385,540
Total	269,182	5,882,379

Source: Dominion Bureau of Statistics.
[r]Revised.

The total volume of stone for all types of rock produced in 1964 amounted to 269,182 short tons which is a 38 per cent increase over the 1963 production of 195,098 short tons. However, this represents a decrease in value of almost 17 per cent, dropping from $6,866,689 in 1963 to $5,882,379 in 1964.

TABLE 2

Production of Building and Ornamental Stone, 1964[r]

	Granite		Limestone		Marble		Sandstone		Total	
	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$
By type										
Building										
Rough	123,107	716,388	29,725	295,714	1,453	64,609	31,209	456,816	185,494	1,533,527
Dressed	15,213	1,617,827	32,212	1,027,391	—	—	4,540	282,600	51,965	2,927,818
Total	138,320	2,334,215	61,937	1,323,105	1,453	64,609	35,749	739,416	237,459	4,461,345
Monumental										
Rough	8,311	316,875	—	—	—	—	—	—	8,311	316,875
Dressed	6,364	807,168	—	—	300	12,500	—	—	6,664	819,668
Total	14,675	1,124,043	—	—	300	12,500	—	—	14,975	1,136,543
Flagstone	625	9,063	5,698	34,739	44	1,100	4,448	62,563	10,815	107,465
Curbstone	5,113	165,186	—	—	—	—	—	—	5,113	165,816
Paving	—	—	—	—	—	—	820	11,840	820	11,840
Total	5,738	174,249	5,698	34,739	44	1,100	5,268	74,403	16,748	284,491
Grand Total	158,733	3,632,507	67,635	1,357,844	1,797	78,209	41,017	813,819	269,182	5,882,379
By areas										
Atlantic provinces	3,383	309,974	—	—	—	—	1,560	85,975	4,943	395,949
Quebec	148,350	3,206,035	12,126	385,784	405	4,710	7,268	66,270	168,149	3,662,799
Ontario	3,153	43,885	46,286	670,373	1,392	73,499	31,816	650,334	82,647	1,438,091
Western provinces	3,847	72,613	9,223	301,687	—	—	373	11,240	13,443	385,540
Total, Canada	158,733	3,632,507	67,635	1,357,844	1,797	78,209	41,017	813,819	269,182	5,882,379

[r]Revised

There is an increased production of rough granite building stone in 1964 amounting to 123,107 short tons compared with the same commodity in 1963 which amounted only to 28,429 short tons. This rough granite was valued at an average price of $20.80 per ton in 1963, while its counterpart was valued at an average price of $5.80 in 1964. The situation is also true (to a lesser degree) for limestone rough blocks which were sold at $15.70 a ton in 1963 and dropped to $9.95 per ton in 1964. Marble however exhibited a reversal of the granite and limestone trends. Rough marble building stone in 1963 averaged $12.30 per ton while the average value for the 1964 product increased to $44.50 per ton. The average price per ton for sandstone as rough building blocks in 1964 remains virtually unchanged from 1963.

Possibly this increased use of rough stone materials from the quarries and dressing plants is an effort to compete with the ceramic, plastics, and artificial stone and concrete producers, resulting in lower valued products.

IMPORTS AND EXPORTS

The value of building and ornamental stone imported into Canada in 1965 was $3,183,217, a decrease of 7.3 per cent from the 1964 value of $3,436,560. The greater part of this decrease is accounted for in the value of imported marble. Both rough and dressed blocks are involved in the decrease which amounted to 13.1 per cent.

Exports from Canada amounting to a value of $1,137,722 are slightly lower in 1965 compared with the 1964 value of $1,184,030, a decrease of 3.9 per cent.

TABLE 3

Building and Ornamental Stone, Imports and Exports

	1964		1965	
	Short Tons	$	Short Tons	$
Imports				
Granite				
Rough	13,148	565,543	13,753	565,555
Dressed	..	218,704	..	232,793
Total		784,247		798,348
Marble				
Rough	2,429	176,313	1,515	121,830
Dressed		1,627,299	..	1,445,021
Total		1,803,612		1,566,851
Building stone, rough, n.e.s.	17,610	476,094	11,778	399,015
Natural stone basic products, n.e.s.[1]	..	372,607	..	419,003
Total imports		3,436,560		3,183,217
Exports				
Building stone, rough	22,254	499,786	20,611	605,374
Natural stone basic products[2]	..	684,244	..	532,348
Total exports		1,184,030		1,137,722

[1]Natural stone basic products including flagstones, floor tiles, roofing slate, slate mantels, etc. [2]Shaped and dressed stone, granite, marble, slate.
.. Not available; n.e.s. Not elsewhere specified.

CANADIAN DEPOSITS OF BUILDING AND ORNAMENTAL STONE

Not all deposits of rock are amenable for the production of sound, unfractured, massive and suitably coloured dimension stone. Quebec and Ontario are the two provinces which are producing, or have the potential to produce granite, limestone, marble and sandstone materials. Nova Scotia produces granite and sandstone rocks for building stones. New Brunswick has granite and sandstone production with potential deposits of marble in the St. John area. Manitoba has production of granite and limestone while British Columbia's production of building stone is principally restricted to granite. Alberta produces a silty quartzite from the Rocky Mountain area for use as a building block. Prince Edward Island has very limited production (if any) from weakly consolidated deposits of sandstone near Charlottetown. Newfoundland has outcrops of igneous and sedimentary rocks which are quarried for local use; the province is inconveniently located for more distant markets.

The following types of stone are being produced or are potentially available for production.

GRANITE

Nova Scotia. Grey granite is produced near Halifax, Middleton-Nictaux and Shelburne and black diorite is quarried in the Shelburne area. A hard, siliceous type of stone referred to as 'iron stone' is produced near Halifax, and quartzitic rocks referred to as 'blue stone' are produced in the Ostrea Lake and Echo Lake areas northeast of Dartmouth.

New Brunswick. A coarse- to medium-grained, grey-brown granite is sporadically quarried near St. Stephen, and fine- to medium-grained, grey, pink and blue-grey granites are quarried in the Hampstead (Spoon Island) district. A brown, pink-grey, coarse-grained granite is quarried sporadically near Bathurst. A deposit of light pink to salmon-coloured, medium-grained granite is quarried in the Antinouri Lake district. A black ferromagnesian rock containing plagioclase feldspar, augite, pyroxene, and hornblende is quarried in the Bocabec River area.

Quebec. Numerous quarries south of the St. Lawrence River supply fine- to medium-grained, grey and grey-white granites. These quarries are in the vicinities of Stanstead, Stanhope, St -Samuel-St -Sebastien and St -Gerard. Fine- and medium-grained, dark grey-blue essexite is quarried on Mont-St -Gregoire. A coarse-grained, dark green nordmarkite is available from the Lake Megantic mountain area. A fine-grained, apple-green granite is also produced near St -Gerard.

North of the St. Lawrence River, red, brown and black granites are quarried in the Lake St. John-Roberval-Chicoutimi area; anorthositic black rocks are quarried north of Alma on the banks of the Peribonka River and from the St -Ludger-de-Milot area. Blue-grey, rose-grey, deeper pink-grey, dark green, black and grey gneissic granites come from the Rivière-à-Pierre district; pink, fine-grained granite is quarried at Guenette, near Mt -Laurier. St -Alban supplies a pink-red granite and St -Raymond a banded gneiss. Brown-red to green-brown granites are quarried in the Grenville district. An augen-type, coarse-grained, rose-pink granite is located south of Mont-Tremblant. A mauve-red granite is produced in the Ville-Marie area on Lake Timiskaming. A dark-coloured anorthositic-type rock is found in the Rouyn area.

Ontario. A salmon-pink, medium-grained granite is available near Kenora at Vermilion Bay. A black anorthosite is produced in the River Valley area near North Bay. Rough building blocks are quarried near Parry Sound from a multicoloured gneissic rock. Potential red granites are available in the Lynhurst and Gananoque areas. Deposits of black and red granite along the north shore of Lake Superior are potential producers of dimension stone. A pink granite deposit located near Belmont Lake shows good potential.

Manitoba. A durable, red granite of good quality is being quarried in the Lac du Bonnet area, 70 miles northeast of Winnipeg.

British Columbia. A light grey and blue-grey, even-grained granite is available from both Nelson Island and from Granite Island.

LIMESTONE

New Brunswick. Limestone for building construction is produced in the Saint John area.

Quebec. A fine- to medium-grained, fossiliferous, brownish grey limestone is produced in the vicinity of St -Marc-des-Carrières. The stone, besides being used in rough and sawn finishes, takes a good polish and is suitable for decorative use. Rough building stones are produced in small quantities from quarries near Montreal particularly on Ile-Jésus, north of the city. Small amounts of building blocks are quarried at scattered points in the province for local use.

Ontario. Much of Ontario's production comes from deposits of a dense, hard, grey-blue limestone in the Niagara Falls area. A thin-bedded, dense, buff to buff-grey limestone is quarried on the Bruce Peninsula near Wiarton and Owen Sound and some dark grey limestone is quarried near Ottawa.

Manitoba. A mottled, buff-brown to grey-brown dolomitic limestone is obtained from quarries in the Garson area. It is effectively used in rough and sawn finishes and can take a polish for use as a decorative stone.

SANDSTONE

Nova Scotia. A massive-textured, fine- to medium-grained, olive-buff stone is quarried in the Wallace area.

New Brunswick. A red, fine- to medium-grained sandstone is available from an old quarry in Sackville. Numerous local-use deposits are situated about the province.

Quebec. A deposit of buff and red sandstone is being quarried in the Trois-Pistoles area.

Ontario. From thin-bedded sandstone deposits, numerous quarries along the scarp face of the Caledon Hills, between Georgetown and Orangeville, produce a fine-grained, sometimes mottled or speckled building stone that is vari-coloured in light buff, brown and deep brown-red. Medium-grained, buff- to cream-coloured stone near Bells Corners is available. A highly coloured, medium-grained, banded and mottled sandstone is produced from deposits 20 miles north of Kingston.

Alberta. A hard, very fine grained, medium-grey sandstone, sometimes referred to as 'rundle stone', is quarried near Banff. It is used as rough building stone.

MARBLE

Quebec. A small quantity of light and dark grey, green-white mottled marble is quarried in the Philipsburgh area, near the United States border south of Montreal. Sporadic quarrying of a white-grey marble is carried on in the western part of the Stukely area. A grey, mottled marble is potentially available from near Marbleton.

Ontario. Production of blue, blue-white, buff, white and grey, recrystallized limestone marbles is available in an area extending from Perth to Almonte. Also available from this area is a serpentinized marble. Potential sources of marble are being investigated as far west as Peterborough and as far north as Bancroft.

Sulphur

C.M. BARTLEY*

The growing world shortage of sulphur in relation to current demand became serious in 1965. It resulted in problems for producers, who could not supply all markets, and consumers, who had difficulty obtaining sulphur, even at increased prices. Against this background Canadian production of sulphur in all forms increased about 10 per cent compared to 1964 production and at year's end efforts were under way to expand production from several sources. Elemental sulphur shipments increased about 6 per cent to 1.9 million tons and exceeded output by drawing on stocks accumulated in past years.

Sulphur imports and exports were higher in 1965 than in 1964 and Canadian consumption of sulphur increased over the 0.54 million tons reported in 1964 although complete data are not available to indicate the amount. New demands, for expanded phosphate fertilizer production and increasing pulp and paper output, are now adding to sulphur consumption. These, together with renewed interest in uranium production, will require additional supplies in the future.

Sulphur production from sour gas in Alberta and British Columbia showed the largest gain of all Canadian sources and is expected to double to nearly 4 million tons by 1970. Several price increases in the past year have made sulphur production highly attractive and aggressive efforts are now under way to expand output from sour gas and several other sources. In particular, sources of very sour gas in Alberta are receiving considerable attention. Sulphur will be obtained from the Great Canadian Oil Sands Limited in 1968, and from expansions and new projects using smelter gas and pyrites, which were under way or being planned in 1965.

The pressing world shortage of sulphur has been caused by unexpectedly high demands from many industries but is mainly attributable to the remarkable and continuing expansion in the world fertilizer industry. Some 30 to 40 per cent of world sulphur is consumed as sulphuric acid to produce phosphate fertilizers. Over the past three years world sulphur consumption has increased at annual rates about twice as high as the historical average of 4 to 5 per cent. To date the sulphur deficits have been balanced by withdrawals from accumulated stocks but these are now seriously depleted and there seems to be little likelihood of any decrease in demand. Because of food-fertilizer requirements, demand may soon rise still further. On the basis of production and trade data, and considering the evident trends in industrial activity, a basic change appears to be taking place in world demands for raw materials. As a leading indicator of industrial activity and as a primary requirement for fertilizer in the expanded food program, sulphur would be one of the first commodities to highlight these new demands. Because of its highly diversified and world-wide use, sulphur production clearly must be increased, and further price increases may be necessary to encourage the necessary output.

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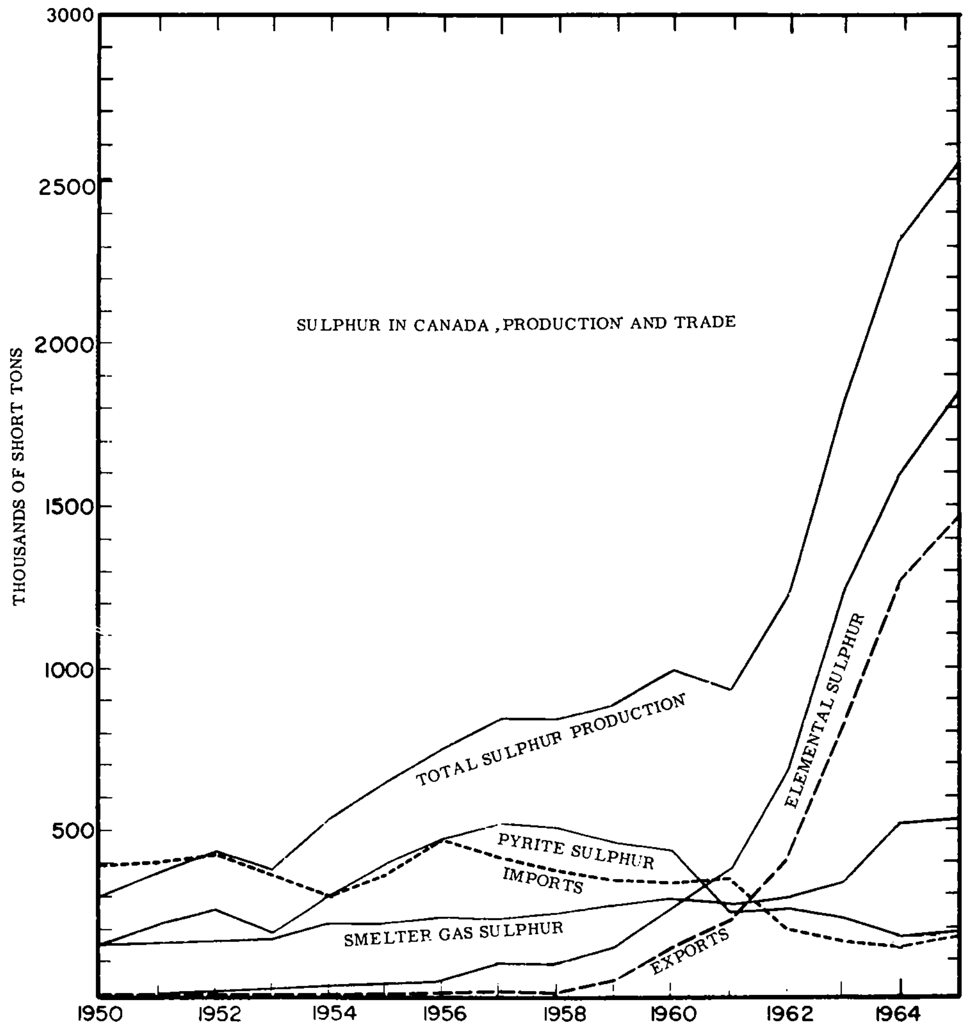


TABLE 1

Sulphur – Production and Trade, 1964-65

	1964		1965P	
	Short Tons	$	Short Tons	$
Production				
Pyrite and pyrrhotite[1]				
Gross weight	351,850		352,808	
Sulphur content	173,182	1,126,167	174,503	1,889,226
Sulphur in smelter gases[2]	443,448	4,261,912	513,122	5,055,120
Elemental sulphur[3]	1,788,165	18,637,597	1,907,723	23,481,947
Total sulphur content	2,404,795	24,025,676	2,595,348	30,426,293

Table 1 (cont.)

	1964		1965p	
	Short Tons	$	Short Tons	$
Imports				
Sulphur, crude or refined				
United States	149,527	3,470,839	162,051	3,821,092
Mexico	—	—	100	2,160
France	40	3,682	50	5,627
Total	149,567	3,474,521	162,201	3,828,879
Exports				
Sulphur in ores (pyrite)				
United States	..	846,570	..	903,358
Japan	—	—	..	53,460
Other countries	..	31,975	..	22,010
Total		878,545		978,828
Sulphur, crude and refined				
United States	633,293	7,986,280	741,723	9,311,259
Australia	143,761	2,488,843	202,408	4,117,033
Republic of South Africa	34,970	577,585	77,786	1,760,945
Hungary	5,040	80,640	74,978	1,512,993
Taiwan	87,335	1,590,792	73,117	1,789,725
Japan	13,302	422,498	46,330	1,347,190
India	5,947	101,568	45,359	1,389,045
Venezuela	23,864	387,624	34,470	946,541
New Zealand	47,899	734,487	34,071	738,163
Poland	15,445	275,800	29,108	556,184
Belgium and Luxembourg	—	—	23,465	430,332
Greece	23,589	448,191	23,140	612,213
Other countries	260,142	4,431,353	91,992	1,979,469
Total	1,294,587	19,525,661	1,497,947	26,491,092
Consumption				
Elemental sulphur	544,392r		585,441	

Source: Dominion Bureau of Statistics.
[1]Producers' shipments of byproduct pyrite and pyrrhotite from the processing of metallic-sulphide ores.[2] Includes also sulphur in acid made from roasting zinc-sulphide concentrate. [3]Producers' shipments of elemental sulphur produced from natural gas. Includes a small quantity of elemental sulphur derived from treatment of nickel-sulphide matte at Port Colborne, Ontario.
pPreliminary; —Nil; ..Not available; rRevised.

PRODUCTION, TRADE AND CONSUMPTION

Canadian production of sulphur from all sources increased moderately to a total of more than 2.59 million tons. Output from the major source, sour natural gases in Alberta and British Columbia, was slightly higher in 1965 than in 1964 and current and planned expansion will add some 600,000 tons per year to capacity by 1967. Increased prices and pressing demands for sulphur now provide incentive to use the high sulphur-content sour gas sources which were avoided a few years ago.

Smelter gas sulphur is produced where markets, or uses, for sulphuric acid are available near the smelter. These producers are often captive or closely integrated with other industries and expansion of this form of sulphur production is thus highly attractive because consumers are assured of supplies at a time when elemental sulphur prices are rising and increasing requirements may be difficult to obtain. Recent expansions at Trail, Sudbury and Valleyfield serve to illustrate this.

Pyrites production recorded a small gain, compared to 1964. This source of sulphur is expected to be used increasingly in the future.

TABLE 2

Consumption of Elemental Sulphur in Canada, 1963–64

(short tons)

	1963	1964
Chemicals, miscellaneous*	129,318	140,526
Pulp and paper	332,550r	306,830
Rubber products	3,125	2,257
Fertilizers	50,131	59,857
Iron and steel and foundry	1,375	8,445
Other industries**	41,951	26,477
Total	558,450r	544,392

*Includes pesticides.**Includes cleansers, detergents, soaps, glass and glass products, adhesive, explosives, starch, sugar processing and titanium and uranium processing.

rRevised.

TABLE 3

Sulphur – Production, Trade and Consumption, 1956–65

(short tons)

	Production					Exports		
	In Pyrites Shipped[1]	In Smelter Gases[2]	Elemental Sulphur[3]	Total	Imports Elemental Sulphur	In Pyrite[4]	Other Sulphur[5]	Consumption Elemental Sulphur[6]
1956	473,605	236,088	33,464	743,157	474,117	$2,649,349	4,331	431,202
1957	515,096	235,123	93,327	843,546	416,930	2,852,753	12,364	480,941
1958	512,427	241,055	94,377	847,859	375,331	1,879,251	7,608	515,047
1959	465,611	277,030	145,656	888,297	332,430	1,018,608	26,526	483,482
1960	437,790	289,620	274,359	1,001,769	328,765	1,259,151	143,040	507,810
1961	255,376	277,056	394,762	927,194	329,556	899,755	217,866	513,048
1962	257,084	292,728	695,098	1,244,910	195,089	890,055	400,026	522,903
1963	235,410	353,243	1,249,887	1,838,540	150,637	937,883	820,929	558,450r
1964	173,182	443,448	1,788,165	2,404,795	149,567	878,545	1,294,587	544,392
1965	174,503	513,122	1,907,723	2,595,348	162,201	978,828	1,497,947	585,441

Source: Dominion Bureau of Statistics.

[1]Sulphur content of pyrite and pyrrhotite shipped by producers. Not necessarily all recovered. Pyrite used to make byproduct iron sinter in 1961, 1962 and 1963 not included. [2]Sulphur in liquid sulphur dioxide and sulphuric acid from the smelting of metal-sulphide ores. For 1956 and years following includes sulphur in acid made from roasting zinc-sulphide concentrates. [3]Elemental sulphur produced from natural gas. Production for the year 1956 and sales from 1957 on. Starting in 1957 elemental sulphur derived from the treatment of nickel-copper sulphide matte at Port Colborne, Ontario is included. [4]Exports of pyrite, sulphur content. Quantities for 1956 and following years are not available for publication. [5]Exports of sulphur produced from natural gas and other sources. [6]Consumption of elemental sulphur by industries as reported by consumers.

pPreliminary; . .Not available; rRevised.

Sulphur imports increased 8.5 per cent to 162,000 tons and exports more than 15 per cent to almost 1.5 million tons. The value of sulphur exports was higher by 35 per cent as prices advanced. Exports of sulphur in pyrite showed a gain in value of $100,000 to $978,828. Industrial nations consume most of their sulphur as sulphuric acid. Consumption of sulphur in Canada shows the normal wide diversity of end-use and, in addition, the unusual feature of a relatively high consumption of non acid sulphur by the large Canadian pulp and paper industry. Sulphuric acid consumption is expanding rapidly in Canada as it is in other countries and additional sulphur will be required for current expansions in the pulp and paper industry.

PYRITES—PYRITE, PYRRHOTITE AND OTHER SULPHIDES

In recent years little pyrites has been consumed in Canada for sulphur production and, although pyrites has been exported continuously for more than 70 years, the value of exports in 1965 had decreased to one third of those of 1957. The continuing shortage of sulphur is expected to encourage the use of pyrites in Canada and exports may again increase.

Domestic pyrites resources are very large but rarely received serious attention. When elemental sulphur was available and low priced the location of most pyrites deposits made them only marginally competitive. Current supply and price considerations in the sulphur industry encourage reappraisal of pyrites as a source of sulphur, iron and possibly other recoverable metals. Pyrites resources consist of iron sulphide deposits, often with small but recoverable amounts of base or precious metal, and also, very large volumes of byproduct pyrite or pyrrhotite concentrate which could be recovered at currently producing base-metal mines. Byproduct pyrrhotite is now used as a source of iron by COMINCO and INCO and several other companies are planning to recover the iron and sulphur values of such concentrates.

Pyrites concentrates have been used extensively as a source of sulphur in Europe and Japan because elemental sulphur has been less available and costlier, but in North America Frasch-mined sulphur largely replaced pyrites 50 years ago. Although production of elemental sulphur from Frasch and other sources will increase, it appears likely that prices must rise to achieve this and such increases will improve the competitive position of pyrites. Known sources of elemental sulphur appear inadequate for expected long-term world needs and pyrites certainly will be increasingly used. North America has most of the world's present capacity to produce elemental sulphur and it is unlikely that pyrites deposits as such will be mined and processed for sulphur. However, more byproduct pyrites probably will be used.

Canadian producers of pyrites are listed in Table 4 with general information on the nature of their operation.

TABLE 4

Producers of Pyrite and Pyrrhotite for Sulphur Content

Company and Location	Products	Uses
The Consolidated Mining and Smelting Company of Canada Limited, Kimberley, B.C.	SO_2 iron ore	H_2SO_4 steel plant
Noranda Mines Limited, Noranda, Que.	pyrite concentrate	sale
Quemont Mining Corporation, Limited, Noranda, Que.	pyrite concentrate	sale
Normetal Mining Corporation, Limited, Normetal, Que.	pyrite concentrate	sale

SMELTER GAS

Smelter gas was first recovered and used as a source of sulphur in Canada in 1928. Since that time output has increased steadily to its current level of 513,122 tons. Low to moderate amounts of sulphur dioxide (SO_2) in the waste gases from smelting operations are collected, concentrated and converted into sulphuric acid (H_2SO_4) or liquid sulphur dioxide. There are fairly rigid limits to the use of smelter gas as a source of sulphur because the logical product is sulphuric acid and although this acid is valuable and widely used its corrosive characteristics make it dangerous and costly to transport. Sulphuric acid is rarely shipped

TABLE 5

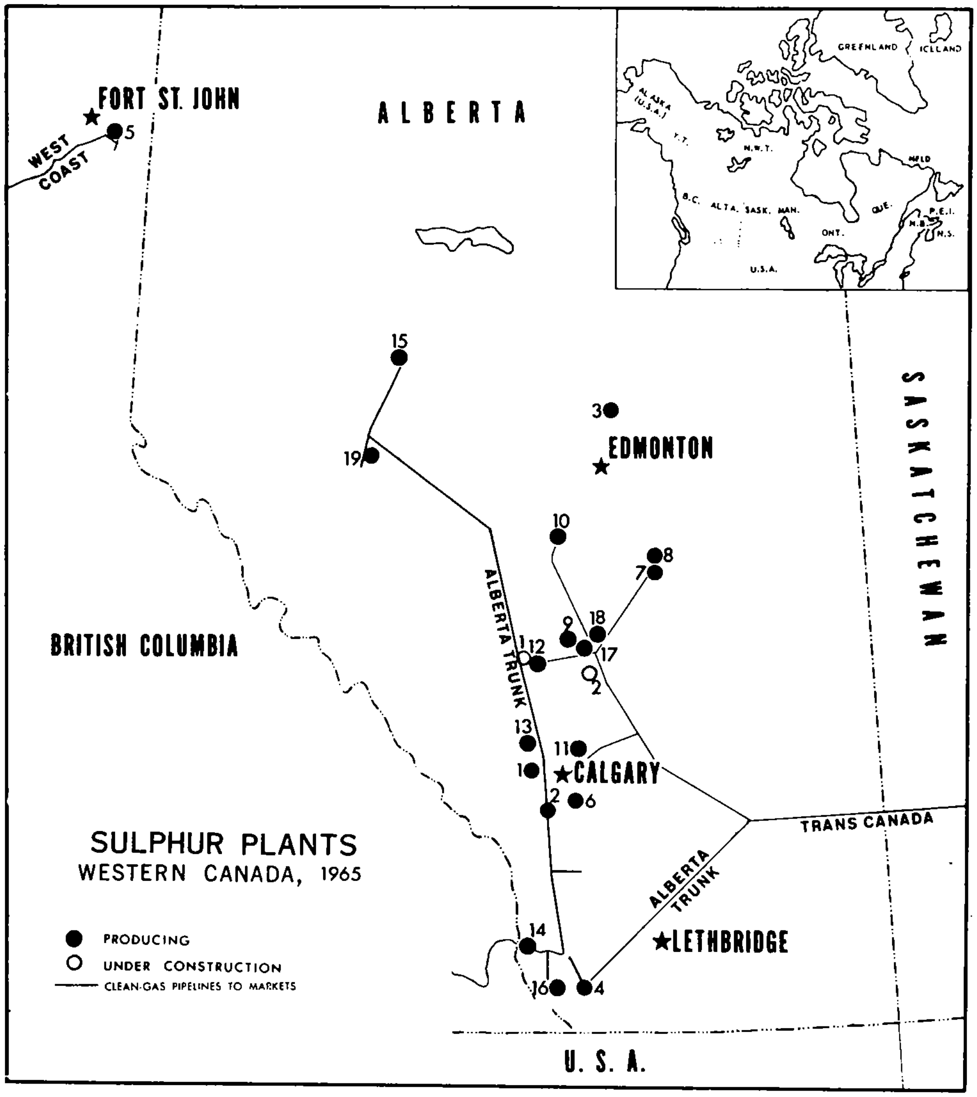
Sulphur Plants, Western Canada, 1965

Operating Company	Source Field	Plant Built	Approximate percentage H_2S	Capacity in Short Tons Daily	Capacity in Short Tons Annual[1]
Producing plants (numbered on map and indicated by ●)					
1 Shell Canada Limited	Jumping Pound, Alta.	1951	4	110	38,000
2 Royalite Oil Company, Limited	Turner Valley, Alta.	1952	4	33	11,500
3 Imperial Oil Limited	Redwater, Alta.	1956	3	10	3,500
4 The British American Oil Company Limited	Pincher Creek, Alta.	1957	10	755	264,000
5 Jefferson Lake Petrochemicals of Canada Ltd.	Taylor Flats, B.C.	1957	3	330	115,000
6 Texas Gulf Sulphur Company	Okotoks, Alta.	1959	35	415	145,000
7 The British American Oil Company Limited	Nevis, Alta.	1959	4–6	85	30,000
8 Chevron Standard Limited	Nevis, Alta.	1959	6	130	42,000
9 Shell Canada Limited	Innisfail, Alta.	1960	14	110	38,000
10 The British American Oil Company Limited	Rimbey, Alta.	1961	2	280	98,000
11 Petrogas Processing Ltd.[2]	Rimbey, Alta.	1961	16	965	337,700
12 Home Oil Company Limited	East Calgary, Alta.	1961	1	56	19,600
13 Canadian Fina Oil Limited	Wildcat Hills, Alta.	1961	4	117	41,000
14 Jefferson Lake Petrochemicals of Canada Ltd.	Coleman, Alta	1961	14	420	147,000
15 Texas Gulf Sulphur Company[3]	Windfall, Alta.	1961	15–20	1290	451,000
16 Shell Canada Limited	Waterton, Alta.	1962	22–27	1550	542,000
17 Amerada Petroleum Corporation	Olds, Alta.	1964	7	120	42,000
18 Socony Mobil Oil of Canada, Ltd.[4]	Wimborne, Alta.	1965	16	368	128,000
19 Hudson's Bay Oil and Gas Company Limited[4]	Edson, Alta.	1966	2	269	94,150
		Total			2,587,450
Plants under construction in 1965 (numbered on map and indicated by o)					
1 Canadian Superior Oil Ltd.	Harmattan, Alta.	1966	42–53	915	320,250
2 Pan American Petroleum Corporation	Crossfield East, Alta.	Sulphur capacity 1800 tons in 1968			

Source: Oil and Gas Conservation Board of Alberta and others.
[1]Calculated on the basis of 350 operating days a year. [2]Capacity to be increased by 890 tons per day in 1966.
[3]Sulphur production owned by Texas Gulf Sulphur Company. Production will increase later to 1, 800 tons a day.
[4]Production started in 1965.

more than 200 miles. Its production is most attractive when it can be consumed in some process industry at or very near its origin. Of ten or more smelting operations in Canada at which sulphur values might be recovered, only half find it attractive to collect SO_2 and convert it to H_2SO_4. At present the sulphur equivalent of the sulphur dioxide wasted to atmosphere in Canada probably exceeds Canadian production of elemental sulphur.

Plants at Arvida and Valleyfield, Quebec, Copper Cliff and Port Maitland, Ontario, and Trail and Kimberley, B.C., convert SO_2 to sulphuric acid. In 1965 expansion was under way or planned at Trail, Valleyfield and Copper Cliff. Brunswick Mining and Smelting Corporation Limited will recover smelter gas for acid in 1967 at Belledune, N.B., and other operations are in the planning stage.



ELEMENTAL SULPHUR FROM SULPHIDES

Elemental sulphur is obtained by the electrolytic refining of nickel sulphide matte in the INCO refineries at Port Colborne, Ontario, and Thompson, Manitoba.

By different processes, sulphur was also recovered from pyrite by Noranda Mines Limited at Port Robinson, Ontario, from 1954 to 1959. Between 1936 and 1943 some 200,000 tons of elemental sulphur were recovered by COMINCO from lead-zinc smelter gases. In 1958 and 1959 INCO and Texas Gulf Sulphur Company operated a pilot plant at Copper Cliff recovering elemental sulphur from smelter gases. Although these two processes used smelter gas as a source of SO_2 gas, pyrites could also be used. Other methods of producing elemental sulphur from sulphides (pyrites) have been used, some quite successfully. The Orkla Grube process was used in Norway and Portugal and, more recently, the Finnish Outokumpu process has been used to produce sulphur at the Kokkola plant in Finland. It has been proposed for the Brunswick Mining and Smelting Corporation Limited plant at Belledune, N.B., where both sulphuric acid and elemental sulphur will be produced from pyrites. For many reasons no one process can be used successfully for all pyrites material but sulphur demand will provide a pressing incentive for the recovery of sulphur values from sulphide minerals.

SULPHUR FROM OIL REFINERIES

Many crude oils contain sulphur compounds which may be released as hydrogen sulphide during refining and recovered by the same processes used in gas-sulphur plants. Foreign crude oils refined in the Montreal area and near Saint John, N.B., supply hydrogen sulphide for sulphur recovery at the plants of Laurentide Chemical & Sulphur Ltd. and Irving Refining Limited, respectively.

Similar plants have been built in Ontario by Shell Canada Limited at Oakville, by The British American Oil Company Limited at Clarkson, and by Imperial Oil Limited at Sarnia. These plants produced more than 60,000 tons of sulphur in 1965 and new plants under construction in 1965 in Dartmouth, Nova Scotia, Winnipeg, Manitoba, and at Sarnia, Ontario, will increase total Canadian oil refinery sulphur capacity to some 140,000 tons per year in 1966.

OTHER SULPHUR

The Fort Saskatchewan, Alberta, refinery of Sherritt Gordon Mines, Limited, uses an ammonia leach process to treat nickel sulphide ores for the recovery of nickel, and recovers ammonia sulphate as a byproduct. It is estimated that the equivalent of more than 20,000 tons of sulphur was recovered by this process in 1965.

NATURAL GAS SULPHUR

Canada has become a major sulphur producer by accident and indirectly. Oil exploration in western Canada, starting about 1910, disclosed natural gas reserves, some of which were 'sour' (containing hydrogen sulphide). For many years the accumulating gas reserves were of little interest because markets were limited in western Canada and the large scale potential markets in eastern Canada and the United States would require costly pipelines. Two conditions had to be satisfied before pipelines to move gas to these markets were justified. First, ample reserves to satisfy both domestic and export demands over a long period had to be proven, and second, the approval of both export and import agencies obtained and satisfactory long term contracts negotiated. By 1960 both conditions had been satisfied and major pipeline construction began.

By the time pipelines were completed gas demands had increased so that sweet gas reserves were largely committed and it was necessary to use sour gases to fulfil the contracts. Sour gases cannot be moved by pipelines or used as fuel with safety because hydrogen sulphide is both toxic and highly corrosive. Therefore, to produce a marketable fuel, gas-cleaning plants were built to remove hydrogen sulphide, excess liquid petroleum gases, and some inert gases, and to produce a fuel gas of standard specifications. Methods were available to convert H_2S to sulphur and, because many gas fields contained considerable amounts of H_2S, the potential sulphur recovery was large and much too valuable to waste. Many natural gas producers were thus required to produce sulphur in order to market gas and the Canadian sulphur industry became a reality.

H_2S is recovered by passing the raw sour gas stream through a solution (usually monoethanolamine) which has an affinity for hydrogen sulphide. The H_2S collects in the solution and, when concentrated, is distilled off and passed to a Claus furnace where it is burned with a controlled amount of air to produce a mist of sulphur droplets. These are condensed to a liquid and pumped to storage vats.

Two significant facts are implicit in the production of elemental sulphur from sour gas. First, the removal of H_2S and the recovery of sulphur is obligatory if the gas is to be marketed, and second, at least two products of value, and sometimes as many as five, are separated from the raw gas. This means that the cost of exploration, production and treatment of the gas may be shared by several end products of which sulphur is but one. A gas with a very high content of H_2S may be primarily a source of sulphur and the value of the sulphur would have to cover most of the production cost. Such gases would be used as sources only when sulphur prices were high. On the other hand, a gas with a medium to low H_2S content would be most valuable for its hydrocarbon content and, in some cases, the sulphur may be regarded as a free byproduct of the necessary cleaning process. The significance of the wide variation in the H_2S content of Canadian gases and the effect that changing sulphur prices exert on such operations can be seen in western Canada. A few years ago, with sulphur prices low, very sour gases were avoided if possible. Now, with sulphur prices higher and still rising, aggressive development of these sources is under way.

Estimated reserves of sulphur in sour gas in the province of Alberta were reported to be in excess of 100 million tons at the end of 1965. Smaller reserves in British Columbia and Saskatchewan would increase this total.

Table 5 lists 18 plants in Alberta and one in British Columbia which produced a total of 1.78 million tons of sulphur in 1965. Two plants, at Wimborne and Edson, Alberta, came into operation in 1965 and two at Harmattan East and East Crossfield, Alberta, were under construction or being planned. These plants, with expansion at East Calgary, Jumping Pound and Nevis, will add substantially to capacity in 1967 and 1968. It is estimated that Canadian sour gas sulphur production will total more than 4.0 million tons by 1970.

ATHABASCA OIL SAND SULPHUR

Oil-bearing deposits along the Athabasca River in northern Alberta have been known since 1883. Their extent and nature were investigated by S. C. Ells of the Federal Mines Branch 50 years ago. Although the sands contain extremely large quantities of oil and a small but significant percentage of sulphur, their location discouraged early attempts at development. However, interest in the oil potential of these deposits has been revived and four proposals have been made to the Government of Alberta regarding various methods of obtaining oil from them. One project, that of Great Canadian Oil Sands Limited, has been approved and production expected in 1967 will include some 150,000 tons of sulphur a year.

Estimated oil reserves in the sands total more than 300 billion barrels and, at a five per cent by weight basis, sulphur reserves would amount to about 1 billion tons. Large-scale production of oil from the sands would appear to reduce the danger of future sulphur shortages.

SULPHURIC ACID

Production of sulphuric acid reached a new high of 2.16 million tons (100 per cent H_2SO_4) in 1965 and only a continued increase will satisfy expansions now under way in consuming industries. Seventeen plants in Canada have a total capacity of about 2.5 million tons of 100 per cent acid per year. Imports were lower than normal at 3,075 tons and exports somewhat higher than average at 57,113 tons. Estimated consumption of sulphuric acid in 1965 was 11 per cent higher than in 1964 at 2.1 million tons.

TABLE 6

Available Data on Consumption of Sulphuric Acid, by Industries, 1963

(short tons – 100% acid)

Iron and steel mills	60,297
Other iron and steel	12,473
Electrical products	5,134
Vegetable-oil mills	225
Sugar refineries	280
Leather tanneries	2,446
Textile dyeing and finishing plants	45
Pulp and paper mills	48,787
Processing of uranium ore	228,800
Manufacture of mixed fertilizers	289,351
Manufacture of plastics and synthetic resins	23,576
Manufacture of soaps and cleaning compounds	16,576
Other chemical industries	12,702
Manufacture of industrial chemicals[1]	916,379
Petroleum refining	12,221
Mining[2]	44,100
Miscellaneous[3]	68,207
Total accounted for	1,741,599

Source: Dominion Bureau of Statistics. [1]Includes consumption of own make or captive acid by firms classified to these industries. [2]Includes metal mines, nonmetal mines, mineral fuels and structural material. [3]Includes synthetic textiles, explosives and ammunition, and other petroleum and coal products.

TABLE 7

Sulphuric Acid — Production, Trade and Apparent Consumption, 1956–65

(short tons — 100% acid)

	Production	Imports	Exports	Apparent Consumption
1956	1,052,000	2,100	23,660	1,030,440
1957	1,290,000	1,046	29,550	1,261,496
1958	1,586,000	39,345	23,252	1,602,093
1959	1,739,000	18,489	27,863	1,729,626
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	1,960,000	4,209	67,409	1,896,800
1965p	2,165,000	3,075	57,113	2,110,962

Source: Dominion Bureau of Statistics.
pPreliminary.

During 1965 sulphuric acid capacity was being expanded at Trail in British Columbia, Fort Saskatchewan in Alberta, Copper Cliff in Ontario, Valleyfield and Arvida in Quebec, and new capacity is planned at Belledune, New Brunswick, in 1967. Most Canadian sulphuric acid is consumed in the production of phosphate fertilizers. Planned expansion in this industry together with forecast increases in uranium demand will require substantial enlargement of sulphuric acid capacity.

WORLD REVIEW AND OUTLOOK FOR CANADIAN SULPHUR

World sulphur production in all forms is estimated at 29.5 million metric tons in 1965, an increase of 2 million tons over that of 1964. World consumption exceeded production by about 1.1 million tons and sulphur stockpiles were again reduced to satisfy demands.

Western world sulphur production in all forms increased some 7.3 per cent to 22.8 million tons and Communist world production increased 5.5 per cent to about 6.4 million tons. The main additions to supply were from the United States Frasch industry. Canadian production increased nearly 10 per cent, French production was unchanged and Mexican production was lower than in 1964.

World consumption increased some 1.8 million tons of which 650,000 tons was in the United States and 550,000 in Western Europe. Exports of sulphur from producing countries were higher than in 1964 by some 0.5 million tons. The major amounts came from the United States, Mexico, Canada and France, and the main addition to exports were from United States, Canada and Poland. Exports from Mexico and France were lower than 1964.

The world-wide surge in construction of phosphate fertilizer facilities continues to be the largest single reason for increased sulphur (as sulphuric acid) demand, although other sulphur consumption has also risen. The United States is estimated to have consumed more than 3.5 million tons of sulphur in 1965 to produce fertilizers. The total for this purpose may reach 7.5 million by 1975. In Canada sulphur consumption for the production of fertilizers is currently about 140,000 tons per year and is expected to double before 1970. The need for fertilizers is universal, urgent and long-term, and sulphur used for this purpose alone will increase at rates considerably above those of the past.

Several developments during 1965 and early 1966 are significant. Sulphur deposits were being explored on numerous leases in the Gulf of Mexico offshore from Texas. Eight major companies paid a total of almost $34 million for rights to explore for sulphur. The leases comprise some 72,000 acres and are located 30 to 80 miles from shore in depths of 100 to 175 feet. Three Frasch sulphur mines, previously abandoned, were being brought back into operation.

Mexican sulphur output decreased slightly in 1965 because of production problems at one property, and exports were restricted by the Mexican Government until reserves could be increased. Several companies carried on exploration in 1965.

Sulphur will be recovered from sour gas and oil refinery sources in the Middle East by 1967. Plants with a total capacity of about 700,000 tons per year are under construction or planned in Iraq, Kuwait and Iran. Other sources are being investigated.

In France a new source of sulphur was discovered in the Meillon gas field and a plant to produce 150,000 tons per year was being built.

TABLE 8

Estimated World Production of Sulphur in All Forms

(thousands of metric tons)

Country	1965 Elemental Sulphur	1965 In Pyrites	1965 In Other Forms*	1965 Total	1964 Total
United States	7,638	366	838	8,842	7,482
Canada	1,685**	158	465	2,308	2,116
Mexico	1,595	–	10e	1,605	1,722
West Europe	1,928	3,462	1,657	7,047	6,995
Other, Free World	412	1,743	1,130	3,285	3,120
Communist countries	1,945	3,310	1,160	6,415	6,115
Totals	15,203	9,039	5,260	29,502	27,550

Sources: Mainly British Sulphur Corp. Ltd. and U.S. Bureau of Mines.

*Sulphur in smelter gas, anhydrite-gypsum, spent oxide, hydrogen sulphide (other than elemental) and other smaller sources. **Total output rather than shipments. eEstimated.

Early in 1966 elemental sulphur was discovered in anhydrite in Nova Scotia and an exploration program was started. Shell Canada Limited planned on incorporating a company, Commercial Solids Pipe Line Company, to build a 750-mile 12-inch pipeline to transport sulphur from southern Alberta to Vancouver. Cost has been estimated at $50 million and operation is expected by 1970.

At the end of 1965 sulphur prices had risen substantially from the low of 1963 and additional increases were being predicted. In North America sulphur is produced in three countries, the United States, Mexico and Canada, and was available at some increase in price. In overseas markets supply was much more difficult and sales were being made at $40 to $50 per ton.

No major new source of sulphur has been discovered in recent years and the rate at which sulphur is being consumed has increased abruptly. The world is now using more sulphur than can be produced from present sources. Since 1963 the deficit between supply and demand has been filled from stocks accumulated in past years. At the end of 1965 such stocks had been reduced to a dangerous low. Some producers were not able to accept new orders and some form of allocation was being considered. There appears to be little chance of sulphur demand lessening. Supplies are required by the rapidly expanding fertilizer industry in particular, and by almost all industry in general.

Under such circumstances of pressing demand and inadequate supply prices inevitably must continue to rise to encourage the development of new sources of supply. From a resources standpoint the world has adequate supplies of sulphur but the price of sulphur determines which sources can be utilized. Although efforts are now being made to increase sulphur production there is no assurance that current prices are sufficient to produce adequate supplies for rapidly increasing world needs. Some estimates of world sulphur consumption by 1970 suggest amounts of as much as 32 million tons and indicate projected growth rates at least twice as high as the historical average.

Canada is one of a very few countries with supplies of sulphur well in excess of domestic needs and with substantial capacity to increase production. The main Canadian sources of sulphur, sour gas and smelter gas, are low in cost since they stem from processes primarily operated for other purposes. Both sources are capable of major expansion and efforts to expand production were in progress at the end of 1965. In addition, sulphur will be produced from oil sands in 1968 and several projects to recover sulphur or sulphuric acid from pyrite materials are under way. These activities alone could result in Canadian sulphur production being doubled before 1970. Any further increase in sulphur prices would speed development of considerably greater production.

The outlook for the Canadian sulphur industry is thus considered to be highly promising. Resources are available, recovery processes are adequate and are being improved, markets are world-wide and expanding, and at present and expected future prices, sulphur production is profitable.

PRICES

In the last quarter of 1965, the Canadian price of sulphur was quoted in *Canadian Chemical Processing*, as follows:

Sulphur, elemental, carloads, works, ton	$17.00

United States prices per long ton quoted by the *Oil, Paint and Drug Reporter* of December 27, 1965, were as follows:

Crude, domestic, bright, bulk f.o.b. cars, mines	$25.50
Crude, exports, f.o.b. vessels, Gulf ports	$36.00
Crude, U.S. and Canada, f.o.b. Gulf ports	27.00
Domestic, dark	1.00 lower
Crude, Mexican, f.o.b. vessel, metric ton	24.30
Pyrites, Canadian 48–50%, S, f.o.b. mines	4.50–5.00

TARIFFS

Canada	
Sulphur, crude, or in roll or flour form	free
United States	
Pyrites	free
Elemental sulphur	free
Sulphuric acid	free
Sulphur dioxide	12.5% ad val.
Sulphur compounds	10.5% ad val.

Talc and Soapstone; Pyrophyllite

D.H. STONEHOUSE*

Production of talc, soapstone and pyrophyllite in Canada during 1965 remained reasonably close to that of 1964 in tonnage. Total value has shown a slight increase because of the processing and shipping of a greater amount of higher-quality material from Quebec deposits.

Imports of talc since 1962 have been greater than domestic production by amounts varying from 1,000 to 5,000 tons per year. Exports have remained about 10 per cent of production. Imports have come from United States and from Italy, the latter supplying high-quality talc for cosmetic and pharmaceutical uses and the former supplying comparatively high-purity talc for the paint, ceramics and paper industries. A small amount of cosmetic-grade talc is reported from France for 1965.

Production of talc, soapstone and pyrophyllite depends upon the market requirement, and available consumption data over past years do not allow for accurate projection to determine future trends. Uses of talc depend on the physical properties of the products and high chemical inertness. For some applications, specifications can be met as well by other natural minerals, making it difficult to develop new markets for talc.

PRODUCERS

QUEBEC

At South Bolton, 60 miles southeast of Montreal, talc and soapstone are produced from an underground operation by Baker Talc Limited. The mined talc is milled at Highwater, about 10 miles south of the mine site. The processing consists of primary and secondary crushing, fine grinding and air classification. The products are shipped in sacks or in bulk and are relatively low-grade material. Rough and sawn blocks of soapstone are sold for sculpturing.

Broughton Soapstone & Quarry Company, Limited quarries talc and soapstone from two separate deposits near Broughton Station in the Eastern Townships. Several low-priced grades of ground talc are produced and soapstone is sawn into blocks for sculpturing, refractory use and metal workers' crayons.

ONTARIO

Two adjacent underground operations at Madoc produce several low-quality grades of ground talc. The mines are operated by Canada Talc Industries Limited. Development of a zone of high-grade, flaky talc was nearly completed by the end of 1965. Early in 1966, the first shipment of this talc was made to a processing plant in northeastern United States for processing to cosmetic- and pharmaceutical-grade products.

NEWFOUNDLAND

Pyrophyllite of relatively high quality is quarried near Manuels by Newfoundland Minerals Limited. Their entire output is shipped to American Olean Tile Company, Inc. at Lansdale, Pennsylvania, where it is processed and used in the manufacture of ceramic wall tile.

*Mineral Processing Division, Mines Branch

TABLE 1
Production, Trade and Consumption

	1964		1965P	
	Short Tons	$	Short Tons	$
Production (shipments)				
Talc and soapstone				
Quebec*	17,256	199,049	17,000	216,000
Ontario**	8,060	136,468	7,900	134,000
Total	25,316	335,517	24,900	350,000
Pyrophyllite: Newfoundland	32,816	492,240	30,134	462,010
Imports (talc)				
United States	29,887	1,266,554	26,849	1,174,491
Italy	1,711	119,071	998	67,597
France	-	-	11	821
Total	31,598	1,385,625	27,858	1,242,909
	1963		1964	
	Short Tons		Short Tons	
Consumption (ground talc, available data)				
Ceramic products	11,382		10,977	
Paints and wall-joint sealers	7,931		7,178	
Roofing	6,855		7,350	
Paper	3,639		1,653	
Rubber	1,994		1,930	
Insecticides	1,691		1,468	
Toilet preparations	1,206		1,346	
Cleaning compounds	782		931	
Pharmaceutical preparations	413		286	
Leather products	26		47	
Other products	3,382		2,880	
Total	39,301		36,046	

Source: Dominion Bureau of Statistics.
*Ground talc, soapstone blocks and crayons. **Ground talc.
PPreliminary; - Nil.

TABLE 2
Production and Trade, 1956–65
(short tons)

	Production*		Imports	Exports
	Talc and Soapstone	Pyrophyllite (all exported)	Talc	Talc
1956	27,947	1,379	16,268	2,613
1957	29,039	5,686	14,949	2,353
1958	27,951	7,454	16,593	1,931
1959	24,733	14,443	18,501	2,053
1960	21,411	20,225	19,153	1,660
1961	23,691	24,425	20,205	2,000e
1962	23,367	22,794	24,148	2,300e
1963	22,467	31,783	27,539	2,200e
1964	25,316	32,816	31,598	2,600e
1965P	24,900	30,134	27,858	3,500e

Source: Dominion Bureau of Statistics.
*Producers' shipments.
eEstimated, not available as a separate trade class after 1960; PPreliminary, pyrophyllite imports are unknown.

TECHNOLOGY

Talc is a hydrous magnesium silicate. It is soft and flaky, has a greasy feel or 'slip' and grinds to a near-white powder. It is relatively inert chemically and has a high fusion point and low electrical and thermal conductivity.

Many kinds of commercial talc are mixtures of talc and other minerals. The deposits in southern Quebec were formed by the alteration of serpentinized peridotite and contain, in addition to talc, serpentine, magnesite and iron-bearing minerals such as chlorite. The ground products are somewhat off-white but can be used where colour specifications are not exacting. Higher-quality products are possible if impurities are removed by some beneficiation process. The Madoc deposits are altered near-white dolomitic marble consisting principally of talc, tremolite and dolomite in various proportions. Ground products are near-white, naturally low in iron but limited in use because of variable amounts of dolomite. Control of the dolomite content could result in widely acceptable high-quality products. Tremolite and similar fibrous minerals contribute properties desirable to some applications of commercial talc.

The processing of talc in Canada is relatively simple, the important step being grinding and particle-size classification. Some beneficiation is achieved during grinding but high-quality products would require the application of electromagnetic separation or flotation.

Soapstone is essentially an impure talcose rock from which blocks and crayons can be readily sawn. The grey soapstone in southern Quebec was altered from serpentinized peridotite.

Pyrophyllite, a hydrous aluminum silicate, is physically similar to talc. An alteration product of siliceous rocks, it is often accompanied by sericite and quartz. The colour, near-white, is generally acceptable to industry but the content of impurities must be controlled.

USES AND SPECIFICATIONS

Commercial talc is a versatile raw material with numerous industrial applications, although most is used in less than a dozen industries.

Higher-quality talc is used as an extender pigment in paints, a filler and coater in the manufacture of papers and an important raw material in the ceramics industry. Specifications for a talc pigment, as established in ASTM Designation D605-53T, relate to chemical limits, colour, particle size, oil absorption and consistency of, and dispersion in, a talc-vehicle system. A low content of such minerals as the carbonates, a near-white colour, a fine particle size with controlled distribution and a specific oil-absorption are important. However, because of the variety of paints and, therefore, of talc pigments, precise specifications are generally based on agreement between consumer and supplier. Paper manufacturers require talc of high reflectance, high retention in the pulp, low abrasiveness and freedom from chemically active substances. The ceramic industry specifies fine particle size and freedom from impurities that would discolour the fired product. Talc of high purity is demanded for use in cosmetic and pharmaceutical preparations.

Lower-grade talc is used as a dusting agent for asphalt roofing and gypsum board; a filler in joint-sealing compounds for dry-wall construction, floor tile, asphalt pipeline enamels and auto-body patching compounds; a diluent for dry insecticides; and a filler and dusting agent in the manufacture of rubber products. Particle size is the main specification; colour and impurity content are generally of little importance, although for asphalt pipeline enamels, low carbonate is specified to avoid a reaction with soil acids.

Because of its unusual characteristics, talc has a number of minor applications, including use in cleaning compounds, polishes, electrical cable, plastic products, foundry facings, adhesives, linoleum, textiles and oil-absorbent preparations.

Particle-size specifications for most uses require the talc to be basically 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 refractory brick or block but, because of its resistance to heat and its softness, 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 basically minus 325 mesh and contain a minimum of quartz and sericite.

PRICES

Quoted prices for talc vary greatly and are generally based on a wide range of specifications. A product of high purity, fine particle size and a high degree of whiteness would command a greater price than darker, coarser material. Although there is no published Canadian price list for talc products, a wide range of prices for ground talc products in the United States appears in the *E & M J Metal and Mineral Markets* and in the *Oil, Paint and Drug Reporter*. Such listings range from $5.50 per ton, crude to $100 per ton, micronized.

TARIFFS

Tariffs in effect at the time of writing include:

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Talc or soapstone	10	15	25
Pyrophyllite	free	free	25
Micronized talc	free	5	25

United States	
Talc, steatite or soapstone:	
crude and unground	0.05¢ per lb
cut or sawed, or in blanks, crayons, cubes, disks or other forms	0.5¢ per lb
Ground, powdered, pulverized or washed	12 1/2%
Other, not specially provided for	24%

Tin

W.H. JACKSON*

Tin and its alloys are vital to a number of industries. Canada is seventh among consuming nations but its current production is negligible. In 1965, production of tin in concentrate plus the tin content of a primary lead-tin alloy amounted to 183 tons**.

New metal supply of 4,993 tons valued at $21.7 million consisted entirely of imports. Malaysia is the main supplier. Tin stocks held by Canadian consumers totalled 915 tons on December 31, 1965, an increase of 139 tons from the previous year. Consumption of primary tin totalled 4,892 tons, a slight increase over the revised total for 1964. Use in tinplate manufacture declined slightly while demand for solders increased with the high level of industrial activity.

The small tonnage recorded as Canadian production is from The Consolidated Mining and Smelting Company of Canada Limited. The tin concentrate is a byproduct of lead-zinc recovery. Mill tailings from the zinc rougher-flotation cells of the Sullivan concentrator at Kimberley, B.C., contain 35 to 40 per cent iron plus cassiterite, and grade 0.04 to 0.06 per cent tin. Some 5,700 tons daily are treated. Iron minerals are floated off and the residue constitutes feed to the gravity section of the tin plant, which contains 22 Buckman tilting tables and 10 standard 12 × 4-foot Deister tables. Recovery is about 47 per cent in a concentrate grading 61 to 68 per cent tin. The concentrate is dewatered, dried and exported for smelting. In addition, small amounts of a lead-tin alloy are produced from the treatment of lead bullion dross in the indium circuit of the Trail smelter.

Other base-metal sulphide deposits now being mined in Canada either do not have tin minerals associated or the quantity is so minor that recovery is not worthwhile. Minor tin values were recorded in the initial drilling of the lead-zinc deposit of Brunswick Mining and Smelting Corporation Limited. More recently, cassiterite is reported as a component of some sections of the copper-lead-zinc-silver orebody near Timmins, Ontario, which will be in production in late 1966.

Work on the lode-deposit of Mount Pleasant Mines Limited in Charlotte County, N.B., was suspended until financing of a test mill and a planned underground program can be arranged.

WORLD DEVELOPMENTS

Canada is a member of the Second International Tin Agreement which terminates June 30, 1966. A Third International Tin Agreement was negotiated under United Nations auspices which will come into effect for a 5-year period commencing July 1, 1966. Votes in a governing body, the International Tin Council, are equally divided between countries designated as producers or consumers. The test is whether or not the mine production of the country results in net exports. Australia is expected to become a producer member in the next few years. Membership in total comprises countries

*Mineral Resources Division
** Long tons (2240 pounds) used throughout.

TABLE 1

Tin – Production, Imports and Consumption, 1964–65

	1964		1965p	
	Long Tons	$	Long Tons	$
Production				
Tin content of tin concentrates and lead-tin alloy	157	533,572	183	810,030
Imports				
Blocks, pig, bars				
Malaysia	4,038	14,464,371	4,258	18,502,824
United States	497	1,698,048	734	3,177,293
Britain	284	1,302,705	1	2,301
Bolivia	30	102,729	–	–
Total	4,849	17,567,853	4,993	21,682,418
Tinplate				
United States	3,135	551,417	3,460	544,739
Britain	1,600	401,646	631	182,728
Total	4,735	953,063	4,091	727,467
Tin fabricated materials, not elsewhere specified				
Britain	1	2,359	14	27,359
United States	11	33,462	12	45,487
Total	12	35,821	26	72,846
Consumption				
Tinplate and tinning	2,573		2,507	
Solder	1,528		1,659	
Babbitt	232		212	
Bronze	233		221	
Galvanizing	9r		7	
Other uses (including collapsible containers, foil, etc.)	247r		286	
Total	4,822r		4,892	

Source: Dominion Bureau of Statistics.
p Preliminary; – Nil; r Revised.

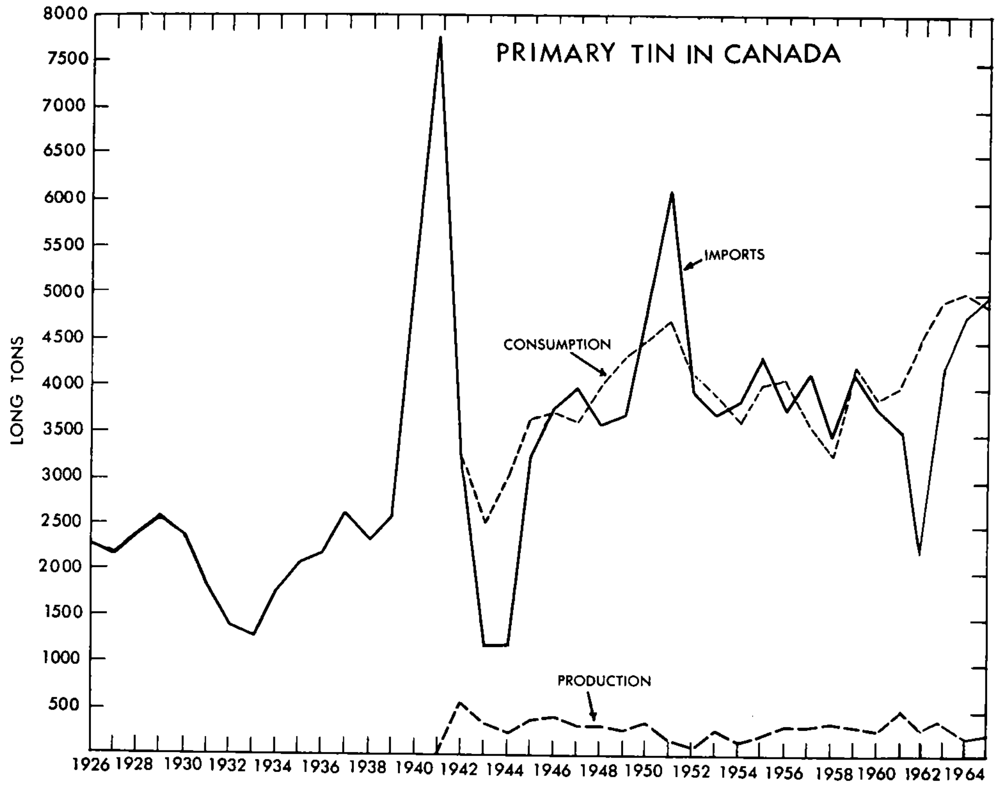
TABLE 2

Tin – Production, Imports and Consumption, 1956–65

(long tons)

	Production[1]	Imports[2]				Consumption[3]
		Blocks, Pigs, Bars	Tinfoil	Babbitt Metal	Tinplate	
1956	338	3,774	7	18	3,417	4,085
1957	317	4,155	7	17	4,884	3,622
1958	355	3,461	9	10	5,960	3,292
1959	334	4,183	8	29	4,977	4,223
1960	278	3,768	9	29	5,626	3,880
1961	500	3,525	12	34	3,080	3,953
1962	291	2,274	6	22	3,712	4,507
1963	414	4,193	6	9	3,726	4,942
1964	157	4,849	..	..	4,735	4,822r
1965p	183	4,993	..	..	4,091	4,892

Source: Dominion Bureau of Statistics.
[1]Tin content. [2]Gross weight. [3]Virgin tin.
p Preliminary; .. Not available; r Revised.

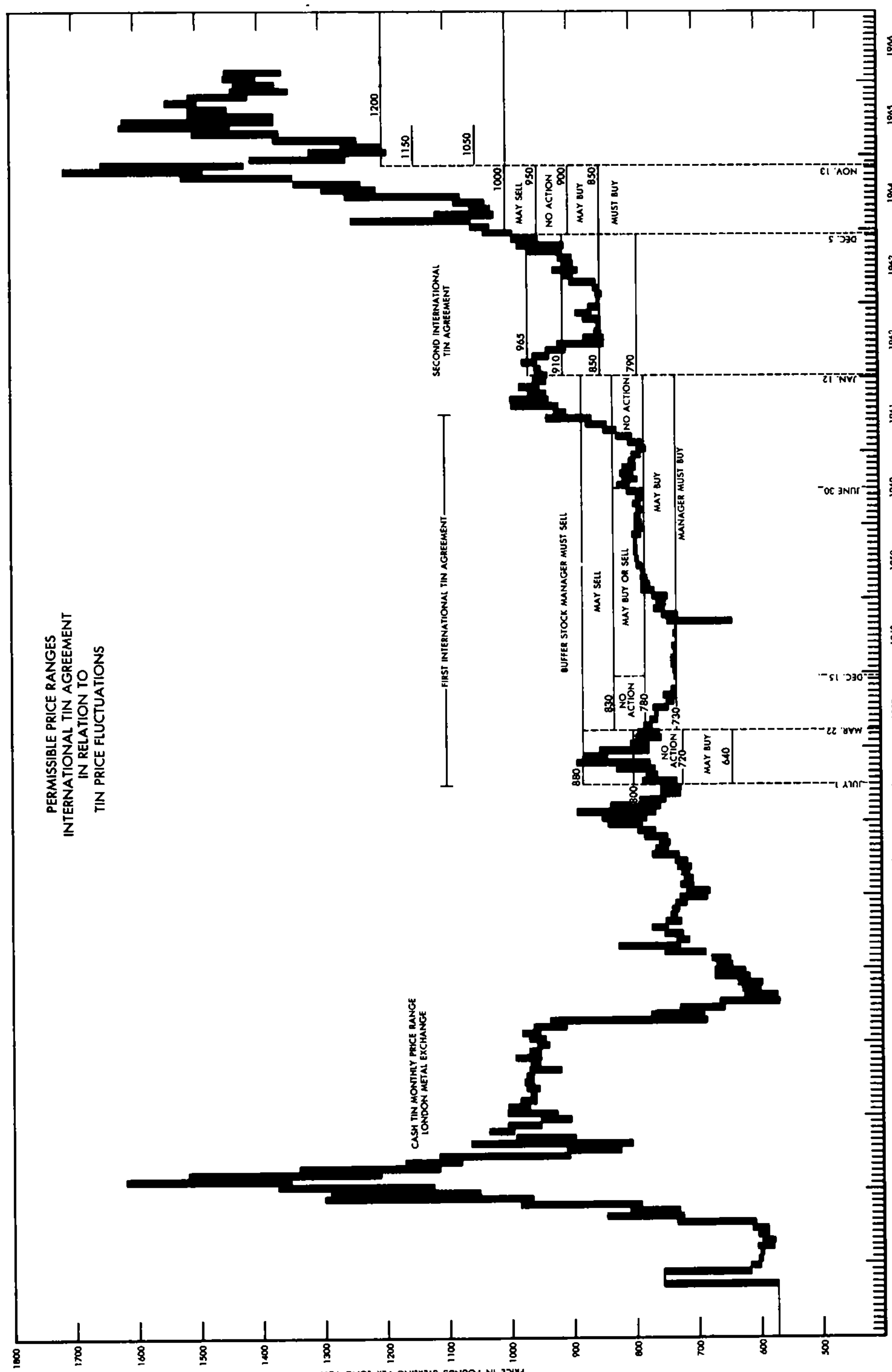


representing some 95 per cent of Free World production.

Producer members of the Second Agreement (Bolivia, Congo, Indonesia, Malaysia, Nigeria and Thailand) contributed cash or tin to a buffer stock. The International Tin Council determined price ranges within which a buffer stock manager could operate to modify market fluctuations by buying or selling tin. Under certain conditions, the Council may also declare controls on the exports of producer members. Tin price fluctuations from 1950 to 1965 are shown on the accompanying graph in relation to price ranges considered desirable at various periods by the Tin Council. Throughout 1964 and 1965 prices have exceeded these ranges.

Problems of oversupply and of price maintenance were critical problems from 1956 to 1960. These were solved by buffer stock activities and export controls. After the lifting of such controls in 1960 it became clear that consumption had recovered quicker than production. Actions since that time, such as revisions to the price ranges, have been designed to encourage profitable mine exploration and development. The supply-demand pattern was outlined by the International Tin Council in a publication entitled *Report on the World Tin Position with Projections for 1965 and 1970*.

Tables 3 and 4 show the production record of the main countries. Small mines have contributed considerably to increased production in the last two years in Malaysia and Thailand. These operate gravel pump and hydraulic mines. In Bolivia, rehabilitation of the lode mines has been under way. In Indonesia, a sea-going dredge capable of operating in 130 feet of water 15 miles from shore is being readied for production in 1966. New placer discoveries offshore in the Gulf of Thailand will make Thailand much more important in coming years. Malaysia and Nigeria are encouraging exploration in ways which will



PERMISSIBLE PRICE RANGES
INTERNATIONAL TIN AGREEMENT
IN RELATION TO
TIN PRICE FLUCTUATIONS
CASH TIN MONTHLY PRICE RANGE
LONDON METAL EXCHANGE
FIRST INTERNATIONAL TIN AGREEMENT
SECOND INTERNATIONAL
TIN AGREEMENT
BUFFER STOCK MANAGER MUST SELL
MAY SELL
MAY BUY OR SELL
NO ACTION
MAY BUY
MANAGER MUST BUY
MUST BUY
880
830
800
780
730
720
640
965
950
910
900
850
790
1000
1050
1150
1200
JULY 1
MAR. 22
DEC. 15
JUNE 30
JAN. 12
DEC. 5
NOV. 13
PRICE IN POUNDS STERLING PER LONG TON
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966

TABLE 3

Estimated Free World Production of Tin in Concentrates, 1964–65

(long tons)

	1964	1965
Malaysia	60,004	63,670
Bolivia	24,199	23,369
Thailand	15,597	18,843
Indonesia	16,345	14,823
Federation of Nigeria	8,721	9,547
Republic of the Congo	6,492	6,211
Total, including countries not listed	147,400	152,600

Source: International Tin Council, *Statistical Bulletin.*

TABLE 4

Estimated Free World Production of Primary Tin Metal, 1964–65

(long tons)

	1964	1965
Malaysia	71,351	72,469
Netherlands	15,858	18,114
Britain	16,849	16,494
Federation of Nigeria	8,748	9,332
Belgium	5,458	4,232
Bolivia	3,611	3,671
Australia	3,045	3,219
Brazil	2,100	2,100
Total, including countries not listed	142,800	144,100

Source: International Tin Council, *Statistical Bulletin.*

facilitate the assessment of reserves and encourage exploitation. Some modern dredges can operate on ground containing only 0.3 pound recoverable tin content per cubic yard. Profitable deposits mined by underground methods currently have grades in the order of 1 to 2 per cent tin.

Production apparently will increase in the next few years but it is not yet possible to predict when the imbalance between production and consumption will be met. A rough estimate of the current supply-demand balance can be worked out from the data in Table 5. The slight improvement in commercial stocks is worth noting. Government stockpile sales, mainly those of the United States, have prevented a physical shortage of metal.

TABLE 5

Estimated Free World Tin Position, 1963–65

(long tons)

	1963	1964	1965
Ore Supply			
Production of tin in concentrates	141,400	147,400	152,600
Stocks at year's end	19,200	20,500	18,700
Primary Metal Supply			
Smelter production of tin metal	143,000	142,800	144,100
Net trade with Communist bloc	1,193	541–	1,750–
Government stockpile sales	12,126	32,147	23,365
Buffer stock, sales +, purchases–	3,270+	–	–
Commercial stocks at year's end	46,700	50,700	51,700
Primary metal consumption	160,700	166,100	164,300

Source: International Tin Council, *Statistical Bulletin.*
– Nil.

Construction of smelters continued in the mining countries supplying tin concentrates. The new smelter at Pukhet Island, Thailand, has capacity equal to the country's production. Union Carbide Corporation has a major interest. Nigeria, Congo, Malaysia and Australia have adequate smelting facilities and Indonesia is expected to join them although construction of the Muntok Island smelter has been slow. Bolivia has made preparations to ensure the availability of its concentrates should new facilities be built there that could treat the various grades.

USES

Information on the most effective way to use tin in manufacturing processes is available through the Tin Research Institute. This organization, financially supported by the miners of tin, is devoted to both research into new uses and practical application of technology. The markets for tin are increasing with industrial expansion. However, as prices increase there has been a noticeable conservation in its application. The thickness of tin on tinplate has been reduced and has been accompanied by increased use of lacquers. In some markets, aluminum, plastic, or glass containers have been found to be competitive. The market potential is being evaluated for aluminum-coated steel sheet and heavily-lacquered steel sheet with welded side-seam. In solders, the trend is to minimum compositions. Solders used in radiators, for example, now contain about 15 per cent tin, approximately half the amount used a few years ago.

In Canada, most tin is used for tinplate and tinning. Straits brand, or equivalent grade, is favoured. Nearly all tinplate is made by electrolytically coating steel with tin; it is used mainly in the manufacture of food containers. Alloying in the manufacture of solder, babbitt and bronze is also important to the domestic economy.

In the Toronto area, Pilkington Brothers (Canada) Limited is building, for completion in 1966, the first float-glass plant outside Britain. This method of producing high quality plate glass involves floating liquid glass on a bed of molten tin in controlled atmosphere and temperature.

PRICES

The average price in cents (U.S.) per pound of tin traded on the three major exchanges in 1965 was: Straits-exworks, Penang, Malaysia, 172.19; Cash, London, England, 176.59; Prompt, New York, U.S.A., 178.17; Smelters in Australia, Thailand, Indonesia, Congo and parts of Europe follow the Penang price as the basis of payment for sale of concentrate and in pricing tin metal. Allowing for differences such as hedging, each of these markets affects the others and the differences relate to transportation costs, insurance and interest on money. In Canada, the larger consumers pay the equivalent of the New York price. Smaller consumers, purchasing from merchants who finance and hold stocks in inventory, would pay more.

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Tin in blocks, pigs, bars or granular form for use in Canadian manufactures	free	free	free
Tin-strip waste and tinfoil	free	free	free
Phosphor tin and phosphor bronze in blocks, bars, plates, sheets and wire	5	7½	10
Oxide of tin	free	15	15
Bichloride of tin and tin crystals	free	10	10
Sheet or strip of iron or steel, corrugated or not, rolled with surface pattern or not, coated with tin	10	15	25
Sheet or strip of iron or steel coated with lead or with an alloy of lead and tin	free	free	15
Manufactures of tinplate, painted, japanned, decorated or not, and manufactures of tin not otherwise provided for	15	20	30

United States

Tin ore and black oxide of tin	free
Tin, other than alloys of tin	free
Tin alloys	
Containing, by weight, over 5% lead	1.0625¢ per lb on lead content
Other	free
Tin waste and scrap	free
Plates, sheets and strips, wrought of tin, cut or not, pressed, or stamped to nonrectangular shapes	
Not clad	12% ad val.
Clad	24
Tin wire	
Not coated or plated with metal	12.5
	0.1¢ per lb plus 12.5% ad val.
Tin bars, rods, angles, shapes and sections	12
Tin powder and flakes	12
Tin pipes and tubes, and blanks therefor, pipe and tube fittings	12
Tinfoil	35
Tin compounds and salts	12.5

Titanium

V.B. SCHNEIDER*

The value of titanium-dioxide (TiO_2) slag shipped during 1965 was $22.4 million, an all-time high. It is a base material for pigment manufacture; both Canadian TiO_2 pigments manufacturers operated at near-capacity and reported expansion programs were under way. Data on the consumption of TiO_2 pigments in Canada for 1965 are not available but preliminary industry estimates indicate that it was nearly 45,000 tons, up slightly from 1964.

Manufacturers of pigments consume from 90 to 95 per cent of titanium mineral production but prospects are good for increasing the use of high-purity titanium and titanium alloys. Optimism over the metal's potential resulted in overexpansion of production facilities in the United States between 1948 and the mid-fifties. When the United States curtailed its manned military aircraft program and stopped its titanium stockpile purchasing program in 1958 the titanium metal industry suffered a severe recession. Starting in 1963 and continuing through 1965 there has been an increasing demand for titanium for military use, space travel and, of more importance, for nonmilitary uses. Some authorities predict that the annual growth rate for titanium ingot during the next 10 years may be about 15 per cent. According to the U.S. Bureau of Mines, *Mineral Industry Surveys, Titanium Quarterly*, March 4, 1966, ingot consumption in the U.S.A. in 1965 was 14,691 tons, a record; imports of sponge metal also set a record. Titanium ingot was imported from Russia for the first time.

Non-Communist world production of titanium ores for 1965 was estimated by the U.S. Bureau of Mines in its *Commodity Data Summaries*, January, 1966, at 2.7 million tons of ilmenite and 223,000 tons of rutile, representing increases of 6 and 11 per cent.

Ilmenite ($Fe TiO_3$), and rutile (TiO_2) are the only commercial ore minerals of titanium. The theoretical titanium-dioxide content of ilmenite is 53 per cent and of rutile it is 100 per cent.

*Mineral Resources Division.

TABLE 1

Titanium — Canadian Production, Imports and Exports, 1964—1965

	1964		1965P	
	Short Tons	$	Short Tons	$
Production*, shipments				
Titanium dioxide	..	21,270,144	..	22,425,094
Imports				
Titanium dioxide, pure				
United States	693	360,725	783	429,021
Britain	1,120	470,562	712	283,348
West Germany	26	11,843	70	29,695
Total	1,839	843,130	1,565	742,064
Titanium dioxide, extended				
United States	10,443	2,000,248	9,534	1,816,869
Titanium metal				
United States	725	3,609,039	769	4,005,127
U.S.S.R.	—	—	33	62,656
Other countries	1	1,122	1	4,999
Total	726	3,610,161	803	4,072,782
Exports				
Titanium, unwrought, waste and scrap, wrought and alloyed**				
United States	31	17,112	38	12,952
Titanium dioxide**				
United States	3,298	1,344,287	3,202	1,344,580

Source: Dominion Bureau of Statistics.

*Producers' shipments of TiO_2 slag. Tonnages not available for publication. **As reported by the U.S. Department of Commerce, *U.S. Imports of Merchandise for Consumption*, Report FT 125. No indentifiable classes are available from official Canadian export statistics.

P Preliminary; .. Not available.

PRODUCTION

CANADA

The Canadian titanium industry is based mainly on the mining of ilmenite for the production of titanium-dioxide slag and, to a minor degree, for use as heavy aggregate. It is mined in the Allard Lake and St. Urbain areas of Quebec. Most of the Allard Lake ilmenite is electrically smelted at Sorel, Quebec, to produce slag containing 70 per cent titanium dioxide and a high-quality pig iron. Much of the slag is exported, mainly to the United States, for use in the manufacture of titanium-base pigments. Some is shipped to the two Canadian pigment producers — Canadian Titanium Pigments Limited at Varennes and Tioxide of Canada Limited at Ville-de-Tracy, both in Quebec.

TABLE 2

Titanium — QIT Production, 1964—65
(long tons)

	1964	1965
Ore treated	1,239,520	1,177,145
Titanium slag produced	486,358	487,425
Iron produced	335,762	332,785

Source: Kennecott Copper Corporation's *Annual Report* for 1965.

With a combined annual capacity in excess of 100 million pounds of titanium-base pigments, the two Canadian pigment producers met most of the domestic requirements and exported 3,202 tons, valued at $1.3 million, to the United States and substantial quantities to Britain on which statistics are not available. Both companies manufacture many grades of anatase and rutile types of titanium-dioxide pigment; many improved grades have been introduced to the trade as they were developed.

Before 1963, Canadian imports of titanium-base pigments were from 25,000 tons to 30,000 tons a year. The United States and Britain were the major suppliers. Since then domestic producers have largely eliminated imports despite rapid growth in domestic consumption. The Canadian market for titanium-dioxide pigments continues to expand and keep pace with requirements of Canada's secondary industries. Consumption in 1965 is estimated* at 85 million pounds of TiO_2.

Quebec Iron and Titanium Corporation (QIT)

This company is owned two-thirds by Kennecott Copper Corporation and one-third by The New Jersey Zinc Company. It operates eight electric-arc smelting furnaces with a combined annual feed capacity of 1.5 million short tons of ilmenite, at its smelter near Sorel.

QIT owns one of the world's largest known reserves of ilmenite – 150 million tons of measured and indicated ore averaging 35 per cent TiO_2 and 40 per cent iron, and many millions of tons of inferred ore. This ilmenite is intergrown with hematite in orebodies consisting of dykes, irregular lenses, and sill-like bodies lying within an anorthosite mass covering 134 acres. The largest orebody is at Lac Tio in the Allard Lake area about 22 miles north of Havre St. Pierre and about 500 miles downriver from Sorel. The Lac Tio deposit contains estimated reserves of 125 million tons of ilmenite. More than 10 million tons of ilmenite have been shipped to the company's smelter since production began 16 years ago.

Before treatment in the electric furnaces, the ilmenite from Allard Lake goes to the beneficiation plant at Sorel where it is crushed and separated into two sizes – minus 5/16 inch to plus 20 mesh, and minus 20 mesh. Upgrading of the two fractions is accomplished in Dutch State Mine cyclones and Humphrey spirals. The combined concentrates, containing about 37 per cent TiO_2 and 42 per cent iron (Fe), are calcined in rotary kilns to lower the sulphur content. Electric smelting of the calcine in arc furnaces with powdered anthracite coal yields a slag containing about 70.5 per cent TiO_2 and 14 per cent FeO, and a low-phosphorus iron containing about 0.12 per cent sulphur and 2.25 per cent carbon.

QIT's slag was developed primarily for the manufacture of pigment by the sulphate process. Its use as a raw material for the chloride process is possible but not economically practicable without further treatment. Anticipating the increased popularity of the chloride process, QIT began a research program designed to develop a slag suitable for use with it. QIT also expects that the development of synthetic rutile will provide a raw material for use in the titanium metal industry, thus opening up an entirely new market.

QIT's production of titanium slag at 487,425 long tons in 1965 was an all-time high and the company expects production to increase in 1966 because of an increase in the transformer capacity of two of the existing furnaces. The company also announced that construction had begun on a ninth furnace, which will have 50 per cent greater capacity than any of the eight other furnaces now operating. The foregoing changes will increase production capacity about 20 per cent by 1967.

Continental Titanium Corp.

Continental Titanium Corp., formerly Continental Iron & Titanium Mining Limited owns mining rights in the St. Urbain area about 8 miles north of Baie St. Paul, which is on the north shore of the St. Lawrence River, 60 miles downriver from Quebec City. The company reports measured and indicated reserves of 12.5 million tons averaging 35 per cent iron and 37 per cent TiO_2, and inferred reserves of 8 million tons. Ilmenite is mined for use as heavy aggregate and for testing in the development of a continuous process designed to produce technical-grade titanium dioxide. The process used is one of high-temperature, pressure-leaching using dilute sulphuric acid. In 1965 Continental continued to ship ilmenite for use as heavy aggregate and reported that it is trying to arrange financing for a titanium-dioxide production facility.

*Estimate by Mineral Resources Division.

TABLE 3

Titanium — Canadian Production, Trade and Consumption, 1956–65

(short tons)

	Production		Imports			Consumption	
	Ilmenite[1]	Titanium Dioxide Slag[2]	Titanium Dioxide Pure	Titanium Dioxide Extended	Total Titanium Dioxide Pigments[3]	Titanium Dioxide Pigments[4]	Ferro-titanium[5]
1956	630,197	157,374	..	..	37,872	32,482	277
1957	824,432	186,422	..	..	34,234	32,622	252
1958	420,932	161,312	..	..	29,439	35,795	210
1959	626,310	234,670	..	..	30,598	35,865	101
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[r]	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	..	27
1965[p]	1,486,986	545,916	1,565	9,534	11,099	..	65

Source: Dominion Bureau of Statistics and company annual reports.

[1]Producers' shipments of ilmenite from Allard Lake and St. Urbain area. For 1956 and 1957 from DBS, and 1958 onwards from company annual reports. [2]TiO_2 content of slag for 1956 to 1958 from DBS; from 1959, gross weight of 70–72% slag produced from company reports. [3]1956 to 1961 Ti and other oxide pigments containing not less than 14% by weight of TiO_2. [4]Includes pure and extended TiO_2 pigments. [5]1956 to 1958 gross weight; from 1959, Ti content.

p Preliminary; .. Not available; r Revised.

Canadian Titanium Pigments Limited

This company, a wholly-owned subsidiary of National Lead Company of New York, operated its Varennes plant at near-capacity throughout the year and further improvements in pigment quality were made involving the introduction of at least one new grade of pigment. Titanium-dioxide slag was purchased from Quebec Iron and Titanium Corporation at Sorel, and liquid sulphur for captive manufacture of sulphuric acid was obtained from Montreal East. Although the output was sold primarily in the domestic market, significant quantities were exported to the United States and overseas. Late in 1965 the company announced plans for a new titanium-dioxide producing unit to use chloride process. It will increase the company's capacity to 40,000 tons a year, 10,000 tons using the new chloride process, and 30,000 tons using the sulphate process.

Tioxide of Canada Limited

This company, previously British Titan Products (Canada) Limited, is a wholly-owned subsidiary of British Titan Products Company Limited, London, England. It manufactures a full range of titanium-dioxide pigments at its plant at Tracy, Quebec. The plant operated close to capacity in 1965 and additional processing equipment was being installed to increase plant capacity from 22,000 tons to 27,000 tons a year. Expansion is expected to be completed early in 1966.

OTHER COUNTRIES

The United States is the largest producer and consumer of ilmenite; it is also the largest consumer of rutile but ranks far behind Australia as a producer. According to U.S. Bureau of Mines, *Commodity Data Summaries*, January 1966, the estimated U.S. production of ilmenite in 1966 was 1,030,000 short tons, up slightly from 1964. The Bureau also estimated that U.S. rutile production decreased some 25 per cent from 1964 to 6,000 tons in 1965. Consumption of ilmenite and rutile were 1,110,000 tons and 95,000 tons compared with 1,109,000 tons and 79,446 tons in 1964. The increase in the consumption of rutile reflected the increased use of rutile in the production of pigments by the chloride process.

Ilmenite is produced in the United States by six companies with eight mining operations in New York, Florida, Virginia and New Jersey. Over half is mined in New York and one third is mined in Florida; Virginia and New Jersey produce the remainder. The value of mine output in 1965 was $20 million. Consumption of the domestically produced ilmenite is by some 100 firms, of which six TiO_2 pigment producers in eastern United States use 95 per cent. Rutile is produced in the United States by three companies, two in Florida and one in Virginia.

Preliminary figures supplied by the Australian Bureau of Mines shows that Australian production of rutile concentrate in 1965 amounted to 214,951 long tons, up 20 per cent from 1964 and production of ilmenite was 450,000 tons, up 40 per cent from 1964. Exports of rutile for the first nine months of 1965 were 186,000 tons; exports in 1964 totalled 193,000 tons.

Preparations begun in Sierra Leone in 1964 by Sherbro Minerals Ltd. for mining very large rutile reserves continued through 1965 with production scheduled to commence early in 1966 at 100,000 tons a year. The reserves are on the coastal plain in southwest Sierra Leone near Gbangbaia. Rutile will be recovered by a large suction dredge operating on a man-made lake 25 miles inland. The rutile concentrate will be trucked 16 miles to Niti on the Gbangbaia River, loaded into barges, and transported 18 miles down river to the Sherbro Estuary for bulk loading by a bucklet-ladder and belt-conveyor system.

TABLE 4

Production of Ilmenite Concentrates, 1964–65

(thousand short tons)

	1964	1965[e]
United States	1,001	1,030
Canada*	545	546
Australia	343	504
Norway	300	300
Malaysia	145	..
Finland	128	..
Other countries**	114	..
Total	2,576	2,740

Source: U.S. Bureau of Mines *Minerals Yearbook 1964* and U.S. Bureau of Mines *Commodity Data Summaries*, January, 1966.

* Slag containing 72% TiO_2. ** Exclusive of Soviet bloc.

[e] Estimate; .. Not available.

TABLE 5

Production of Rutile Concentrates, 1964–65

(short tons)

	1964	1965[e]
Australia	201,522	241,000
United States	8,062	6,000
India	2,062	..
Other countries	–	..
Total	211,600	..

Source: U.S. Bureau of Mines *Minerals Yearbook 1964* and U.S. Bureau of Mines *Commodity Data Summaries*, January, 1966; Bureau of Mineral Resources, Australia.

[e] Estimate;.. Not available.

India was once one of the world's leading suppliers of ilmenite but since the end of World War II production and exports have declined and ilmenite is recovered now only for consumption by the domestic pigment-producing industry. Minerals & Metal Trading Corp. has been trying to revive the export business, particularly to Japan.

Ilmenite concentrates are produced in many other countries in addition to those outlined. The most important producers are Norway, Finland, Malaysia and Ceylon. Nearly all rutile supply comes from Australia; several other countires produce small amounts.

USES AND CONSUMPTION

Most ilmenite mined is used for the manufacture of titanium-dioxide pigments. Pigment-grade titanium dioxide is made principally by treating ilmenite with sulphuric acid, removing the iron of the ilmenite in solution, and grinding the titanium component to pigment size. Ilmenite mined by Quebec Iron and Titanium Corporation does not readily lend itself to this process because hematite is finely disseminated throughout the ilmenite and cannot be removed by standard ore-dressing methods. Thus, the amount of sulphuric acid consumed in iron removal would be economically excessive. At Sorel, a pyrometallurgical process is used to separate the iron as molten metal from the ilmenite and associated hematite. The high-titania slag so produced is then converted to TiO_2 pigments with a much lower acid consumption than if ilmenite itself was used as base material.

Titanium dioxide owes its value as a pigment to its high refractive index. To take full advantage of this property, the TiO_2 must be in powder form of extremely small, uniform-sized particles. It is the high refractive index of TiO_2 pigment that accounts for its opacity. The amount of pigment required per unit area to block out, or obscure, a checkerboard surface is a measure of the relative opacifying power of pigments. In comparison with other white pigments, titanium dioxide has 10 to 12 times the opacifying power of white lead, six times that of zinc oxide or antimony oxide and four times that of lithopone.

In addition to their superior opacity, titanium-dioxide pigments have a high degree of whiteness and brightness, enhance the durability of many media into which they are incorporated and are chemically inactive and nontoxic. Because of this combination of properties, titanium-dioxide pigments have largely replaced the materials formerly used as white pigments. Consumption of TiO_2 pigments in Canada was about 42,500 tons in 1965 with their use by industry in percentage terms being approximately as follows:

Paint	66%
Floor covering	10
Paper	10
Rubber and plastics	7
Ink	1
Ceramics	2
Textiles	2
Others	2
Total	100%

Rutile is essentially TiO_2. Concentrates from Australia are much better than any others so far available as they have a content of over 95 per cent TiO_2, a very important factor in the manufacture of welding electrode coating, and sponge metal from which titanium ingot is produced. Until the development of the chloride process for the manufacture of titanium dioxide pigment, by far the greatest demand for rutile was for the manufacture of welding electrodes followed by its use in the manufacture of titanium sponge metal. Now, some 50 per cent of the rutile consumed is used in the manufacture of pigments.

TITANIUM METAL PRODUCTION AND FABRICATION

Using technical-grade dioxide manufactured by Canadian Titanium Pigments Limited, Dominion Magnesium Limited, near Haley, Ontario, produces titanium in the form of sintered pellets weighing from 5 to 7 grams each. The principal application of these pellets, which are sold almost entirely in Britain, is for special fuses.

Atlas Titanium Limited, the 'special-metals' subsidiary of Atlas Steels Company Division of Rio Algom Mines Limited, continued to carry out second-stage melting of imported ingots and process them to mill products for sale in domestic and export markets. As in previous years, a good portion of the company's production was material converted for its U.S. associate, Reactive Metals Inc. The success in exporting plating baskets and other mill products led to the establishment of a permanent international sales office in Wembley, England, in June 1964.

Macro Division of Kennametal Inc., Port Coquitlam, B.C., is the only Canadian manufacturer of titanium carbide powder. It also uses titanium in the manufacture of tungsten-titanium carbide and several other multicarbides; the raw material is rutile.

There are two commercial manufacturers of titanium sponge in the United States – Titanium Metals Corporation at Henderson, Nevada, and Reactive Metals Inc. at Ashtabula, Ohio. Reactive Metals is jointly owned by National Distillers & Chemical Corp. and United States Steel Corporation. Two others announced plans to build facilities to produce sponge metal and mill products. They are Carborundum Metals Climax, Inc., (CMC), jointly owned by Carborundum Co. and Climax Molybdenum Company, and Oregon Metallurgical Corp. (ORMET). CMC will produce sponge metal at Parkersburg, W. Va., and mill products at Akron, Ohio; ORMET will produce sponge metal in its plant at Albany, Oregon, where it already makes titanium castings, ingots and mill products.

The principal producers of titanium mill products in the United States are Reactive Metals Inc., Titanium Metals Corporation, Oregon Metallurgical Corp., Crucible Steel Company of America and Republic Steel Corporation. Metal Producers in Japan are Osaka Titanium Manufacturing Co., Osaka, Toho Titanium Industry Co., Tokyo, and Nippon Soda Co. Ltd., Tokyo.

In the United States, all segments of the titanium metal industry increased production sharply in 1965. Shipments of mill products at 19 million pounds reached a record with the major consumer being the military, but non-military uses are increasing rapidly. About 10 per cent of the market was in the industrial or nongovernment motivated sector of the economy. Titanium's use in pipe and tubing in corrosive environments such as water desalination apparatus and chemical processing equipment is significant and is expected to grow. The new Lockheed C5A transport plane will have perhaps 30,000 pounds of titanium in its frame as well as some in its power plant. Titanium is added to iron and steel in the form of low-carbon ferrotitanium where it acts as a deoxidizer, grain refiner and alloying ingredient, particularly for high-temperature and stainless steels. Pure or alloyed with small amounts of aluminum, vanadium, molybdenum and chromium, titanium has about the same strength as high-grade steels but is 45 per cent lighter.

PRICES

United States prices quoted in *E & MJ Metal and Mineral Markets* of December 27, 1965, were as follows:

Titanium ore, f.o.b. cars, Atlantic ports	
Ilmenite 54% TiO_2, per l.t.	\$21.00 – \$24.00
Rutile, 96% per s.t.	\$107.00 – \$111.00
Titanium metal, per lb delivered	
Max. 120 Brinell, 99.3%, 500 lb	1.32
Max. 90 Brinell, 99.9%, 25 lb	1.90
Max. 75 Brinell, 99.9%, 10 lb	4.00
Ferrotitanium, f.o.b. destination, northeastern United States	
Low-carbon, per lb Ti content, lump (½–in.) packed, 38–43% Ti, max. 0.10% C	1.35
Medium-carbon, net ton, carload lots, lump, packed, 17–21% Ti, 3–5% C	375.00
High-carbon, same basis as medium C, 15–19%, Ti, 6–8% C	310.00

TARIFFS

	British Preferential	Most Favoured Nation (%)	General (%)
Canada			
Titanium ore	free	free	free
Titanium oxide, and white pigments containing not less than 14% TiO_2 by weight	free	12½	15
Titanium sponges and sponge briquettes, ingots, blooms, slabs, billets of titanium, or titanium alloys for use in Canadian manufactures (expires June 30, 1966)	free	free	25
Ferrotitanium	free	5	5

United States

Titanium ore, crude	free
Titanium metal, unwrought waste and scrap*	20% ad val.
Titanium, wrougnt	18% ad val.
Ferrotitanium	10
Titanium dioxide	15
Titanium compounds	15

* Duty temporarily suspended on scrap to June 30, 1967.

Tungsten

V.B. SCHNEIDER*

Canadian tungsten production amounted to approximately 3 million pounds, all from Canada Tungsten Mining Corporation Limited. The mine is just east of the Yukon-Northwest Territories boundary and 135 miles north of Watson Lake. According to the company's annual report, production in 1966 should amount to 4 million pounds. This would be an all-time Canadian record and will account for about 15 per cent of expected non-Communist world production.

In 1958 Canada Tungsten announced the discovery of the tungsten deposit on its property in the Northwest Territories. Subsequent exploration and development indicated that it was one of the highest-grade tungsten deposits in the world. In 1963 and 1964 trial lots of concentrates were shipped. The company estimated in its annual report, that reserves at the end of 1965 were 920,000 tons grading 2.49 per cent WO_3. A depressed market for tungsten that developed in 1961 and milling problems influenced the company's decision to delay commercial production until 1965.

During the depressed period, the quoted price in New York for imported tungsten concentrates dropped from $24 a short-ton unit** of WO_3 on a 65 per cent WO_3 —content basis in July 1961 to $7.50 in August 1962. The market remained depressed until August 1964 and from that time the price rose almost steadily to $31 by the end of December 1965; much of the increase came in the second half of 1965. U.S. consumers pay an additional tariff of 50 cents a pound on the tungsten content of imported concentrates, which amounts to $7.93 for each short-ton unit of WO_3.

Complete statistical data on tungsten are not available but apparently non-Communist world tungsten production did not keep pace with rising consumption in 1964–65. The expansion of production and especially the reopening of mines is a costly and risky venture because of the dominance of mainland China as the world's main producer. The shortfall in production and, more important, the withdrawal of supplies of tungsten concentrates from the world market by mainland China resulted in the price rise.

Canadian imports of tungsten in ores and concentrates decreased about 8 per cent from 1964 but the unit cost of imported material increased 170 per cent; imports of ferrotungsten increased by 103 per cent over the same period but the unit cost increase was only 40 per cent. Consumption of tungsten, all forms, for the year was 877,614 pounds, an increase of about 12 per cent from 1964.

To relieve the tungsten shortage in the United States, the General Services Administration (GSA) sold some 900,000 pounds of tungsten to industry in 1965 from government stockpiles and indicated that greater amounts would be made available during 1966. In addition to the foregoing tungsten sales, some 104,000 pounds of tungsten were committed by GSA for use as payment-in-kind for two upgrading contracts for columbium and tantalum concentrates.

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*Mineral Resources Division

** A short-ton unit is 1% of a short ton, i.e., 20 pounds.

TABLE 1

Tungsten – Production, Imports and Consumption, 1964–65

	1964		1965P	
	Pounds	$	Pounds	$
Production[1] shipments WO_3	..	..	..	..
Imports				
Tungsten in ores and concentrates				
United States	203,200	111,105	320,300	370,019
Britain	–	–	37,100	43,690
Other countries	186,600	56,360	–	–
Total	389,800	167,465	357,400	413,709
Ferrotungsten[2]				
Britain	50,000	20,708	168,000	124,931
Austria	60,000	57,825	138,000	199,900
United States	30,000	35,115	48,000	59,891
Sweden	32,000	20,754	–	–
Total	172,000	134,402	354,000	384,722
Consumption, W content				
Scheelite	285,795		449,341	
Tungsten metal and metal powder	208,569		262,511	
Tungsten wire	10,167		11,613	
Ferrotungsten	87,316		[4]	
Other[3]	148,563		154,149	
Total	740,410		877,614	

Source: Dominion Bureau of Statistics
[1]Producers' shipments of tungsten concentrates (scheelite) not available for publication. [2]Gross weight. [3]Includes tungsten carbide powder, tungsten rod, tungstic oxide and sodium tungstate. [4]Included with 'Other'.
P Preliminary; .. Not available; – Nil.

TABLE 2

Production, Trade and Consumption, 1956–65

(pounds)

	Production* (WO_3 content)	Imports		Exports Scheelite (W content)	Consumption (W content)
		Tungsten Ore**	Ferro-tungsten		
1956	2,271,437	123,800	205,500	1,763,793	284,318
1957	1,921,483	230,700	170,200	1,524,851	277,972
1958	690,976	884,100	199,000	477,079	316,738
1959	–	840,000	828,600	–	659,991
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
1965P	..	357,400	354,000	..	877,614

Source: Dominion Bureau of Statistics.
* Producers' shipments of scheelite (WO_3 content). ** Prior to 1964 reported in gross weight. Commencing 1964 reported in W content.
P Preliminary; .. Not available; – Nil.

The two principal minerals of tungsten are scheelite ($CaWO_4$) and wolframite (Fe, Mn) WO_4. Scheelite is the ore mineral at the Canada Tungsten Mine. The deposit is a pyrometasomatic replacement of limestone. Scheelite is also found in association with gold-quartz veins at many active and long-dormant gold mines in Nova Scotia, Quebec, Ontario, Manitoba, British Columbia and Northwest Territories. These occurrences are not of present economic significance, though byproduct scheelite was recovered from gold-mining operations during World War II and the Korean conflict. Wolframite has been found in stream gravels and in quartz veins in the Atlin area of northern British Columbia and the Yukon Territory.

WORLD PRODUCTION AND TRADE

According to the U.S. Bureau of Mines*, world mine production of tungsten in 1965 amounted to 62.6 million pounds of which some 39 million pounds came from Communist-bloc countries. With only a very limited movement of tungsten, in any form, between Communist and non-Communist countries in 1964–65, one might well ask what mainland China and Russia are doing with all the tungsten they are suspected of producing.

The United States is the largest consumer of tungsten among the countries that provide data. The U.S. Bureau of Mines, in its *Mineral Industry Surveys, Tungsten Monthly*, March 4, 1966, reported that U.S. consumption of tungsten in concentrates amounted to 13 million pounds of contained wolfram. Production of tungsten in the United States comes from two mines, that of Union Carbide Nuclear Company, near Bishop Creek, Calif. and the one of Climax Molybdenum Company, at Climax, Colo. Tungsten is a coproduct of molybdenum, copper and silver at the Bishop Creek mine and a byproduct of molybdenum recovery at Climax. Union Carbide also recovers small amounts of tungsten from stockpiled material from many small operations in California that have ceased active mining operations. Production at Climax in 1965 was 1,180,000 pounds. Union Carbide does not report its tungsten recovery. Unofficial estimates indicate that the U.S. domestic production was around 9 million pounds in 1965.

* U.S. Bureau of Mines, Division of Minerals, *Commodity Data Summaries*, January 1966.

Portugal has long been a major source of wolframite for western European consumers mostly from the mines of Metallium Corporation and of Beralt Tin and Wolfram Ltd. According to company reports, production for each organization was down slightly in 1965 because some of the operations that were closed during the depressed market period had difficulty reopening because of a labour shortage. However, Portuguese production in 1966 is expected to be about 1,500 long tons of 65 per cent WO_3 material. Portuguese wolframite often sells at a premium because of its uniform high purity. Britain, Germany, France and Japan are large importers of tungsten concentrates.

The United Nations Committee on Tungsten held its fourth session in New York in May to review the tungsten market, to consider the desirability of intergovernmental arrangements for tungsten and of establishing an international tungsten institute, and to discuss the representativeness of the price quotations for tungsten ores and concentrates. Before the fourth meeting, the Tungsten Committee had an ad hoc status; however, at the fourth meeting the Tungsten Committee became a regular United Nations committee within the framework of UNCTAD and its reports are made available for general distribution.

Among the many problems besetting producers of tungsten concentrates is that of grade and specifications and the penalties that are usually written into long-term contracts for material that does not meet specifications. There are nearly as many grades and specifications as there are consumers. An impurity that is acceptable to one consumer may not be acceptable to another and, unless a producer can ship its entire output to one consumer, recovery losses can be serious as the mill tries to meet all demands.

Secondary or scrap tungsten undoubtedly is a substantial supply source of material. Tungsten metals or compounds are recovered from tool tips, dies, rod ends, powder, wire, tungsten scrap steel and master alloys. Some of this material can be reused directly for alloy steel production but most has to be treated chemically to produce a synthetic scheelite.

TABLE 3

World Production of Tungsten in Concentrates

(short tons, 60% WO_3 basis)

	1963	1964	1965[e]
Canada	—	..	3,000
China	24,900[e]	22,500[e]	24,000
U.S.S.R.	12,100[e]	12,100[e]	12,000
United States	5,657	9,244	9,000
South Korea	6,092	6,600	7,000
North Korea	4,400[e]	4,400[e]	5,000
Bolivia (exports)	2,513	2,285	2,600
Australia	1,793	1,860	2,000
Other countries	7,145	5,911	1,400
Total	64,600	64,900	66,000

Source: U.S. Bureau of Mines *Minerals Yearbook, 1964;* U.S. Bureau of Mines *Commodity Data Summaries,* January 1966; company reports; and Department of National Development, Bureau of Mineral Resources, Canberra, Australia.

[e] Estimate; .. Not available; — Nil

increase wear life is another interesting potential for expanding the use of tungsten. Many new uses for tungsten are envisaged by people in the industry but the wide gyrations in price and supply have greatly discouraged the development of tungsten's potential.

TABLE 4

Consumption of Tungsten in Canada, by Use, in 1964

(lb of contained W)

Carbides	456,871
Electric and electronics	12,210
Nonferrous alloys	12,502
Iron and steel	239,777
Pigments	19,050
Total	740,410

Source: Compiled in Mineral Resources Division from data supplied by the Dominion Bureau of Statistics.

CONSUMPTION AND USES

The use of cemented tungsten carbide has increased greatly in recent years through improvements in the technology of tungsten-carbide manufacture. Tungsten in tungsten-carbide tools does much more work in metal-cutting operations than is possible with steel tools containing the same amount of tungsten. This has changed the end-use pattern of tungsten. About 20 years ago, 90 per cent of the tungsten consumed went into the manufacture of ferrous alloys and 5 per cent into the manufacture of tungsten carbides. In the United States in 1964, about 44 per cent was used in the manufacture of tungsten carbides, 24 per cent in ferrous alloys, 20 per cent as tungsten metal, 11 per cent in high-temperature and other nonferrous alloys and 1 per cent in chemicals. The consumption pattern in Canada is noted in Table 4.

Tungsten carbide is used for tipping such tools as milling cutters, reamers, punches and drills; as dies for wire- and tube-drawing; in such wear-resistant parts as gauges, valve seats and valve guides, and as cores in armour-piercing steels. Its use in tire studs in recent years has created much controversy but many believe that this might ultimately become a very big use for tungsten. Vapour deposition of tungsten carbide on other steel surfaces to

In the nonferrous or superalloy field, tungsten is alloyed with cobalt, chromium, nickel, molybdenum, titanium and columbium in varying amounts to produce a series of hard-facing, heat- and corrosion-resistant alloys. High-temperature alloys are used mainly in turbojet engines for such parts as nozzle guide vanes, turbine blades, combustion-chamber liners and tail cones. They are also used in heat exchangers, boiler superheaters and boiler supercharges. Stellite, a nonferrous alloy containing from 5 to 20 per cent tungsten with chromium and cobalt, is used in the production of welding rods for hard-facing and in making high-speed tools.

The metal is used in ignition and other contact points in the automotive industry. It is also used for incandescent lamp filaments and in making certain types of bronze.

In Canada, the following are the leading consumers of tungsten:

Ontario

Atlas Steels Company, a division of Rio Algom Mines Limited	Welland
Canadian General Electric Company Limited	Toronto
A.C. Wickman Limited	Toronto
Johnson Matthey & Mallory Limited	Toronto
J.K. Smit & Sons of Canada Limited	Toronto

Canadian Westinghouse Company Limited	Hamilton
Dominion Colour Corporation Limited	New Toronto
Deloro Smelting & Refining Company, Limited	Belleville
Wheel Trueing Tool Company of Canada Limited	Windsor
Quebec	
Crucible Steel of Canada Ltd.	Sorel
Ferro Technique Limited	Montreal
British Columbia	
Kennametal of Canada, Limited	Victoria
Boyles Bros. Drilling Company, Ltd.	Vancouver
Kennametal Inc., Macro Division	Port Coquitlam

Macro Division of Kennametal Inc. is the only manufacturer of tungsten-carbide powder in Canada. The company also manufactures tungsten trioxide powder, tungsten metal powder, tungsten-titanium carbides, tungsten-tantalum-niobium carbides and vacuum-fuzed tungsten eutectic carbides. Other products containing tungsten manufactured at this plant include tungsten carbides, ball-mill balls, matrix powders for diamond bits and diamond tools, and carbide powders of tungsten, titanium and tantalum that are used for plasma spraying. The company uses wolframite and scheelite concentrates as raw material. Other Canadian consumers start with partially processed and semifabricated tungsten products. Masterloy Products Limited is the only manufacturer of ferrotungsten in Canada, which it manufactures at its plant on the Domtar Road, Gloucester township, Ontario, near Ottawa.

PRICES

According to *E & MJ Metal and Mineral Markets* of December 27, 1965, tungsten prices in the United States were:

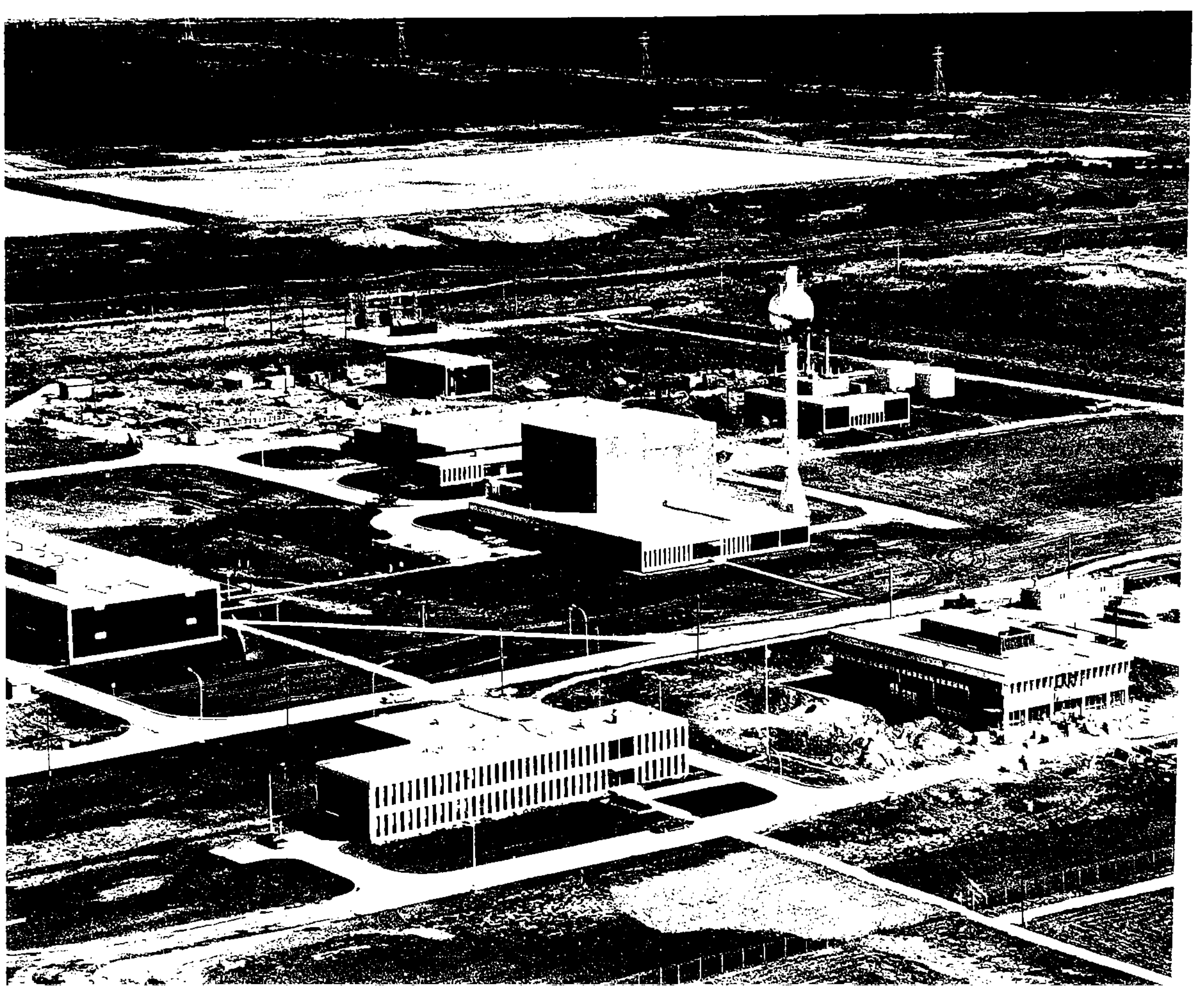
Tungsten ore, per short-ton unit of WO_3 (20 lb), basis 65%, foreign, c.i.f. U.S. ports	
Wolfram	\$30.75 to \$31.25
Scheelite	30.75 to 31.25
(50¢ per lb W duty extra)	
Tungsten metal, per lb	
98.8% min., 1,000–lb lots	2.75
Hydrogen reduced 99.99%	3.38 to 4.19
Ferrotungsten, per lb contained W. 70–80%	
Regular	3.00 (nominal)
"UCAR"	1.90
Tungstic acid, 92.5%, per lb, 1,000-lb lots in drums (according to *Oil, Paint and Drug Reporter*, Dec. 27, 1965)	1.90

TARIFFS

	British Preferential	Most Favoured Nation	General
Canada			
Tungsten ores and concentrates	free	free	free
Tungsten oxide in powder or lumps or in briquettes made with binding material used in steel manufacture	free	free	5%
Tungsten carbide, in metal tubes for use in Canadian manufacturing	free	free	free
Ferrotungsten	free	5%	5%
Tungsten rod and tungsten wire when used in Canadian manufacture	free	free	25%
Tungsten metal, in lumps, powder, ingots, blocks, or bars, and scrap of alloy metal containing tungsten, for use for alloying purposes	free	free	free

United States	
Tungsten ore	50¢ per lb on tungsten content
Tungsten metal	
Unwrought:	
Other than alloys	
Lump, grains and powders	42¢ per lb on tungsten content + 25%
Ingots and shots	21%
Other	25.5%
Alloys	
Containing by weight not over 50% tungsten	42¢ per lb on tungsten content + 12.5%
Containing by weight over 50% tungsten	25.5%
Waste and scrap	
Containing by weight not over 50% tungsten	42¢ per lb on tungsten content + 12.5%
Containing by weight over 50% tungsten	21%
Wrought	25.5%
Ferrotungsten	42¢ per lb on tungsten content + 12.5% ad val.

Part of the new Whiteshell nuclear research centre on the Winnipeg River near Pinawa, Manitoba, operated by Atomic Energy of Canada Limited. The organic-cooled reactor is a distinctly Canadian development.



Uranium and Thorium

R.A. SIMPSON*

Uranium

Production of uranium oxide (U_3O_8) continued its decline from 15,892 tons in the peak year 1959 to 4,307 tons in 1965. But, by year's end, there was an air of renewed optimism in the industry. For some time, uranium producers had been encouraged by statements from atomic scientists that nuclear power eventually would provide renewed demand for uranium. The first evidence that users were preparing to sign supply contracts appeared in 1965 as contracts for very large nuclear power plants were being negotiated at an unprecedented rate in a number of countries. The era of atomic power seems to be much closer to realization than had been forecast.

Of particular interest were the negotiations between Denison Mines Limited and Commissariat à l'Energie Atomique of France for the long-term sale of 50,000 tons of U_3O_8. National policies of France and Canada prevented conclusion of the contract.

In June the Canadian Government made known its policy on the export of uranium. It is prepared to grant export permits only if the uranium is to be used solely for peaceful purposes. Before such sales are authorized Canada will require an agreement with the government of the importing country to ensure, through appropriate verification and control, that the uranium is to be used for peaceful purposes only. Two general principles apply to such exports. First, the Government of Canada is prepared to authorize forward commitments by Canadian producers to supply uranium for foreign reactors that are already in operation, under construction, or firmly committed for construction for the anticipated life of each reactor. Second, the Government will be prepared to authorize the export for periods of up to five years of reasonable quantities of uranium for the accumulation of inventory in the importing country.

The Government decided in June to purchase uranium from companies that have previously produced uranium. Purchases would be made up to maximum quantities for a period of five years from July 1, 1965. The price to be paid for the uranium is \$4.90 a pound of U_3O_8 f.o.b. plant. Quantities to be purchased will assure that the industry could operate at roughly the 1965 rate for the next five years to provide a nucleus of operations that would allow for more orderly industry expansion than occurred in the mid-nineteen-fifties. Any outside additional sales will reduce the delivery commitment to the Government by an amount equal to such outside sales.

Eldorado Mining and Refining Limited began to receive concentrates delivered under the new stockpiling proposal. Denison Mines Limited and Rio Algom Mines Limited made scheduled deliveries during the last half of the year.

*Mineral Resources Division

TABLE 1

Uranium Production, by Province, 1964–65

	1964		1965P	
	Pounds	$	Pounds	$
Production (U_3O_8) shipments				
Ontario	11,805,143	63,606,944	6,800,000	49,200,000
Saskatchewan	2,765,164	19,902,485	1,815,000	15,100,000
Total	14,570,307	83,509,429	8,615,000	64,300,000

Source: Dominion Bureau of Statistics.
PPreliminary.

TABLE 2

Canadian Uranium Production, Sales and Exports, 1955–65

	Production[1] lb U_3O_8	Sales[2] lb U_3O_8	Sales[2] $	Exports[3] $
1955	..	2,030,767	24,878,129	..
1956	4,561,060	4,223,704	42,297,289	45,776,875
1957	13,271,414	12,152,916	125,539,886	127,934,804
1958	26,805,232	26,796,084	279,914,565	276,505,957
1959	31,784,189	30,996,065	325,328,282	311,904,143
1960	25,495,369	24,960,435	265,757,907	263,540,932
1961	19,281,465	19,270,884	202,330,734	192,722,397
1962	16,859,169	17,080,037	173,682,395	166,008,879
1963	16,703,066	15,216,812	139,900,174	137,531,381
1964	14,570,307	11,259,229	76,298,692	74,653,172
1965	8,615,000P	7,059,466	55,128,622	53,697,706
Total	177,946,271	171,046,399	1,711,056,675	1,650,276,246

Sources: [1]Dominion Bureau of Statistics. [2]Eldorado Mining and Refining Limited. These sales were to U.S. Atomic Energy Commission and U.K. Atomic Energy Authority. [3]Export values are from DBS and cover radioactive concentrates that cleared customs.

.. Not available; PPreliminary.

Note: The discrepancies between sales and exports are likely the result of dissimilar reporting periods and for uranium sales outside of those to the U.K. and U.S.A.

INDUSTRY DEVELOPMENTS

Only four companies produced uranium in 1965 and one, Stanrock Uranium Mines Limited, is a small producer that is not mining by conventional means. It uses a much-publicized method of recovery that depends upon bacterial leaching of uranium from ore remaining in stopes, by washing down the walls and floor with water under pressure. Uranium that has been leached from the ore by bacterial action is taken into solution and washing continues until the concentration of uranium in the solution running to sumps becomes too low to be effective. The stope is then left for bacteria to continue the leaching process and after an appropriate interval the stope is washed down again. The solution that runs to the sumps is pumped to the mill on the surface. Recovery of uranium from the solution is by the established method beginning at ion exchange. Just how long profitable recovery of uranium can be continued by this means before new ore surfaces or new ore must be exposed is not yet known. The other mines, while not doing as much bacterial leaching as Stanrock, do run their mine waters to the mill circuit to recover contained uranium. Rio Algom Mines Limited recovered 120,000 pounds of U_3O_8 from mine waters in 1965.

DENISON MINES LIMITED

During the first half of 1965, Denison Mines Limited continued to produce uranium to fill the portion of Gunnar Mining Limited's contract that was undelivered when the Gunnar mine depleted its ore. The mine was scheduled to close in July 1965 unless new contracts could be obtained. The Government decision to stockpile uranium, therefore, had its most immediate effect on Denison and allowed the company to continue to operate but at a reduced delivery rate. Under terms of an agreement with the Canadian Government, Denison will be permitted to deliver 15,000,000 pounds of U_3O_8 over the period from July 1, 1965, to June 30, 1970, at 3,000,000 pounds per annum.

Denison produced 2,561,164 pounds of U_3O_8 from 889,391 tons of ore milled with a 95.27 per cent recovery factor. The average content of uranium in the ore was 2.93 pounds a ton, somewhat lower than the ratio of the two previous years but more than the average rate over the operating life of the mine.

STANROCK URANIUM MINES LIMITED

Stanrock Uranium Mines Limited continued to produce uranium solely from the treatment of mine waters from the old workings. Since October 1964 Stanrock Uranium Mines Limited has not broken new ore but has produced from 9,000 to 15,000 pounds of U_3O_8 a month by the leaching of uranium from the ore by bacterial action. The company improved production during 1965 when output increased from an average of 9,500 pounds of U_3O_8 a month in the first quarter to about 15,000 pounds a month in the fourth quarter.

RIO ALGOM MINES LIMITED

Production of uranium by Rio Algom Mines Limited in 1965 was 2,717,193 pounds including 40,000 pounds recovered by treating Nordic mine waters and 80,000 pounds obtained by treating Milliken mine waters. Nordic continued to be the only Rio Algom uranium property actually mining in 1965. A total of 1,190,000 tons of ore were treated, having an average grade of 2.33 pounds of U_3O_8 per ton. Recovery averaged 94.8 per cent.

The underground water leaching program at Milliken was terminated in September 1965 when yields became too low to be economical. Remaining track and underground electric equipment and pumps were salvaged and the property was placed in the idle mine category.

In July 1965 the company entered into an agreement with the Canadian Government that will allow Rio Algom to deliver a total of 3,000,000 pounds of U_3O_8 over a five-year period at a rate of 600,000 pounds annually. During 1965 a total of 275,000 pounds of U_3O_8 were delivered under this contract. At year's end the remaining uranium to be delivered under terms of its master contract with Eldorado Mining and Refining Limited totalled 13,870,976 pounds of U_3O_8.

The company started work in the fall on dewatering the Quirke mine. The dewatering should be completed by June 1966 when the mine workings will be on a ready standby basis and the mine could be brought back into production at an estimated $2.5 million in a relatively short time.

In November 1965 Rio Algom acquired from Dow Chemical of Canada, Limited the latter's 50 per-cent interest in the capital of Rio Tinto Dow Limited. It changed the name of the new wholly-owned subsidiary to Rio Tinto Nuclear Products Limited with plans to construct a uranium refinery, which will have a capacity of 150 tons annually, at the Nordic mine site. Initial operations are expected to begin in May 1966 with full commercial production in 1967. The initial refined product will be reactor grade natural ceramic uranium dioxide powder. The company is anticipating that it may be the first step in providing customers with more comprehensive fuel services. These could include other forms of uranium dioxide, uranium carbide, uranium nitride and uranium hexafluoride or tetrafluoride. These, along with other uranium products, are now produced in Canada only by Eldorado. Rio Algom visualizes savings in producing these uranium products since it will be possible to commence production of higher-grade products from uranium while it is still in solution in the mill circuit.

ELDORADO MINING AND REFINING LIMITED

Production of U_3O_8 at its Beaverlodge mine in 1965 was down slightly from the previous year despite an increase in tons of ore milled. A total of 1,800,467 pounds of U_3O_8 were recovered from 536,132 tons of ore milled for an average of 3.36 pounds a ton. The company continued a program of ore development but, because of an increase in the plunge of the orebodies, newly-developed reserves were only sufficient to offset production. The company reported reserves at 1,500,000 tons grading 0.21 per cent U_3O_8 at the end of 1965, the same as a year earlier.

A new autogenous grinding mill was installed in the mill to replace two smaller, ball-mill circuits. Mechanical difficulties, which hampered efficient mill operation, were largely resolved.

Table 3 presents an interesting table of production history at the Beaverlodge mine, which was in the company's 1965 annual report.

TABLE 3

Production* at Beaverlodge Mine, 1953–65

	Ore Treated (short tons)	U_3O_8 Recovered (pounds)	Average Recovery (pounds per ton)
1953–1958	5,873,505	22,093,408	3.76
1958	676,354	2,507,663	3.71
1959	657,521	2,392,770	3.64
1960	625,127	2,454,400	3.93
1961	542,157	2,214,894	4.09
1962	563,580	1,959,788	3.48
1963	544,177	1,855,212	3.41
1964	522,148	1,837,029	3.52
1965	536,132	1,800,467	3.36

*Excludes custom-treated ores.

TABLE 4

Canadian Uranium Producers' Statistics for 1965

Company and Location	Mill Capacity (tons ore/ day)	Production (tons U_3O_8)	Ore Treated (millions of tons)	Millhead Grade (lb U_3O_8/ ton)	Mill Recovery (%)	Remarks
Elliot Lake District, Ont.						
Denison Mines Limited	6,000	1,281	0.89	2.93	95.27	
Rio Algom Mines Limited						
Milliken mine	3,000	40	..	..	..	Mine closed in 1964 but uranium recovered from mine waters.
Nordic mine	3,400	1,319	1.19	2.33	94.8	
Stanrock Uranium Mines Limited	3,000	74	..	..	..	Ceased mining Oct. 1964 but uranium recovered from mine waters.
Beaverlodge Area, Sask.						
Eldorado Mining and Refining Limited	2,000	900	0.53	3.36*	..	

Source: Company annual reports.

*Average recovery.

. .Not available or applicable.

TABLE 5

World Estimated Resources of Uranium
(excluding uranium already mined)
(10^3 short tons U_3O_8*)

Country	Price Range per lb U_3O_8					
	$5 to $10		$10 to $15		$15 to $30	
	Type of Resources					
	Reasonably Assured Resources	Possible Additional Resources	Reasonably Assured Resources	Possible Additional Resources	Reasonably Assured Resources	Possible Additional Resources
Canada	210	290	130	170	100[1]	200[1]
United States	195[2]	325	150[3]	200[4]	170[5]	440[6]
South Africa	140					
Europe						
France	37	28	5	10		
Spain	11			40		250
Portugal	7	3		6		10
Denmark[7]			5			
Sweden			350	50	150	200
Others	5[8]	20[9]	6[10]			
Total Europe	60		366			
Australia	15		2.8		1.4	
Congo (Leopoldville)	6					
Gabon	5					
Portugal (Angola)				15[13]		
Morocco[11]	6		11		8	
India			16.5[12]			
Japan			2.6[12]			
Argentina	5	15	5	12		
Total	642	**	684	**	**	**

Source: *World Uranium and Thorium Resources*, OECD, August 1965.

[1]Estimated for a slightly different price range, $15-20. [2]Includes 175,000 s.t. in conventional deposits and 20,000 as byproduct from phosphate operations (600 tons per year).[3]Includes 100,000 s.t. from conventional deposits and 50,000 as byproduct from phosphate mining. Production from phosphates limited to average of 1,950 s.t. of U_3O_8 (including lower-cost production). [4]Conventional deposits only. [5]Includes 100,000 s.t. from conventional deposits and 70,000 from phosphate operation. Production from phosphate deposits limited to 4,000 tons per year including lower-cost production. [6]140,000 s.t. from conventional deposits and 300,000 primary production from Florida, phosphate leached zone mined independently of phosphate operations. [7]Deposits in Illimaussaq, Greenland. [8]Mainly Germany, Italy, Turkey and Yugoslavia. [9]Mainly Germany, Italy, Spain, Turkey and Yugoslavia. [10]Germany and Yugoslavia. [11]Phosphate rock. [12]Information on prices not sufficient to determine whether these belong here or in column 1. [13]Information on prices is sufficient to determine whether these belong here or in column 2 or 6.

*1 short ton U_3O_8 = 770 kg. uranium metal. ** Total meaningless; lack of information for many countries.

RESOURCES

Uranium resources are currently of considerable interest not only to the mining fraternity but also to electricity-producing agencies. They see in atomic energy the eventual large-scale production of economical electrical power that is now produced from either hydraulic stations or thermal stations from low-cost coal. A natural corollary is that adequate resources of uranium must be assured for future nuclear power plants.

Much has been written about the future of uranium as it relates to nuclear-generated electricity. Without exception the outlook has been pronounced optimistic. Forecasts of expected consumption are available from a number of authoritative sources and the recent increase in construction contracts for nuclear plants in several countries is sound support for these forecasts. As to actual amounts of uranium that will be required, forecasts are being changed rather rapidly but consistently to higher values. A recent report* by the United States Atomic Energy Commission predicts that the U.S. will require at least 170,000 tons of U_3O_8 from now until 1980 and that by 1980 the annual requirement will be 27,000 tons. If we consider Europe and parts of Asia, which do not enjoy the comparatively low power costs of North America, then the U.S.'s figures can easily be doubled to give a Free World requirement of at least 300,000 tons of U_3O_8 to 1980 with annual requirements to reach over 50,000 tons.

The onus to meet these requirements seems to rest with Canada, the U.S. and the Republic of South Africa where the bulk of the known world resources has been found. South African resources are mainly in the gold ores of the Witwatersrand and maximum output is consequently related to gold mining. The deposits in Canada and the U.S. are worked for the uranium and sometimes thorium; therefore, output is directly related to demand for uranium alone.

A report on world uranium resources was prepared in 1965 by authorities from producing nations under the auspices of the Organization for Economic Co-operation and Development. The resources are listed in Table 5.

MARKETS AND PRICES

The bulk of uranium produced in Canada has been marketed through the crown corporation, Eldorado Mining and Refining Limited. None the less, private producers are free to negotiate sales of uranium consistent with the government's policy outlined earlier in this review and such sales have been made in the past. However, all sales remain subject to control measures administered through the Atomic Energy Control Board. Sales of small quantities of uranium, up to a maximum of 2,500 pounds in total for a country, may be made to countries not holding agreements for the peaceful uses of atomic energy.

Prices for uranium, unlike most mineral commodities, have not been consistent throughout the world and uranium is not sold through metal exchanges. The original requirement for uranium was for defence purposes. Because known exploitable deposits were scarce at the time, most uranium was purchased under conditions that would guarantee recovery of all expenditures and give a profit margin as long as there was an acceptable ore. Uranium procured from South Africa prior to the nineteen-sixties, averaged \$11.80 per pound of U_3O_8. Canadian uranium at the same period was about \$10.50 a pound. The average price received by Canadian uranium producers from the United Kingdom Atomic Energy Authority in the 1962 contract is \$5.03 a pound. The Canadian government stockpile price is \$4.90 a pound in 1965. Such variations in prices indicate unsettled conditions. However, both of the latter prices could be construed as distress prices made to meet unusual conditions at producing sites and should not be looked upon as market indicators in normal times. Few mines, if any, could tolerate such prices and carry out normal mining and necessary exploratory work.

Thorium

Canada began producing thorium concentrate in March 1959 when Rio Tinto Dow Limited made trial shipments from the Elliot Lake district. In 1965 Rio Tinto acquired from Dow Chemical of Canada, Limited, the latter's 50 per cent interest in the capital of Rio Tinto Dow and the name will be changed to Rio Tinto Nuclear Products Limited. The plant at Elliot Lake remains Canada's only producer of thorium salts and as a result production and other data have not been released for publication. The plant has an originally designed capacity of from 150 to 200 tons of thorium compounds annually.

Sales of thorium concentrates during 1965 were listed by the company as only moderately satisfactory.

Dominion Magnesium Limited, at Haley, Ontario, manufactures three thorium products — sintered pellets of pure thorium, thorium powder

*Faulkner, R.L., Dir. Div. of Raw Materials USAEC. *The coming uranium market.* May 6, 1966.

and thorium-magnesium master alloy (40% thorium). The company obtains thorium concentrates from Elliot Lake and ships finished products. Annual plant capacity is 200,000 pounds of thorium metal in the form of pellets of 98 per cent purity or powder of 99.5 per cent purity. Actual output is very much below this capacity. Output in 1965 aggregated 6,534 pounds of thorium compared with 6,455 pounds in 1964 and 7,099 pounds in 1963.

RESOURCES

The principal sources of thorium in Canada are the uranium ores of the Elliot Lake district, which are estimated to average 0.05 per cent thorium dioxide (ThO_2). The thorium is carried in the minerals monazite, uraninite and brannerite. The ores that were being mined near Bancroft for uranium are estimated to carry from 0.02 to 0.2 per cent ThO_2, but there has been less sampling for thorium than at Elliot Lake. Certain Bancroft deposits that have not been mined for uranium apparently carry considerably more thorium than do the uranium ores. The uranium ore reserves of the Elliot Lake and Bancroft areas are estimated to contain 82,000 tons of thorium. At the 1961 rate of uranium production in these camps it would be possible to recover approximately 4,000 tons of thorium oxide a year as a byproduct.

EXTRACTION PROCESS

The Rio Tinto thorium recovery plant, near Elliot Lake, was constructed at a cost of $1 million. The first operating unit was put up near the Quirke mine of Rio Algom Mines Limited. Early in 1961 the closing of the Quirke mine led to the construction of a second unit at Rio Algom's Nordic mill.

If the thorium market improves, additional thorium recovery units can readily be built to treat the waste solutions from other uranium mines of the Elliot Lake and Bancroft areas.

Thorium is obtained in dilute solution from the uranium treatment of plant wastes. It is usually discarded in the uranium mine-tailing dumps and is then not economically recoverable. The solution contains about a pound of thorium and about half a pound of rare earths to a thousand gallons. A relatively new process of solvent extraction* is used to extract and precipitate the thorium to separate it from iron, aluminum and the rare earths. The process, primarily chemical, consists of extracting the thorium from the waste liquor of the uranium circuits by solvent extraction, then stripping the thorium from the organic solvent with a strong sulphuric acid solution, followed by precipitating and thickening the thorium product. The thorium sludge is then filtered and dried, giving a crude product of about 25 per cent ThO_2.

Part of the cake is further refined to metallurgical-grade thorium oxide (99.8+ % ThO_2) at the Quirke plant. One hundred pounds of thorium oxide contain about 88 pounds of thorium.

The rare earths – ytterbium, thulium, irbium, europium, holmium, dysprosium, terbium, gadolinium, neodymium, praseodymium, lanthanum and particularly yttrium – are contained in the Elliot Lake ores. In 1965 Rio Algom installed a plant in its Rio Tinto Nuclear Products Limited operations at the Nordic mine to extract yttrium from the waste liquors from the uranium circuit. Yttrium is used in the manufacture of colour television tubes. This new plant has the capacity to produce 100,000 pounds per annum. First shipments of the new product were made in December 1965.

USES

Apart from its use as an alloying constituent, thorium has few major industrial applications. Because of its great tensile strength at high temperatures, it is alloyed with magnesium for use in the skin components of supersonic aircraft and space vehicles. These alloys also go into castings such as those in the compressor housings of jet engines. Thorium has been used for some time in incandescent gas mantles for gasoline lanterns, which are growing in popularity with campers.

In atomic energy, thorium is one of the two naturally occurring source materials from which nuclear fuels may be generated. Over the past few years, experiments on the use of thorium as a fuel in 'breeder' reactors have been carried out in the United States and Britain. A breeder reactor is one that converts a fertile material,

*Foreign plants use the sulphuric acid process or that of caustic attack on monazite. Thorium products are then separated from the accompanying rare earths.

such as thorium, into a fissile material which is capable of sustaining a chain reaction. In a breeder reactor it is theoretically possible to create more new fissionable material than is consumed. However, a number of technical obstacles must be overcome if such a reactor is to become more attractive than the uranium-fuelled type.

Thorium has a number of uses. It is used in arc-welding electrodes, in the filaments of incandescent electric lamps along with tungsten and as a deoxidant in the production of such metals as molybdenum and molybdenum-rich alloys. It also is used in electron tubes and lamps for controlling starting voltages and maintaining stability, and as a catalyst in the chemical and petroleum industries. Because of its extremely high melting point, thorium oxide has been used as a refractory material and as an ingredient in special optical glass.

MARKETS AND PRICES

Although Canada has been able to make significant inroads into the established thorium market that was largely dominated by operations based on monazite sand, the thorium market is small and no rapid expansion is foreseen for the near future. At the present time, Canadian thorium dominates the non-energy market which is anticipated for a slow but steady increase in the coming years. The principal purchasers of Canadian thorium, in addition to Dominion Magnesium, are in the United States and the United Kingdom.

Because of the relatively restricted market for thorium, prices are not generally available. However, the following price list for thorium and thorium compounds in the U.S., a major consumer, indicates the various prices prevalent there in 1965:

Compound	Price Range (U.S. $ per lb)
Thorium metal, powder or pellets	15.00 – 50.00
Thorium nitrate	2.65 – 6.00
Thorium oxide	5.80 – 20.00
Thorium oxalate	6.00 – 7.20
Thorium-magnesium hardener (30–40% Th)	9.18 – 10.00*

Source: Baroch, C.T., U.S. Bureau of Mines, *Engineering and Mining Journal*, February 1966.

*Does not include value for magnesium.

TARIFFS

The Canadian tariff rates listed below were obtained from the Department of National Revenue, Customs and Excise Division. Those for the U.S. are from tariff schedules of the U.S., as of the end of 1965.

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Thorium ores	free	free	free
Thorium isotopes	free	free	25
Thorium dioxide	15	20	25
Thorium bases or salts for the manufacture of incandescent gas mantles	free	free	free

United States	(%)
Thorium metal, unwrought	12½
Alloys of thorium, unwrought	15
Nitrates, oxides and other salts	35
Monazite sand and other thorium ores	free

Vanadium

V.B. SCHNEIDER*

Vanadium is recovered in Canada by Canadian Petrofina Limited in the form of vanadium pentoxide (V_2O_5), which it recovers from Venezuelan crude at its refinery at Pointe-aux-Trembles, Quebec. Production in 1965 was around 500 pounds of V_2O_5 a day and this rate will be increased to 1,000 pounds a day in 1966. The saleable product contains 98 per cent V_2O_5 maximum, 1 per cent Fe_2O_3, and traces of nickel, silicon, sodium and aluminum. Masterloy Products Limited, near Ottawa, is the only domestic producer of ferrovanadium, which it produces for domestic consumption and export.

Although Petrofina's is the first commercial operation for the recovery of vanadium in Canada, ash from the bitumen of the Athabasca tar sands contains about 4 per cent vanadium; this is equivalent to 240 parts per million in the bitumen. Should Great Canadian Oil Sands Limited decide to recover the V_2O_5 from its operations at Fort McMurray, it would probably do so at the power plant where some 2,800 tons of coke will be consumed daily. This will be produced at the coking plant where the lighter oils will be distilled off, leaving a coke residue.

Like other additive agents used in the manufacture of steel, vanadium was in short supply during 1965. In the United States the General Services Administration (GSA) sold 100 tons of contained vanadium in the form of pentoxide from surplus Atomic Energy Commission (AEC) stocks and in December accepted bids on an additional 1,120 tons. The generally high level of economic activity and the demand for vanadium in the United States was reflected in price increases for fused vanadium pentoxide and ferrovanadium. This was a reversal of a downward trend in prices that prevailed through 1963–64. One authority predicted that U.S. requirements in 1966 will exceed domestic production by from 6 to 12 million pounds and advocated continued releases from AEC stockpile of about 8 million pounds.** Releases from the AEC stockpile can be made under authority now held by GSA and do not require Congressional approval.

*Mineral Resources Division

**G.L. Weissenburger, President, Vanadium Corp. of America, *Engineering and Mining Journal*, February 1966.

TABLE 1

Canadian Imports and Consumption of Vanadium, 1964–65

	1964		1965	
	Short Tons	$	Short Tons	$
Imports				
Ferrovanadium				
United States	96	309,697	216	816,692
Belgium-Luxembourg	76	196,521	54	156,724
United Kingdom	–	–	33	104,252
Austria	77	257,121	16	49,624
Czechoslovakia	–	–	6	24,361
W. Germany	11	35,297	–	–
Total	260	798,636	325	1,151,653
Consumption				
Ferrovanadium				
Gross weight	204		218	
Vanadium content	115		133	

Source: Dominion Bureau of Statistics.
– Nil.

WORLD PRODUCTION AND CONSUMPTION

CANADA

Canadian Petrofina first announced that it would construct a vanadium recovery plant in connection with an expansion program at its Pointe-aux-Trembles (Montreal) oil refinery in 1964. The vanadium content of Venezuelan crude, processed by Canadian Petrofina at Montreal, is about 130 parts per million, which is considered to be relatively low for vanadium recovery. Petrofina processes about 32,000 barrels of Venezuelan crude oil a day, equivalent to about 1 million gallons. This crude contains about 1,200 pounds of vanadium, or 2,000 pounds of vanadium pentoxide, the form in which the metal is recovered. Construction of the plant was decided upon when a process for the extraction of V_2O_5 from crude oil was developed by Canadian Petrofina in conjunction with the federal Department of Mines and Technical Surveys.

The company reported that with an estimated processing cost of 30 cents a pound the project seemed sufficiently attractive to warrant commercial production, particularly as the crude oil capacity of the refinery will be increased from 30,000 to 50,000 barrels daily, with the expansion program scheduled to start in 1966.

OTHER COUNTRIES

The U.S. Bureau of Mines estimated in its *Commodity Data Summaries*, January 1966, that non-Communist world production of vanadium amounted to 9,822 tons, of which the United States produced 6,012 tons. This compares with 7,600 tons in 1965, of which the United States produced 4,362 tons.

In the United States, most vanadium is recovered as a byproduct of uranium mining. However, byproduct recovery from phosphate rock production as well as from vanadium ores mined by Union Carbide Corporation at its mine at Rifle, Colo., increased appreciably during 1965. Late in the year Union Carbide announced plans for a $5-million vanadium mill to be built at Wilson Springs, Ark. The new mill, which is scheduled to commence late in 1966 or early 1967, will have ore-processing capacity of more than 1,000 tons a day. Ore supplied to the mill will come from open-pit operations in the vicinity of Wilson Springs; pentoxide produced at the mill will be shipped to the company's ferroalloy manufacturing plant at Marietta, Ohio.

The United States is the largest consumer of vanadium and for many years has been a net exporter but because of the trend towards increased consumption it is expected that it will

TABLE 2

World Production of Vanadium in Ores and Concentrates, 1962–65
(short tons)

	1962	1963	1964	1965[e]
United States	5,211	3,853	4,362	6,012
Republic of South Africa	1,393	1,391	1,282	1,520
South West Africa	1,019	1,134	1,165[e]	1,275[e]
Finland	629	771	770	950[e]
Other countries	12	6	21	65
Total	8,264	7,155	7,600	9,822

Source: U.S. Bureau of Mines *Minerals Yearbook, 1964* and *Commodity Data Summaries* January 1966; and Republic of South Africa Department of Mines, *Quarterly Information Circular*, October to December 1965.
[e] Estimate.

soon be a large importer of vanadium in concentrates. Vanadium Corporation of America has entered into an agreement with a subsidiary of Anglo American Corporation of South Africa Limited, for the purchase of vanadium material from the latter's titaniferous magnetite operation currently being developed at the Mapoch mine in the Transvaal. Initial operations, scheduled for 1968 or 1969, are expected to supply 25 million pounds of vanadium a year.

The European market has been increasing rapidly with an estimated consumption of 8.4 million pounds of contained vanadium in 1965. This compares with the U.S. consumption of 9.4 million pounds and if the trend continues the European market may exceed that of the United States in a year or two. The major suppliers of European requirements are the Republic of South Africa, South West Africa, Finland and U.S.S.R.

In the Republic of South Africa, Transvaal Vanadium Co. (Pty) Ltd. is the major producer from its mine near Lyndenburg in the Transvaal. Total production for the Republic in 1965 amounted to 2,713 tons, up 423 tons from 1964.* Output from South West Africa is derived as a coproduct of lead-vanadate concentrates produced by the Berg Aukus mine of South West Africa Company Ltd. Production in 1965 amounted to 12,650 tons* of lead-vanadate concentrate and it is estimated that these concentrates contain 18 per cent V_2O_5. In Finland, vanadium is recovered as a byproduct of the beneficiation of titaniferous magnetite from the Otanmaki deposits.

*Republic of South Africa, Department of Mines, *Quarterly Information Circular*, October to December 1965.

TABLE 3

Vanadium Consumed in the United States
by End-Use, 1965

	Pounds
Steel	
High-speed	608,387
Hot-work tool	228,857
Other tool	228,712
Stainless	63,120
Other alloy[1]	5,649,923
Carbon	1,312,252
Grey and malleable castings	65,372
Nonferrous alloys[2]	702,445
Chemicals	389,333
Other[3]	120,756
Total	9,369,157

Source: U.S. Bureau of Mines, Mineral Industry Surveys, *Vanadium in December 1965*, March 1, 1966

[1] Includes some vanadium used in high-speed or other tool steels not specified by reporting firms. [2] Principally high-temperature alloys. [3] Principally high-temperature alloys, welding rods, cutting and wear-resistant materials.

USES

Vanadium is consumed principally in the form of ferrovanadium, an alloy of iron and vanadium, as additives to steel for castings, forgings and rolled products, particularly tool steels. It is used mainly for its grain-refining and alloying effects. It is also used in permanent magnetic alloys to which it provides good workability, both hot and cold. Besides ferrovanadium and vanadium pentoxide, other commercial forms of vanadium are ammonium metavanadate, vanadium oxytrichloride, and fused vanadium pentoxide and vanadium carbide, also used as steel-alloying agents.

Compounds of vanadium are used in non-ferrous industries. The main one is vanadium pentoxide which is widely used in industrial catalysts, notably in sulphuric acid manufacture. Other uses appear certain for the near future, for example, in the automotive field as a catalyst to reduce the emission of noxious or smog-forming fumes from automobile exhausts. Sodium and ammonium metavanadate have important uses in catalyst production, as an ingredient in coloured glazes for porcelain enamels and ceramic ware, and as driers or colour fixatives in paints, inks and dyes.

PRICES

E & M J Metal and Mineral Markets of December 27, 1965, quoted vanadium prices in the United States as follows:

Vanadium ore per lb V_2O_5, f.o.b. mine or mill, domestic, nominal, 31¢

Vanadium metal per lb, 90% purity, 100-lb lots, $3.45.

Ferrovanadium per lb V content, packed Vanadium Corp., delivered, $2.88

Union Carbide, f.o.b. shipping point, $2.62

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
Canada			
Vanadium ores and concentrates	free	free	free
Vanadium oxide in powder, lumps, formed into briquettes, for use in mfr. of steel	free	free	5
Vanadium metal, in lump, powder, ingot, block, (class or kind ruled to be not produced in Canada)	free	15	25
Vanadium metal, bars, rods, processed forms	15	20	25
Ferrovanadium	free	5	5

United States	(%)
Vanadium ore, concentrates	free
Vanadium metal, unwrought	10 ad val.
Vanadium metal, wrought	18
Ferrovanadium	12.5
Vanadium metal waste and scrap*	free
Vanadium carbide	12.5
Vanadium pentoxide	32
Vanadium compounds, other	32
Vanadium salts	32

*Temporarily suspended to June 30, 1967.

Zinc

D.B. FRASER *

Recoverable zinc production in 1965 rose to 831,902 short tons, 22 per cent more than in 1964. The value of production rose 30 per cent to $251,234,372 as a result of increased output and a higher average price of zinc, which was nearly a cent a pound more in 1965 than in 1964.

In terms of the assay content of zinc contained in ores and concentrates produced, total output was 910,929 tons in 1965 compared with 729,939 tons the previous year. A large new mine at Pine Point, Northwest Territories, came into production early in the year to ship high-grade zinc-lead ore from open pit operations and, late in the year, started shipments of zinc and lead concentrates from a 5,000-ton-a-day concentrator along with high-grade ore. New mines were opened at Manitouwadge, Ontario, and near Sherbrooke, Quebec. Three mines– the Brunswick No. 12 Mine in New Brunswick, the Lake Dufault mine in western Quebec, and the Rambler mine in Newfoundland – completed their first full year of operation in 1965. Mine output from some older mines at Kimberley, British Columbia, at Manitouwadge, Ontario, and at Noranda-Rouyn, Quebec, was considerably reduced in 1965 resulting in lower production for British Columbia and Ontario.

Exploration and development were carried forward on a wide front in 1965. Mines were being prepared for production in Vancouver Island, northern Manitoba, northern Ontario, western Quebec and New Brunswick. Exploration was particularly active in the Vangorda Creek district of the Yukon Territory and the Pine Point district of the Northwest Territories where large deposits of zinc and lead were discovered.

As a result of new mine capacity now under development and scheduled for production in the next year or two, mine output should continue to rise, though not as sharply as in 1964 and 1965. The extent of the increase will depend to a large degree on increases in world demand for zinc. During 1965 world consumption did not increase as much as in earlier years. The forecast for 1966, however, is for a growth of about 5 per cent, which would be near the average of the past several years and would represent increased world requirements of about 210,000 tons.

Production of refined zinc rose from 337,728 tons in 1964 to 358,779 tons in 1965, reflecting the high level of demand during the year. Capacities at the Trail plant of Cominco Ltd. (formerly The Consolidated Mining and Smelting Company of Canada Limited) and at the Valleyfield plant of Canadian Electrolytic Zinc Limited were expanded. Canadian primary refinery capacity at the end of 1965 was

	Annual Capacity (short tons)
Cominco Ltd., Trail, B.C.	232,000
Hudson Bay Mining and Smelting Co., Limited, Flin Flon, Manitoba	79,000
Canadian Electrolytic Zinc Limited, Valleyfield, Quebec	84,000*

*Further expansion to 400 tons daily under construction; increase to 250 tons daily in 1965.

*Mineral Resources Division

TABLE 1

Zinc – Production, Trade and Consumption, 1964–65

	1964		1965p	
	Short Tons	$	Short Tons	$
Production				
All forms[1]				
Quebec	236,540	67,035,531	275,788	83,287,850
British Columbia	200,398	56,792,873	160,559	48,488,706
New Brunswick	54,372	15,408,927	129,150	39,003,300
Northwest Territories	3,920	1,111,016	93,562	28,255,875
Ontario	72,076	20,426,433	59,945	18,103,427
Manitoba	42,645	12,085,508	40,345	12,184,343
Newfoundland	38,982	11,047,407	37,169	11,224,932
Saskatchewan	28,438	8,059,144	28,134	8,496,439
Yukon	6,547	1,855,512	7,000	2,114,000
Nova Scotia	595	168,546	250	75,500
Total	684,513	193,990,897	831,902	251,234,372
Mine output[2]	729,939		910,929	
Refined[3]	337,728		358,779	
Exports				
Zinc blocks, pigs and slabs				
Britain	97,991	25,598,291	109,567	28,861,422
United States	78,563	20,442,703	91,605	26,033,977
India	15,126	3,910,987	23,423	6,377,857
Netherlands	15,534	4,721,877	13,337	3,870,630
West Germany	6,211	1,456,991	8,590	2,072,288
Italy	4,096	819,170	7,083	1,477,441
Belgium and Luxembourg	5,702	1,208,230	3,700	740,057
Thailand	1,656	331,775	2,179	435,803
Other countries	13,197	3,235,614	4,716	1,114,613
Total	238,076	61,725,638	264,200	70,984,088
Zinc contained in ores and concentrates				
United States	188,750	19,541,874	231,597	29,702,380
Belgium and Luxembourg	93,377	15,015,361	156,725	23,370,982
Poland	28,356	4,404,345	35,118	5,358,365
West Germany	32,298	5,308,016	22,034	3,383,200
France	16,219	2,538,626	16,661	2,564,418
Britain	7,490	1,315,325	11,742	1,865,938
Norway	5,403	1,091,905	6,936	999,464
Japan	24,384	3,481,500	5,835	772,584
Other countries	6,825	990,614	797	110,673
Total	403,102	53,687,566	487,445	68,128,004
Zinc fabricated materials, n.e.s.				
Britain	691	247,482	943	230,286
United States	1,022	305,838	656	335,447
Guatemala	124	51,733	48	23,160
Other countries	31	13,986	43	14,752
Total	1,868	619,039	1,690	603,645
Zinc and zinc-alloy scrap, dross and ashes				
United States	3,972	717,290	6,047	1,390,321
Belgium and Luxembourg	2,238	149,304	1,884	180,377
Britain	465	68,183	371	43,781
Netherlands	239	27,757	245	26,543
Yugoslavia	–	–	240	37,296
Other countries	875	125,554	356	42,437
Total	7,789	1,088,088	9,143	1,720,755

Table 1 (cont.)

	1964 Short Tons	1964 $	1965P Short Tons	1965P $
Imports				
In ores and concentrates	13,511	2,250,632	8,919	1,827,973
Dust and granules	1,845	606,665	1,342	521,618
Slabs, blocks, pigs, and anodes	22	8,403	17	6,808
Bars, rods, plates, strip and sheet	832	530,665	928	608,590
Slugs, discs, shells	482	192,762	441	183,212
Zinc oxide	1,170	273,369	1,093	303,341
Zinc sulphate	1,515	178,260	2,355	293,232
Lithopone	539	80,987	574	79,520
Zinc fabricated materials n.e.s.	1,318	1,142,177	1,110	1,082,232
Total	21,234	5,263,920	16,779	4,906,526

	1964 Primary	1964 Secondary (short tons)	1964 Total	1965P Primary	1965P Secondary (short tons)	1965P Total
Consumption						
Zinc used for or in the manufacture of						
Copper alloys (brass, bronze, etc.)	10,166	101	10,267	9,284	370	9,654
Galvanizing:						
electro	830	73	903	909	61	970
hot-dip	43,283	325	43,608	45,764	517	46,281
Zinc die-cast alloy	17,966	—	17,966	20,982	—	20,982
Other products (including rolled and ribbon zinc, zinc oxide)	16,249	2,059	18,308	16,857	2,601	19,458
Total	88,494	2,558	91,052	93,796	3,549	97,345
Stocks on hand at end of year	11,569	626	12,195	9,040	691	9,731

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; —Nil; n.e.s. Not elsewhere specified.

Zinc concentrates produced in Manitoba and Saskatchewan were refined at Flin Flon. Most of the ores and zinc concentrates produced in British Columbia and the two Territories were treated at Trail; the remainder was exported to refineries in Idaho and Montana. Production from eastern mines, except that going to Valleyfield for treatment, was exported to the United States and Europe and, to a small extent, to Japan. In addition to the roasting facilities at Valleyfield, zinc roasters were operated in eastern Canada at Port Maitland, Ontario, by Sherbrooke Metallurgical Company Limited and at Arvida, Quebec, by Aluminum Company of Canada, Limited.

Exports of zinc in concentrates and as metal were again at record levels, rising to a total of 751,645 tons. Exports of concentrates, amounting to 487,445 tons, were about equally divided between the United States and Europe; those to Japan were notably lower than in 1964. Refined exports, totalling 264,200 tons, went to 24 countries and were distributed as follows: 41 per cent to Britain, 35 per cent to United States, 13 per cent to Europe, 10 per cent to Asia, and less than 0.5 per cent to South and Central America.

Reported domestic consumption of refined zinc rose to 97,345 tons, including 3,549 tons of secondary zinc. Gains were reported in all major outlets except in the use of zinc in copper alloys, which was down slightly from the 1964 level.

TABLE 2

Zinc – Production, Exports and Consumption, 1956–65

(short tons)

	Production		Exports			Consumption[3]
	All Forms[1]	Refined[2]	In Ore and Concentrates	Refined	Total	
1956	422,633	255,564	199,313	183,728	383,041	61,173
1957	413,741	247,316	187,141	202,007	389,148	52,713
1958	425,099	252,093	217,823	195,708	413,531	56,097
1959	396,008	255,306	181,084	179,552	360,636	64,788
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	337,728	403,102	238,076	641,178	88,494
1965p	831,902	358,779	487,445	264,200	751,645	93,796

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.

[p]Preliminary.

WORLD PRODUCTION AND CONSUMPTION

Free World mine production of zinc in 1965 rose to 3.8 million short tons, about 315,000 tons more than in 1964. The main increases were in Canada, United States and Peru. Metal production was 175,000 tons higher at 3.4 million tons, the main increases being in Japan, United States and Canada.

Free World zinc consumption in 1965, as estimated at the November meeting of the International Lead and Zinc Study Group, exceeded metal production by about 260,000 short tons. The difference was made up by imports from Communist-bloc countries, amounting to 175,000 tons, and by sales of zinc metal from the United States government stockpile, amounting to 220,000 tons. The forecast for 1966 was for a bigger rise in consumption, 5½ per cent compared with 3 per cent in 1965 over 1964, and for continuing increases in mine and metal production. Supply and demand, based on forecasts of production and consumption and of imports from Communist-bloc countries, were expected to be in approximate balance in 1966 in contrast to the shortages experienced in 1964 and 1965. The Study Group noted that sales of zinc from the U.S. stockpile in 1966 would alter the forecast of a balanced position.

TABLE 3

World Mine Production of Zinc, 1964–65

(excluding Communist-bloc countries)

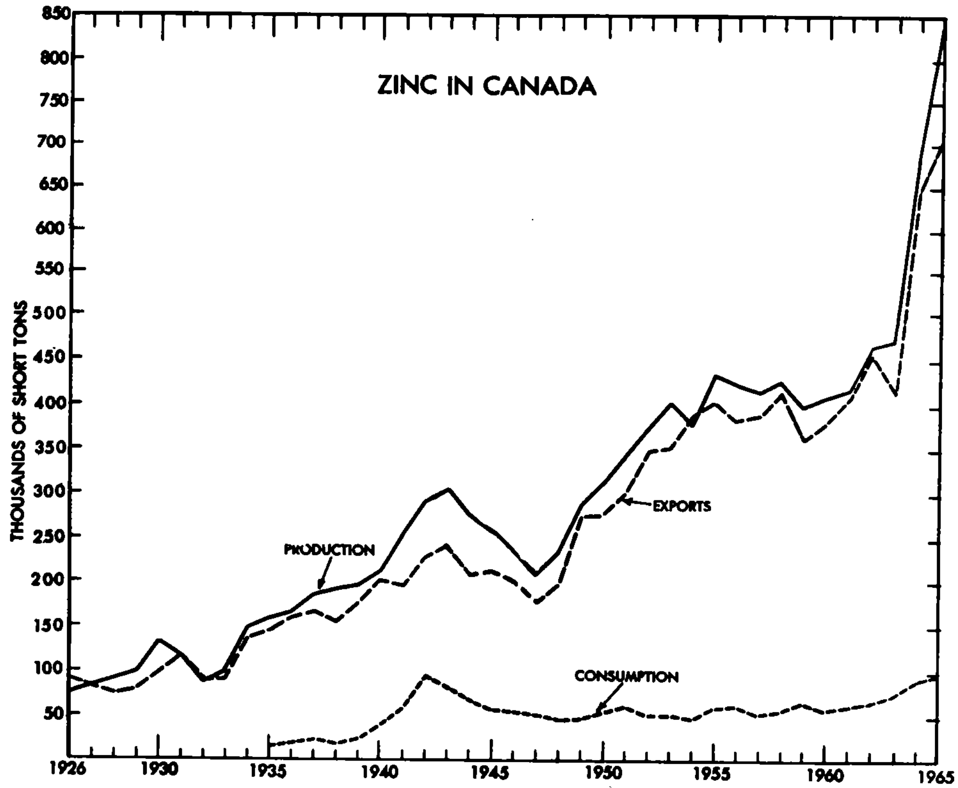
	1964	1965
	(short tons)	
Canada	729,900	910,900
United States	631,700	670,600
Australia	351,100	361,000
Peru	299,800	353,200
Mexico	251,700	..
Japan	238,600	243,400
Germany, F.R.	130,000	129,000
Italy	123,000	127,200
Congo (Leopoldville)	115,700	..
Sweden	78,900	81,700
Yugoslavia	72,900	74,000
Spain	89,500	41,900
Zambia	51,800	..
Morocco	48,500	..
Other countries	309,000	..
Total	3,522,100	3,837,200e

Source: International Lead and Zinc Study Group.

[e]Estimate; .. Not available.

UNITED STATES IMPORT QUOTAS AND STOCKPILES

The United States import quotas on unmanufactured lead and zinc that had been in effect since October 1, 1958, were ended by Presidential Proclamation effective October 22,



1965 for ores and concentrates, and 30 days later for metals. It was announced by the President that "the Tariff Commission, in a unanimous decision, found that ending the quotas was not likely to have a detrimental effect on domestic producers. Additionally, the United States companies which require unmanufactured lead and zinc in their processing and manufacturing activities have made clear their great need for additional lead and zinc — in fact, many have indicated that without immediate relief they will be forced to suspend operations."

Imports of lead and zinc from Canada for consumption in the United States were limited under the quota system to 80 per cent of annual average imports from 1953 to 1957. The annual allotment was 132,960 tons of zinc in concentrate and 75,680 tons in refined and other metallic form. The Canadian quarterly quotas in all categories were filled during the 8-year period when quotas were in effect except during the first three quarters of 1961 when the zinc ore quota was, on the average, 77 per cent filled and the zinc metal quota was 96 per cent filled.

Disposals from U.S. government stockpiles continued in 1965 following the sale of 75,000 tons of zinc in the last half of 1964. In April 1965 the disposal of 150,000 tons of zinc to producers and distributors was authorized with an additional 50,000 tons authorized for government use only. The 150,000 tons was sold by August. After consideration of a further disposal of from 150,000 to 300,000 tons, it was announced on November 4 that 200,000 tons had been authorized for release, of which 75,000 tons would be offered in 1965 and the balance in 1966. By December 21, sales totalled 69,175 tons. In January 1966 it was announced that the remainder of the 200,000 tons not sold at that time, or about 129,000 tons, would be offered during one week of each month from February through September, 1966.

The total amount of zinc in the stockpile at the end of 1965 was 1,315,167 tons.

PRINCIPAL DEVELOPMENTS AT PRODUCING MINES AND REFINERIES

BRITISH COLUMBIA

Ore production at the Sullivan mine of Cominco Ltd. at Kimberley totalled 2,301,000 tons, 410,000 tons less than the previous year. The availability of ore from Pine Point made possible a reduction of the extraction rate according to the planned return to the long-term mining program at the Sullivan mine. Ore production from Cominco's Bluebell mine was 256,000 tons and from the H.B. mine, 416,000 tons. Ore reserves at the three mines at September 30, 1965, totalled 73,900,000 tons containing 8,100,000 tons of lead and zinc.

Zinc concentrates from these mines and from custom shippers were treated at the Trail metallurgical works where zinc production was at a record 213,082 tons. The increase from 199,000 tons produced in 1964 resulted from the availability of high grade direct shipping ore from Pine Point and from an extension to the electrolytic zinc plant bringing its rated capacity to 232,000 tons annually. Lead and zinc production was derived approximately 48 per cent from the Sullivan mine, 12 per cent from other company mines, 29 per cent from Pine Point and 11 per cent from purchased ores and concentrates.

NORTHWEST TERRITORIES

Production of zinc-lead ore by the Cominco subsidiary, Pine Point Mines Limited, which began in 1965, was mainly responsible for raising the value of mineral production in the Northwest Territories from $18 million in 1964 to $73 million in 1965.

Shipments of high-grade lead-zinc ore by Pine Point Mines Limited, which were first made in November 1964 for mill-testing, increased during 1965, amounting to 364,000 tons assaying 29.1 per cent zinc and 22.5 per cent lead. Of this total, 314,000 tons were shipped to Cominco plants for treatment, mostly to the Sullivan concentrator at Kimberley, and the remainder went to Kellogg, Idaho, for treatment by The Bunker Hill Company.

Construction of the 5,000-ton mill and service buildings at Pine Point was completed about the middle of November, 1965. The Taltson River hydroelectric plant and transmission line was completed about the same time and from mid-November to the end of the year 75,356 tons of ore averaging 7.63 per cent zinc and 4.27 per cent lead were milled. Production was 8,377 tons of zinc concentrates and 3,524 tons of lead concentrates, all shipped to Trail. The company reported a total of 26 orebodies found to date; stripping of overburden continued during 1965 and was completed at three orebodies. Ore reserves were approximately 21,500,000 tons averaging 4 per cent lead and 7.2 per cent zinc.

MANITOBA AND SASKATCHEWAN

Hudson Bay Mining and Smelting Co., Limited operated three mines near Flin Flon, two near Snow Lake, and copper-zinc milling and smelting works at Flin Flon. Total ore treated was 1,640,328 tons, or 54,934 tons more than in 1964. Fifty-three per cent was from the Flin Flon mine, 7 per cent from the Schist Lake mine, and 5 per cent was from the Coronation mine, all at or near Flin Flon. Production from the Coronation stopped in August 1965 due to depletion of ore reserves. The Chisel Lake mine supplied 18 per cent of total ore treated, and the Stall Lake mine 17 per cent; both are near Snow Lake, 90 miles east of Flin Flon. Production of slab zinc at the electrolytic plant, from the treatment of zinc concentrates and of fume recovered from copper slag, totalled 71,435 tons, 425 tons more than in 1964.

ONTARIO

Zinc production was from three mines at Manitouwadge (Geco, Willroy, and Willecho) and from the Kam-Kotia mine near Timmins.

Test shipments from the Willecho mine, about 2 miles northwest of the Willroy mine, were made in January and February 1965 and regular shipments to the Willroy mill averaged 918 tons daily during the remainder of the year. Total ore delivered during the year amounted to 283,259 tons.

QUEBEC

Output of zinc in Quebec was 17 per cent higher in 1965 than in 1964. Lake Dufault Mines, Limited completed the first full year of operation at its copper-zinc mine near Noranda-Rouyn, producing 30,000 tons of zinc in concentrates, compared with 6,000 tons produced during the last quarter of 1964 when regular production began.

Output from Mattagami Lake Mines Limited and Orchan Mines Limited, in the Matagami Lake district, where production started late in 1963, totalled 194,600 tons of zinc in concentrates, about 5,000 tons more than in 1964. Operations at other mines of the province were generally high.

Production of copper-zinc-lead ore by Cupra Mines Ltd., one of the Sullivan mining group, began in September 1965. The property is 3 miles south of the Solbec mine. The ore was trucked to the Solbec mill for treatment at a rate of approximately 1,000 tons daily.

Production of slab zinc at Valleyfield totalled nearly 74,000 tons, an average of just over 200 tons daily. Capacity was raised during the year to 250 tons daily and will be raised further to 400 tons daily by the second half of 1966. Roasting and acid-production facilities will be added in the expansion.

NEW BRUNSWICK

Recoverable zinc output rose from 54,000 tons in 1964 to 129,000 tons in 1965. Brunswick Mining and Smelting Corporation Limited completed the first full year's operation at the No. 12 mine and 4,500-ton concentrator near Bathurst. Production at the property of Heath Steele Mines Limited remained approximately at the 1964 level. A shaft sinking and mine development program was started by Heath Steele Mines which will double ore production to 600,000 tons by 1968.

NEWFOUNDLAND

Production was mainly from the Buchans zinc-lead-copper mine operated by American Smelting and Refining Company, where operations were about normal. The only other producer was Consolidated Rambler Mines Limited, which completed its first full year of operations at its copper-zinc mine at Baie Verte. An expansion of the mill from 500 to 1,500 tons of ore daily was begun at the Rambler mine and scheduled for completion in August 1966.

OTHER DEVELOPMENTS

BRITISH COLUMBIA

Western Mines Limited concluded plans for bringing the Lynx mine, at Buttle Lake, Vancouver Island, into production in mid-1966 at a rate of 750 tons daily. Shaft sinking was completed and five new levels were established. Ore reserves were increased from 1,613,000 tons to 2,054,000 tons as of September 30, averaging 10.01 per cent zinc, 1.10 per cent lead and 2.19 per cent copper. It is planned to produce a zinc, a copper, and a bulk lead-zinc concentrate.

YUKON TERRITORY

No further exploration was carried out by Vangorda Mines Limited at its Vangorda Creek zinc-lead property near Ross River, where 9,400,000 tons had been previously indicated. Kerr Addison Mines Limited, which owns approximately two thirds of the shares of Vangorda Mines Limited, continued exploration at Swim Lake, 6 miles southeast of the Vangorda property, testing by diamond drilling an extensive gravity anomaly disclosed in 1963 and 1964. The company reported that the grade appeared similar to that at Vangorda.

Dynasty Explorations Limited, in association with Cyprus Mines Corporation, reported discovery of a zinc-lead-silver deposit containing a potential of 30 million tons averaging 8 to 11 per cent combined lead-zinc. Located about 10 miles northwest of the Vangorda property and known as the Faro group, the claims were explored by diamond drilling and a new company, Anvil Mining Corporation Limited, was set up to continue the exploration program. Ownership is 60 per cent by Cyprus and 40 per cent by Dynasty. The discovery, in conjunction with earlier results obtained by Kerr Addison Mines Limited, led to a staking rush in Vangorda district.

NORTHWEST TERRITORIES

Pyramid Mining Co. Ltd. conducted an induced polarization survey on its extensive holdings on the south border of the Pine Point Mines Limited claims, from which three anomalies were indicated. Diamond drilling began in October and continued through the winter. By March 1966, a total of 139 holes had been drilled on two anomalies and the company reported that approximately 11.2 million tons averaging 8 per cent zinc and 2.5 per cent lead were indicated.

Exploration in the Pine Point area was particularly active during the year and geophysical surveys were carried out on many properties and diamond drilling on several.

TABLE 4

Principal Zinc Mines in Canada, 1965

Company and Location	Mill Capacity (tons ore/day)	Grade of Ore (Principal Metals) Zinc (%)	Lead (%)	Copper (%)	Silver (oz/ton)	Ore Produced 1965 (1964) (short tons)	Contained Zinc Produced 1965 (1964) (short tons)	Remarks
British Columbia								
Aetna Investment Corporation Limited, Toby Creek	500	..	..	..	..	145,196 (182,958)	5,043 (6,971)	Formerly Sheep Creek Mines Limited. Shaft sinking in 1965.
The Anaconda Company (Canada) Ltd., Britannia Beach	4,000	0.54	—	1.24	0.09	226,005 (493,700)	455 (1,985)	Strike ended March 1965. Mine development and exploration continued.
Canadian Exploration, Limited, Salmo	1,900	3.54	1.06	—	..	377,124 (407,062)	12,175 (13,326)	Exploration continued.
Cominco Ltd.								
Sullivan, Kimberley	10,000	..	..	—	..	2,301,071 (2,711,000)	107,417 (133,424)	High-grade ore from Pine Point treated during year.
Bluebell, Riondel	700	..	..	—	..	256,332 (258,000)	14,496 (14,413)	Exploration continued.
H.B., Salmo	1,200	..	..	—	..	415,290 (478,000)	20,449 (20,941)	Exploration below and east of known ore.
Johnsby Mines Limited, Silverton	150	4.9	3.9	—	13.5	10,925 (2,988)	546 (122)	
London Pride Silver Mines Ltd. Kaslo	100	7.4	2.1	—	1.9	26,019 (6,742)	1,795 (336)	
Mastodon-Highland Bell Mines Limited, Beaverdell	100			—	27.92	23,213 (25,090)	298 (382)	Increased underground exploration.
Reeves MacDonald Mines Limited, Remac	1,200	3.65	1.21	—	..	409,504 (379,269)	13,690 (12,958)	Increased exploration.
Yukon Territory								
United Keno Hill Mines Limited, (Hector-Calumet, Elsa, Keno, Silver King)	500	6.22	7.06	—	33.25	146,850 (181,849)	8,350 (8,240)	

Northwest Territories								
Pine Point Mines Limited, Pine Point	5,000	29.1	22.5	–	–	364,168[1]	..	Direct shipping ore shipped during full year. Milling began in mid-Nov.
		7.63	4.27	–	–	75,356[2]	8,377[3]	
Manitoba and Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited (Flin Flon, Schist Lake, Coronation, Chisel Lake and Stall Lake mines)	6,000	4.3	0.4	2.64	0.86	1,640,328 (1,585,394)	64,562 (58,912)	Osborne Lake, Anderson Lake mines being prepared for production.
Ontario								
Kam-Kotia Porcupine Mines, Limited, Timmins	1,750	1.37	–	1.56	0.25	597,623 (638,000)	3,883 (1,660)	New ore indicated by diamond drilling.
Noranda Mines Limited, Manitouwadge	3,300	4.26	..	1.97	2.17	1,326,400 (1,299,300)	42,880 (56,640)	Sinking of No. 4 shaft completed.
Willroy Mines Limited, Manitouwadge	1,500	4.25	0.29	0.79	1.84	293,989 (530,151)	11,164 (15,353)	
Willecho Mines Limited		4.16	0.19	0.60	1.73	283,259 (–)	10,530 (–)	Production started March, 1965, ore treated at Willroy Mill.
Quebec								
The Coniagas Mines, Limited, Bachelor Lake	500	8.31	0.52	–	3.14	123,059 (114,459)	8,809 (8,963)	
Cupra Mines Ltd., Stratford Centre		3.18	0.44	3.35	1.342	82,427 (–)	1,586 (–)	Production started Sept. 1965, ore treated at Solbec mill.
Lake Dufault Mines, Limited, Noranda	1,300	8.51	5.85			475,007 (112,117)	30,145 (6,094)	Production started Oct. 1964.
Manitou-Barvue Mines Limited, Val d'Or	1,300	4.48	0.43	–	2.85	168,895 (142,925)	6,992 (6,740)	
		–	–	0.81	0.13	283,875 (244,980)	– (–)	Copper production 2,156 tons. Copper production 1,888 tons.
Mattagami Lake Mines Limited, Matagami Lake	3,850	11.7	–	0.69	..	1,406,000 (1,282,072)	156,313 (148,282)	
New Calumet Mines Limited, Calumet Island[4]	800	6.08	1.66	–	3.58	97,586 (94,823)	5,837 (6,134)	Completed No. 5 internal shaft, new ore lens discovered.

Table 4 (cont.)

Company and Location	Mill Capacity (tons ore/day)	Grade of Ore (Principal Metals) Zinc (%)	Lead (%)	Copper (%)	Silver (oz/ton)	Ore Produced 1965 (1964) (short tons)	Contained Zinc Produced 1965 (1964) (short tons)	Remarks
Normetal Mining Corporation, Limited, Normetal	1,000	8.10	–	1.58	1.59	350,693 (348,924)	24,984 (21,641)	No. 5 internal shaft deepened to 7,952 ft. nearing objective at year end.
		3.66	–	2.03	0.55	3,402 (–)	93 (–)	Production from adjoining property.
Orchan Mines Limited, Matagami Lake[5]	1,900	13.34	–	1.25	1.64	368,877 (369,272)	43,292 (41,570)	Installed hydraulic backfill system, changed over to cut-and-fill mining in some areas of mine.
Quemont Mining Corporation, Limited, Noranda	2,300	2.29	–	1.06	0.86	657,307 (752,691)	11,322 (13,574)	Progressive reduction in milling rate.
Solbec Copper Mines, Ltd., Stratford Centre	1,500	4.36	0.56	1.69	1.234	403,869 (424,127)	13,579 (13,880)	
Sullico Mines Limited, Val d'Or[6]	3,000	0.191	–	0.535	0.130	993,321 (988,023)	532 (2,268)	
New Brunswick								
Brunswick Mining and Smelting Corporation Limited, Bathurst	4,500	9.51	3.96	0.30	2.76	1,657,519 (777,902)	.. (..)	No. 6 mine, concentrator under preparation and construction; production June 1966 at 2,250 tons daily.
Heath Steele Mines Limited, Newcastle[7]	1,50u	6.01	2.41	0.97	2.61	.. (290,000)	13,352 (14,960)	Preparing to sink new shaft.
Nova Scotia								
Magnet Cove Barium Corporation, Walton	125	1.7	3.98	0.62	12.5	48,594 (48,927)	876 (702)	

Newfoundland								
American Smelting and Refining Company, Buchans	1,250	13.37	7.53	1.12	4.24	366,000 (383,000)	45,071 (45,115)	
Consolidated Rambler Mines Limited, Baie Verte	500	1.98	–	1.48	0.93	136,999 (57,381)	1,966 (685)	Preparation of East zone for production; expansion of mill capacity to 1,500 tons daily for increased production August 1966.

[1]Direct shipping ore. [2]Ore milled. [3]Zinc concentrate. [4]Data for fiscal year ending September 30, 1965. [5]Nine hundred tons of copper ore daily custom-milled for New Hosco Mines Limited. [6]Data for fiscal year ending August 31, 1965. [7]About half mill capacity is used to treat copper ore from Cominco's Wedge mine.

– Nil; .. Not available.

MANITOBA AND SASKATCHEWAN

Hudson Bay Mining and Smelting Co., Limited carried out shaft sinking and mine development at the Osborne Lake mine near Snow Lake, Manitoba, and at the Flexar mine in Saskatchewan near Flin Flon. Preparation for mine development, including construction of surface buildings and of the power line, was continued at Anderson Lake, near Snow Lake.

Diamond drilling was continued at Fox Lake by Sherritt Gordon Mines, Limited and shaft sinking was planned for early in the summer of 1966. The surface drilling indicated 12,269,000 tons averaging 2.35 per cent zinc and 1.74 per cent copper, and a substantial tonnage of massive pyrite in the walls of the deposit averaging 2.38 per cent zinc and 0.41 per cent copper.

ONTARIO

Texas Gulf Sulphur Company continued development of the Kidd Creek mine 15 miles north of Timmins. Work included stripping overburden at the open-pit site, construction of a concentrator at Hoyle, 15 miles southeast of the mine on the Ontario Northland Railroad, and bulk pilot testing of the zinc-copper-silver ore starting in October with the mining of about 10,000 tons of ore monthly. This test ore was treated at the Kam-Kotia mill, 20 miles west of Timmins. Design capacity of the concentrator was raised from 2 million to 3 million tons of ore annually. Regular production was scheduled to begin in September 1966. A railway spur-line from the mill to the open pit will be built. Three types of concentrates will be produced – zinc, copper and lead. Annual production of contained metals is planned at rates of 250,000 tons of zinc, 50,000 tons of copper, and 10,000 tons of lead. Silver recovery will be primarily in lead and copper concentrates, and cadmium will be recovered in zinc concentrates.

Canadian Jamieson Mines Limited sank a 700-foot shaft at its copper-zinc deposit, about 10 miles northwest of Timmins, where ore reserves were reported to be 531,000 tons averaging 2.48 per cent copper, 4.22 per cent zinc and 0.85 ounce of silver per ton. The 400-ton mill was opened in April 1966.

Zenmac Metal Mines Limited, near Schreiber, carried out mine development and construction and opened a 100-ton mill in January 1966.

QUEBEC

Mines de Poirier inc., a subsidiary of Rio Algom Mines Limited, continued development of a copper-zinc deposit 60 miles north of Amos and began shipments of copper and zinc concentrates from a 1,500-ton mill in January 1966. Ore reserves were 1,860,000 tons averaging 3 per cent copper and 0.7 per cent zinc, and 1,380,000 tons averaging 0.37 per cent copper and 8.32 per cent zinc.

Development by Joutel Copper Mines Limited at its copper-zinc deposit near the Poirier deposit, was continued and ore shipments were expected to begin late in 1966.

New Hosco Mines Limited at Matagami Lake, which began shipping copper ore to the Orchan mill, 8 miles distant, in 1963, planned to recover zinc as well through the addition by Orchan Mines Limited of a zinc circuit to its mill. Zinc production was expected to begin in mid-1966.

NEW BRUNSWICK

Preparation of the No. 6 mine of Brunswick Mining and Smelting Corporation Limited for operation as an open pit continued and a new 2,250-ton concentrator adjacent to the concentrator at the No. 12 mine was under construction. Production from the No. 6 mine, which is 6 miles southeast of the No. 12, was scheduled for mid-1966. Reserves at the No. 6 at the end of 1964 were reported as 27 million tons, of which 11.3 million tons, grading 2.5 per cent lead, 6.3 per cent zinc, 0.44 per cent copper and 2.1 ounces of silver per ton, were being developed for open-pit mining.

Construction of a zinc-lead smelter by a Brunswick subsidiary, East Coast Smelting and Chemical Company Limited, which began in 1963, continued during the year with start-up scheduled for August 1966. Included is a furnace of the Imperial Smelting type and a sulphuric acid plant; fertilizer and iron and steel production are also planned.

Mine development was continued at the New Larder 'U' property of Key Anacon Mines Limited, 8 miles east of the Brunswick No. 6 mine. Exploration of the No. 2 zone indicated 1,500,000 tons to a depth of 1,350 feet averaging 7.23 per cent zinc, 2.95 per cent lead, 0.32 per cent copper and 3.05 ounces silver per ton. Further work was planned for No. 1 and No. 3 zones.

Teck Corporation Limited announced that, in association with The New Jersey Zinc Company, it was planning to bring the Portage Lakes deposit, about 50 miles west of Bathurst, into production. Previous detailed exploration by The New Jersey Zinc Company indicated 2,620,000 tons averaging 6.76 per cent zinc, 5.49 per cent lead, and minor values in copper, silver and gold.

Nigadoo River Mines Limited, one of the Sullivan group of companies, continued mine development at its property 12 miles northwest of Bathurst. Production was planned for early 1967 at 1,000 tons daily. Ore reserves to a vertical depth of 1,000 feet were reported at August 31, 1965 to be 1,390,000 tons averaging 2.77 per cent zinc, 2.97 per cent lead, 0.34 per cent copper and 4.36 ounces silver per ton.

The Anaconda Company (Canada) Ltd. continued underground diamond drilling at the Caribou zinc-lead-copper property 35 miles west of Bathurst. The exploration adit was extended and metallurgical tests on bulk ore samples were carried out.

NEWFOUNDLAND

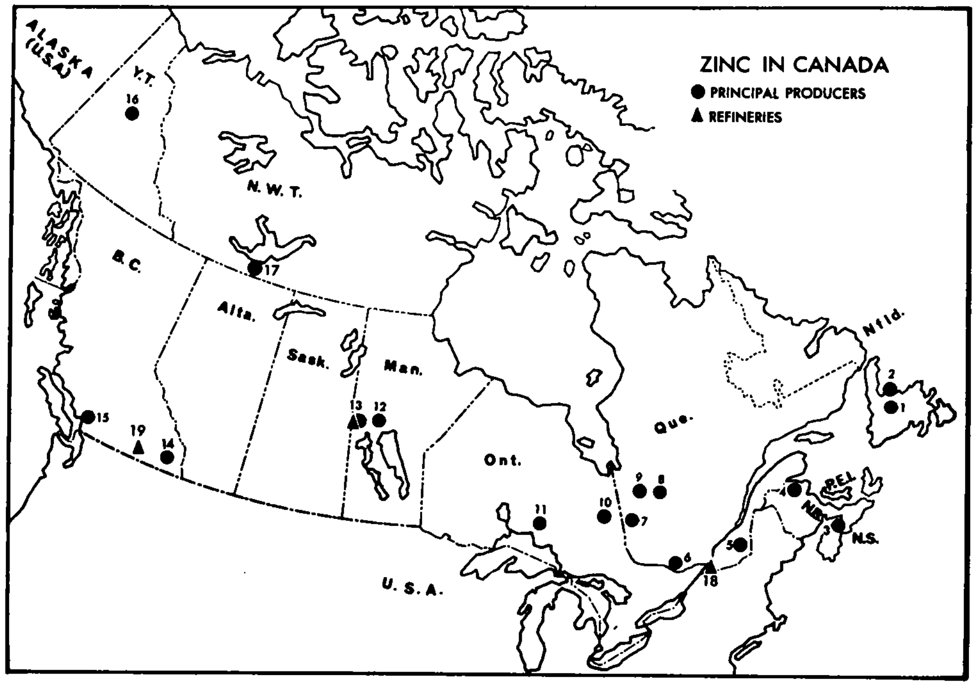
Newfoundland Zinc Mines Limited drilled 133 holes totalling 14,204 feet on a zinc property in the Great Northern Peninsula. An estimated 1,563,000 tons were outlined to the end of 1965 in five zones grading from 4 to 11 per cent zinc. Investigation of four other zones was planned.

USES

Canadian consumption of primary zinc has risen steadily in the past five years and in 1965 reached a record 94,000 tons, nearly 70 per cent greater than in 1960. Increases have taken place in all major outlets but have been largest in the use of zinc in die-casting alloys, which has more than doubled. Galvanizing remains the main outlet, accounting for about 50 per cent of all zinc used in Canada.

Producers' domestic shipments in 1965 were 104,605 tons; in 1964 they were 103,483 tons.

In galvanizing, zinc is applied as an impervious, corrosion-resistant coating to iron



PRINCIPAL PRODUCERS
(numbers refer to numbers on map)

1. American Smelting and Refining Company (Buchans Unit)
2. Consolidated Rambler Mines Limited
3. Magnet Cove Barium Corporation
4. Brunswick Mining and Smelting Corporation Limited
   Heath Steele Mines Limited
5. Solbec Copper Mines, Ltd.
   Cupra Mines Ltd.
6. New Calumet Mines Limited
7. Manitou-Barvue Mines Limited
   Normetal Mining Corporation, Limited
   Quemont Mining Corporation, Limited
   Sullico Mines Limited
   Lake Dufault Mines, Limited
8. The Coniagas Mines, Limited
9. Mattagami Lake Mines Limited
   Orchan Mines Limited
10. Kam-Kotia Porcupine Mines, Limited
11. Noranda Mines Limited (Geco Division)
    Willroy Mines Limited
    Willecho Mines Limited
12. Hudson Bay Mining and Smelting Co., Limited – 2 mines: Chisel, Stall Lake
13. Hudson Bay Mining and Smelting Co., Limited – 3 mines: Flin Flon, Coronation, Schist Lake
14. Canadian Exploration. Limited
    Cominco – 3 mines: Sullivan, H.B., Bluebell
    Mastodon-Highland Bell Mines Limited
    Reeves MacDonald Mines Limited
    Aetna Investment Corporation Limited
    Johnsby Mines Limited
    London Pride Silver Mines Ltd.
15. The Anaconda Company (Canada) Ltd.
16. United Keno Hill Mines Limited
17. Pine Point Mines Limited

REFINERIES

18. Canadian Electrolytic Zinc Limited, Valleyfield
13. Hudson Bay Mining and Smelting Co., Limited, Flin Flon
19. Cominco Ltd., Trail

and steel products as protection against rust. Galvanized sheet is used in industrial, agricultural and residential construction, and in highway construction for guardrails, culverts and signs. Its use in automobile underbodies as protection against the attack of road-salt solutions has recently become a major outlet in North America. Galvanized wire is widely used as fencing. Many hundreds of steel articles, from small hardware items to large structural shapes, are commonly galvanized after fabrication to reduce maintenance cost.

Die castings of zinc-base alloys are used by the automotive industry for such parts as grilles, head- and taillight assemblies, carburetors, fuel pumps, and door and window hardware. These castings are also used as components in household appliances and in plumbing and hardware supplies. The alloys most commonly used for die casting are made of high-purity zinc to which is added about 4 per cent aluminum, 0.04 per cent magnesium and from 0 to 1 per cent copper.

Brass, a copper-zinc alloy containing as much as 40 per cent zinc, is widely used in the form of sheets and strips, tubes, rods and wire, castings and extruded shapes. Zinc oxide is used in compounding rubber and in making paint, rayon yarn, ceramic materials, inks, matches and many other commodities. Rolled zinc is used in Canada mainly for making dry-cell batteries, terrazzo strip, weather stripping, roofing drains and gutters, and anticorrosion plates for boilers and ships' hulls. Zinc dust is used to make zinc salts and compounds, to purify fats, to manufacture dyes and to pre-

TABLE 5

United States Consumption, by End Use, 1964-65
(short tons)

	1964	1965p
Galvanizing	456,336	458,455
Brass products	135,095	123,949
Zinc-base alloy	524,582	608,176
Rolled zinc	44,181	42,441
Zinc oxide	19,991	25,781
Other uses	27,083	31,000
Estimated undistributed consumption.	–	54,000
Total	1,207,268	1,343,802

Source: U.S. Bureau of Mines Mineral Industry Surveys *United States Zinc Industry in January 1966.*

pPreliminary; – Nil.

cipitate gold and silver from cyanide solutions. The more industrially important compounds of zinc are zinc chloride, zinc sulphate and lithopone, a mixture of barium sulphate and zinc sulphide used for making paint.

Refined zinc is marketed in grades that vary according to the content of such impurities as lead, iron and cadmium. The principal grades produced are: Special High grade, used chiefly for die casting, High grade, used for making brass and miscellaneous products, and Prime Western for galvanizing.

In Canada, the electrolytic process produces Special High grade and High grade zinc. To meet consumer requirement for Prime Western, Canadian producers add small amounts of lead to the higher grades.

ZINC RESEARCH IN 1965

In 1965, the Mines Branch of the Department of Mines and Technical Surveys continued work on the zinc research projects co-operatively sponsored by the Canadian Zinc and Lead Research Committee and the International Lead Zinc Research Organization. Emphasis was retained on investigations dealing with galvanized coatings.

Study of the elevated temperature behaviour of conventional galvanized coatings in the temperature range of 150°-400°C (300°-750°F) revealed significant reaction effects which were largely influenced by coating composition, as well as the time and temperature of heating. Coatings containing lead, or elements which are near neighbours of lead in the periodic table (tin, bismuth, indium and thallium), were distinguished by characteristic separation of the outer zinc layer resulting from bond destruction at the zinc-zeta interface. This separated outer zinc layer may or may not peel off, depending on local conditions.

Unalloyed coatings (containing 0.001 per cent Pb maximum), on the other hand, did not show separation at any stage and the zinc layer gradually thinned and finally disappeared by reacting to form iron-zinc alloy. Intimate contact at all interfaces was retained in these coatings, thus resulting in a high zinc dissolution rate and rapid transformation effects in the underlying iron-zinc alloy layers. The same response was also obtained with a group of coatings individually alloyed with ten other common metallic elements. From these experiments, it can be concluded that alloying of conventional galvanized coatings with lead, or other related elements, modifies the elevated temperature diffusion mechanism and thereby contributes significantly to the peeling failure on heating of this class of coating.

PRICES AND TARIFFS

The Canadian price of Prime Western zinc, f.o.b. Toronto and Montreal during 1965 was 14.5 cents a pound. The United States price, f.o.b. East St. Louis, was also 14.5 cents a pound during the year.

The producer basis price was £ 110 per long ton (14.8 cents a pound Canadian).

Canadian and United States tariffs during 1965 were as follows:

	British Preferential	Most Favoured Nation	General
Canada			
In ores and concentrates	free	free	free
Zinc spelter, zinc and zinc alloys containing not more than 10% by weight of other metal or metals in form of pigs, slabs, blocks, dust or granules, per lb.	½¢	½¢	2¢
Zinc, or zinc alloys containing not more than 10% by weight of other metal or metals, in form of foil, ribbon, strip, plate, discs, slugs; coated or not	5%	7½%	20%
Dross and scrap for remelting or processing into zinc dust.	free	free	10%
Manufactures not otherwise provided for	15%	17½%	25%
Flat rolled; strip or sheet for lithographing	free	free	10%

United States	
Ores and concentrates*	0.67¢ per lb on zinc content
Unwrought:*	
other than alloys of zinc	0.7¢ per lb
alloys of zinc	19% ad val.
Waste and scrap	0.75¢ per lb

Varying tariffs on other forms of zinc and zinc manufactures are applied.

*Zinc-bearing ores and concentrates were subject to quarterly import quotas until October 22, 1965. Unwrought zinc, excepting alloys of zinc and zinc dust but including zinc waste and scrap, were subject to quarterly import quotas until November 22, 1965.

Statistical Tables

Table No. Title and Page

PRICES

PRINCIPAL STATISTICS

EMPLOYMENT, SALARIES AND WAGES

MINING, QUARRYING, PROSPECTING AND DRILLING

TRANSPORTATION

TAXATION

INVESTMENT AND OWNERSHIP

TABLE 1

Mineral Production of Canada, 1964 and 1965

	Unit of Measure	1964 Quantity	1964 $000	1965[p] Quantity	1965[p] $000
Metals					
Antimony	000 lb	1,592	700	1,233	653
Bismuth	"	400	817	475	1,482
Cadmium	"	2,773	8,984	2,009	5,586
Calcium	"	138	152	159	153
Cobalt	"	3,185	5,991	3,799	8,205
Columbium (Cb_2O_5)	"	2,163	2,282	2,300	2,350
Copper	000 st	487	324,468	517	388,005
Gold	000 troy oz.	3,835	144,788	3,615	136,377
Indium	000 oz.	..	..	..	..
Iron ore	000 lt	34,219	404,952	35,526	419,353
Iron, remelt	000 st	429	18,700	368	16,597
Lead	"	204	54,759	287	88,911
Magnesium	000 lb	18,706	5,588	22,266	6,698
Mercury	"	6	23	1	13
Molybdenum	"	1,225	2,057	10,165	17,509
Nickel	000 st	228	379,321	261	435,332
Platinum group	000 troy oz.	376	25,404	452	35,678
Selenium	000 lb	466	2,259	504	2,436
Silver	000 troy oz.	29,903	41,864	32,964	46,117
Tellurium	000 lb	78	506	86	555
Thorium	"	..	..	..	..
Tin	"	352	534	409	810
Titanium ore	000 st	-	-	-	-
Tungsten (WO_3)	000 lb	..	..	..	..
Uranium (U_3O_8)	"	14,570	83,509	8,615	64,300
Zinc	000 st	685	193,991	832	251,234
Total metals			1,701,649		1,928,354
Nonmetals					
Arsenious oxide	000 lb	324	16	300	15
Asbestos	000 st	1,420	145,193	1,380	139,805
Barite	000 st	169	1,574	203	2,167
Diatomite	st	1,143	65	1,200	65
Feldspar	000 st	9	212	11	242
Fluorspar	"	..	2,259	..	2,547
Gem stones	000 lb	12	14	11	14
Graphite	st	-	-	-	-
Grindstone	"	-	-	9	2
Gypsum	000 st	6,361	11,524	6,211	11,438
Helium	Mcf	..	..	..	..
Iron oxide	000 st	1	79	-	22

Table 1 (cont'd)

	Unit of Measure	1964 Quantity	1964 $000	1965[p] Quantity	1965[p] $000
Nonmetals (cont'd)					
Lithia	000 lb	1,056	1,155	1,035	1,164
Magnesitic dolomite and brucite	"	..	3,570	..	4,007
Mica	"	1,198	86	887	30
Nepheline syenite	000 st	290	3,097	329	3,549
Nitrogen	Mcf	..	..	..	..
Peat moss	000 st	255	8,400	267	8,195
Potash (K_2O)	"	858	31,162	1,430	54,400
Pozzolana	st	..	35	..	35
Pyrite, pyrrhotite	000 st	352	1,126	353	1,889
Quartz	"	2,117	4,506	2,382	4,944
Salt	"	3,989	20,204	4,331	21,565
Soapstone, talc, pyrophyllite	"	58	828	55	802
Sodium sulphate	"	333	5,222	346	5,590
Sulphur, in smelter gas	"	443	4,262	513	5,055
Sulphur, elemental	"	1,788	18,638	1,908	23,482
Titanium dioxide, etc.	"	..	21,270		22,425
Total nonmetallics			284,497		313,449
Fuels					
Coal	000 st	11,319	72,735	11,589	75,901
Natural gas	000 Mcf	1,407,098	172,967	1,442,448	193,337
Natural gas byproducts	000 bbl	..	78,689	..	92,548
Petroleum, crude	"	274,626	674,377	296,419	725,484
Total fuels			998,768		1,087,270
Structural materials					
Clay products	$		40,830		43,206
Cement	000 st	7,847	130,704	8,427	144,582
Lime	"	1,541	19,409	1,517	17,730
Sand and gravel	"	193,791	125,232	192,857	129,330
Stone	"	69,794	86,883	69,156	88,337
Total structural materials			403,058		423,185
Total all minerals			3,387,972		3,752,258

.. Not available or not applicable; - Nil; [p]Preliminary.

TABLE 2

Value of Mineral Production of Canada and its Per Capita Value, Selected Years 1927-65
($ millions)

	Metallics	Industrial Minerals	Fuels	Total	Per Capita Value
1927	113	63	71	247	25.67
1932	112	30	49	191	18.19
1937	335	57	66	458	41.49
1942	392	83	92	567	48.63
1947	395	139	111	645	51.38
1952	728	293	264	1,285	88.90
1957	1,159	466	565	2,190	131.87
1962	1,496	574	781	2,851	153.53
1963	1,510	632	908	3,050	161.43
1964	1,702	687	999	3,388	176.14
1965[p]	1,928	737	1,087	3,752	191.73

[p] Preliminary.

TABLE 3

Indexes of Physical Volume of Total Industrial Production and Mineral Production in Canada, 1951-65
Unadjusted (1949 = 100)

	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
Total industrial production	117.4	122.4	131.3	131.1	145.5	160.7	163.3	162.4	176.5	179.8	186.2	201.7	215.3	235.3	254.9
Total mining	123.5	131.6	143.3	158.9	187.8	218.3	239.3	243.3	275.4	275.6	283.0	304.7	318.3	346.4	365.6
Metals															
All metals	108.1	111.4	118.0	130.0	147.3	160.1	188.4	210.4	242.5	236.4	220.4	225.2	227.5	245.7	249.5
Gold	103.9	106.9	97.9	104.5	107.7	103.2	104.9	109.2	107.2	109.5	104.9	96.8	92.0	85.9	80.6
Nickel	107.2	109.2	111.7	125.3	135.9	138.7	146.1	108.4	145.0	166.7	181.0	180.5	168.6	181.0	209.9
Lead	99.0	105.7	121.2	136.8	126.9	118.2	113.5	116.8	116.8	128.7	144.2	134.8	125.9	126.3	179.9
Zinc	118.3	129.0	139.4	130.6	150.3	146.6	143.5	147.5	137.4	141.1	144.3	160.7	164.3	233.7	281.2
Copper	102.5	97.9	96.1	114.9	123.7	134.7	136.3	131.0	150.0	166.7	166.7	173.6	171.8	187.8	195.6
Iron ore	117.9	137.4	178.2	203.9	406.1	519.6	544.1	395.0	587.7	578.8	558.7	781.0	916.8	1,185.3	1,236.8
Fuels															
All fuels	143.5	163.9	192.7	215.6	273.0	346.9	360.3	331.6	364.6	377.7	433.4	483.5	516.6	557.7	592.8
Coal	95.6	90.5	81.5	75.2	74.1	74.6	65.4	56.8	51.8	53.4	49.9	48.8	51.9	55.1	56.3
Natural gas	120.5	128.9	147.8	169.6	204.5	232.8	290.2	402.9	488.3	591.7	709.7	1,000.6	1,179.8	1,382.3	1,476.4
Petroleum	226.9	291.8	385.5	457.8	616.8	819.5	866.5	788.6	880.4	903.1	1,052.3	1,163.2	1,231.6	1,319.2	1,405.5
Nonmetals															
All nonmetals	155.9	154.7	151.4	157.6	180.4	190.3	182.0	172.4	197.6	196.5	214.7	233.6	273.0	312.8*	377.2
Asbestos	170.7	171.5	162.3	167.8	191.9	192.1	186.3	177.3	192.1	200.7	222.3	233.5	240.4	259.9	269.4
Other nonmetals	120.5	114.6	125.4	133.3	152.9	185.9	171.8	160.6	210.8	186.5	196.6	233.8	351.0	439.4	635.1
Quarrying and sand pits	141.9	153.6	152.9	188.6	201.3	231.9	259.4	255.4	293.8	300.1	291.5	367.1	357.8	416.5	456.7

* Includes potash production which was not included in previous years.

TABLE 4

Percentage Contributions of Leading Minerals to Total Value of Mineral Production in Canada, 1956-65

	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965^p
Petroleum	19.5	20.7	19.0	17.5	17.0	18.9	19.4	20.2	19.9	19.3
Nickel	10.7	11.8	9.2	10.7	11.9	13.6	13.5	11.8	11.2	11.6
Iron ore	7.7	7.6	6.0	8.0	7.0	7.3	9.2	10.3	12.0	11.2
Copper	14.1	9.4	8.3	9.7	10.6	9.9	9.9	9.3	9.6	10.3
Zinc	6.0	4.6	4.4	4.0	4.4	4.1	3.9	4.0	5.7	6.7
Natural Gas	0.8	1.0	1.5	1.6	2.1	2.6	3.8	4.9	5.1	5.2
Cement	3.6	4.3	4.6	3.9	3.7	4.0	4.0	3.9	3.9	3.9
Asbestos	4.8	4.8	4.4	4.5	4.9	5.0	4.6	4.5	4.3	3.7
Gold	7.2	6.8	7.4	6.2	6.3	6.1	5.5	5.0	4.3	3.6
Sand and gravel	3.9	4.1	4.6	4.3	4.6	4.1	4.2	4.1	3.7	3.4
Lead	2.8	2.3	2.0	1.6	1.8	1.8	1.5	1.5	1.6	2.4
Stone	2.3	2.7	2.6	2.5	2.4	2.6	2.4	2.6	2.6	2.4
Coal	4.6	4.1	3.8	3.1	3.0	2.7	2.4	2.4	2.1	2.0
Uranium (U_3O_8)	2.2	6.2	13.3	13.7	10.8	7.6	5.5	4.5	2.5	1.7
Potash (K_2O)	-	-	-	-	-	-	0.1	0.7	0.9	1.4
Silver	1.2	1.1	1.3	1.2	1.2	1.1	1.2	1.4	1.2	1.2
Clay products	1.8	1.6	2.0	1.8	1.5	1.4	1.3	1.3	1.2	1.2
Platinum metals	1.1	1.2	0.7	0.7	1.2	0.9	1.0	0.7	0.7	0.9
Elemental sulphur	..	..	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.6
Titanium dioxide	0.4	0.4	0.3	0.4	0.5	0.6	0.4	0.5	0.6	0.6
Salt	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.7	0.6	0.6
Lime	0.8	0.8	0.9	0.9	0.8	0.7	0.6	0.6	0.6	0.5
Molybdenum	0.1	0.05	0.05	0.04	0.04	0.04	0.04	0.04	0.06	0.5
Gypsum	0.3	0.4	0.2	0.3	0.4	0.3	0.3	0.4	0.3	0.3
Other minerals	3.5	3.5	2.7	2.6	2.9	3.6	4.2	4.3	4.9	4.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

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

TABLE 5

Value of Mineral Production in Canada by Main Geological Regions, 1965p

	Metals		Industrial Minerals		Fuels		Total, All Minerals	
	$ Millions	% of Total	$ Millions	% of Total	$ Millions	% of Total	$ Millions	% of Total
Canadian Shield	1,552.1	80.5	38.2	5.2	-	-	1,590.3	42.4
Appalachian region	139.0	7.2	174.1	23.6	54.2	5.0	367.3	9.8
St. Lawrence Lowlands	2.4	0.1	311.6	42.4	9.4	0.9	323.4	8.6
Interior plains	53.2	2.8	146.9	19.9	976.9	89.8	1,177.0	31.4
Cordilleran region	181.7	9.4	65.8	8.9	46.8	4.3	294.3	7.8
Total, Canada	1,928.4	100.0	736.6	100.0	1,087.3	100.0	3,752.3	100.0

pPreliminary; - Nil.

TABLE 6

Value of Mineral Production in Canada by Provinces and Mineral Classes, 1965p

	Metals		Industrial Minerals		Fuels		Total	
	$000	% of Total	$000	% of Total	$000	% of Total	$000	% of Total
Ontario	780,881	40.5	195,754	26.6	9,380	0.9	986,015	26.3
Alberta	8	-	57,264	7.8	746,207	68.6	803,479	21.4
Quebec	433,302	22.5	274,839	37.3	-	-	708,141	18.9
Saskatchewan	41,584	2.2	75,030	10.2	211,123	19.4	327,737	8.7
British Columbia	168,548	8.7	60,178	8.2	54,201	5.0	282,927	7.5
Newfoundland	203,144	10.5	17,339	2.3	-	-	220,483	5.9
Manitoba	149,062	7.7	21,116	2.9	11,530	1.1	181,708	4.8
New Brunswick	64,974	3.3	10,559	1.4	8,755	0.8	84,288	2.3
Northwest Territories	72,402	3.8	-	-	501	-	72,903	1.9
Nova Scotia	1,317	0.1	23,570	3.2	45,487	4.2	70,374	1.9
Yukon Territory	13,132	0.7	-	-	86	-	13,218	0.4
Prince Edward Island	-	-	985	0.1	-	-	985	0.03
Total, Canada	1,928,354	100.0	736,634	100.0	1,087,270	100.0	3,752,258	100.0

- Nil; pPreliminary.

TABLE 7

Value of Mineral Production in Canada by Provinces, 1956-65
($ millions)

	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965[p]
Ontario	651	749	790	971	983	944	913	874	901	986
Alberta	411	410	346	376	396	473	567	669	736	803
Quebec	423	406	366	441	446	455	519	541	685	708
Saskatchewan	123	173	210	210	212	216	240	272	292	328
British Columbia	203	179	151	159	186	188	235	261	269	283
Newfoundland	84	83	65	72	87	92	102	138	182	221
Manitoba	68	64	57	55	59	101	159	170	174	182
New Brunswick	18	23	16	18	17	19	22	28	49	84
Northwest Territories	22	21	25	26	27	18	18	16	18	73
Nova Scotia	66	68	63	63	66	62	62	66	66	70
Yukon Territory	16	14	12	13	13	13	13	14	15	13
Prince Edward Island	-	-	-	5	1	1	0.7	0.8	0.8	1
Total, Canada	2,085	2,190	2,101	2,409	2,493	2,582	2,851	3,050	3,388	3,752

- Nil; [p] Preliminary.

TABLE 8

Percentage Contribution of Provinces to Total Value
of Mineral Production in Canada, 1956-65

	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965p
Ontario	31.2	34.2	37.5	40.3	39.4	36.6	32.0	28.7	26.6	26.3
Alberta	19.7	18.7	16.5	15.6	15.9	18.3	19.9	21.9	21.7	21.4
Quebec	20.2	18.5	17.4	18.3	17.9	17.6	18.2	17.7	20.2	18.9
Saskatchewan	5.9	7.9	10.0	8.7	8.5	8.4	8.4	8.9	8.6	8.7
British Columbia	9.7	8.2	7.2	6.6	7.5	7.3	8.2	8.6	7.9	7.5
Newfoundland	4.0	3.8	3.1	3.0	3.5	3.6	3.6	4.5	5.4	5.9
Manitoba	3.3	2.9	2.7	2.3	2.4	3.9	5.6	5.6	5.1	4.8
New Brunswick	0.9	1.1	0.8	0.8	0.7	0.7	0.8	0.9	1.5	2.3
Northwest Territories	1.1	1.0	1.2	1.1	1.1	0.7	0.6	0.5	0.5	1.9
Nova Scotia	3.2	3.1	3.0	2.6	2.6	2.4	2.2	2.2	2.0	1.9
Yukon Territory	0.8	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5	0.4
Prince Edward Island	-	-	-	0.2	0.05	0.02	0.02	0.03	0.02	0.03
Total, Canada	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

- Nil; p Preliminary.

TABLE 9 Production of Leading Minerals in

	Unit of Measure	Nfld.	P.E.I.	N.S.	N.B.	Que.	Ont.
Petroleum, crude	bbl	-	-	-	4,103	-	1,279,321
	$	-	-	-	5,703	-	4,119,413
Nickel	st	-	-	-	-	3,305	192,655
	$	-	-	-	-	5,552,450	319,771,106
Iron Ore	st	14,606,915	-	-	-	14,781,630	8,295,969
	$	168,498,171	-	-	-	141,584,305	90,558,867
Copper	st	17,348	-	205	9,696	176,074	219,183
	$	13,045,795	-	154,160	7,291,392	132,407,661	163,860,900
Zinc	st	37,169	-	250	129,150	275,788	59,945
	$	11,224,932	-	75,500	39,003,300	83,287,850	18,103,427
Natural Gas	Mcf	-	-	-	105,359	-	12,619,867
	$	-	-	-	111,677	-	5,260,716
Cement	st	91,000	-	57,245	174,672	2,870,930	3,148,824
	$	1,840,000	-	999,000	2,801,000	45,845,120	50,594,000
Asbestos	st	56,400	-	-	-	1,236,260	2,100
	$	6,985,140	-	-	-	119,022,297	79,863
Gold	oz	25,491	-	8	1,691	913,987	1,946,816
	$	961,775	-	302	63,801	34,484,730	73,453,367
Sand and Gravel	st	4,590,194	526,850	6,505,874	5,141,543	44,000,000	77,813,712
	$	4,108,500	635,171	4,226,394	2,831,851	20,600,000	56,762,201
Lead	st	23,318	-	1,700	46,537	3,977	1,958
	$	7,228,447	-	527,000	14,426,470	1,232,987	607,080
Stone	st	82,186	500,000	999,776	2,329,915	36,976,743	23,263,280
	$	197,676	350,000	1,922,485	2,666,526	43,564,302	30,372,408
Coal	st	-	-	4,134,161	996,328	-	-
	$	-	-	45,486,833	8,637,619	-	-
Uranium (U_3O_8)	lb	-	-	-	-	-	6,800,000
	$	-	-	-	-	-	49,200,000
Potash (K_2O)	st	-	-	-	-	-	-
	$	-	-	-	-	-	-
Silver	oz	1,127,980	-	400,000	2,914,600	5,315,163	11,203,506
	$	1,578,044	-	559,600	4,077,525	7,435,913	15,673,705
Clay products	$	71,900	-	1,551,637	600,000	6,562,548	25,337,874
Platinum metals	oz	-	-	-	-	-	452,063
	$	-	-	-	-	-	35,678,078
Elemental sulphur	st	-	-	-	-	-	. .
	$	-	-	-	-	-	26,074
Titanium dioxide	st	-	-	-	-	. .	-
	$	-	-	-	-	22,425,094	-
Salt	st	-	-	469,000	-	-	3,649,000
	$	-	-	5,172,430	-	-	12,372,850
Lime	st	-	-	-	3,823	350,634	1,054,422
	$	-	-	-	109,054	3,862,115	11,876,403
Molybdenum	lb	-	-	-	-	2,693,470	-
	$	-	-	-	-	4,858,441	-
Gypsum	st	422,000	-	4,806,000	100,800	-	515,000
	$	1,139,400	-	7,609,273	210,360	-	1,383,695
Total leading minerals	$	216,879,780	985,171	68,284,614	82,836,278	672,725,813	965,092,027
Total, all minerals	$	220,483,234	985,171	70,373,689	84,288,119	708,141,229	986,014,968
Leading minerals as % of all minerals		98.4	100.0	97.0	98.3	95.0	97.9

P Preliminary; - Nil; . . Not available.

Canada by Provinces and Territories, 1965[p]

Man.	Sask.	Alta.	B.C.	N.W.T.	Y.T.	Total Canada
4,946,509	87,775,205	188,298,021	13,470,757	644,998	-	296,418,914
11,530,312	200,741,894	481,478,039	27,126,064	482,458	-	725,483,883
63,284	-	-	1,911	-	-	261,155
106,798,018	-	-	3,210,480	-	-	435,332,054
-	-	-	2,104,071	-	-	39,788,585
-	-	-	18,711,715	-	-	419,353,058
31,011	19,236	-	44,069	425	-	517,247
23,320,582	14,465,309	-	33,139,640	319,600	-	388,005,039
40,345	28,134	-	160,559	93,562	7,000	831,902
12,184,343	8,496,439	-	48,488,706	28,255,875	2,114,000	251,234,372
-	42,768,901	1,225,826,579	161,084,296	43,068	-	1,442,448,070
-	4,395,735	165,702,873	17,848,199	18,088	-	193,337,288
373,462	250,000	876,828	584,010	-	-	8,426,971
8,139,000	5,670,000	16,711,000	11,983,007	-	-	144,582,127
-	-	-	85,450	-	-	1,380,210
-	-	-	13,718,022	-	-	139,805,322
65,657	50,417	200	113,222	452,816	44,243	3,614,548
2,477,239	1,902,233	7,546	4,271,866	17,084,748	1,669,289	136,376,896
9,780,627	8,980,463	14,858,291	20,659,821	-	-	192,857,375
7,553,555	5,583,477	12,507,651	14,520,847	-	-	129,329,647
1,230	-	-	121,222	78,362	8,507	286,811
381,151	-	-	37,578,680	24,292,220	2,637,325	88,911,360
734,125	-	146,809	4,123,341	-	-	69,156,175
1,284,475	-	456,285	7,523,322	-	-	88,337,479
-	2,063,933	3,413,928	971,465	-	8,801	11,588,616
-	3,715,385	12,173,846	5,801,817	-	85,626	75,901,126
-	1,815,000	-	-	-	-	8,615,000
-	15,100,000	-	-	-	-	64,300,000
-	1,430,000	-	-	-	-	1,430,000
-	54,400,000	-	-	-	-	54,400,000
697,389	685,130	17	4,851,193	1,274,200	4,495,121	32,964,299
975,647	958,497	24	6,786,819	1,782,606	6,288,674	46,117,054
531,000	1,330,143	3,822,477	3,398,250	-	-	43,205,829
. .	-	-	-	-	-	452,063
. .	-	-	-	-	-	35,678,078
. .	. .	. .	. .	-	-	1,907,723
27,473	792,400	20,709,000	1,927,000	-	-	23,481,947
-	-	-	-	-	-	. .
-	-	-	-	-	-	22,425,094
30,700	77,000	105,400	-	-	-	4,331,100
697,811	1,527,168	1,794,475	-	-	-	21,564,734
50,472	-	57,632	-	-	-	1,516,983
817,285	-	1,065,188	-	-	-	17,730,045
-	-	-	7,471,900	-	-	10,165,370
-	-	-	12,650,546	-	-	17,508,987
162,000	-	-	205,160	-	-	6,210,960
504,535	-	-	591,090	-	-	11,438,353
177,222,426	319,078,680	716,428,404	269,276,070	72,235,595	12,794,914	3,573,839,772
181,707,794	327,737,527	803,478,951	282,927,411	72,902,795	13,217,474	3,752,258,362
97.5	97.4	89.2	95.2	99.1	96.8	95.2

TABLE 10

World Role of Canada as Producer of Certain Important Minerals

	Year		World Production	Rank of the Six Leading Countries With % of World Total: 1	2	3	4	5	6
Nickel (mine production)	1965	st	445,700	Canada 261,155 59	U.S.S.R. 95,000 21	New Caladonia 53,063 12	Cuba 16,300 4	U.S.A. 13,510 3	Republic of S. Africa 3,400 1
Zinc (mine production)	1965	st	4,535,000	Canada 910,929 20	U.S.A. 610,059 13	U.S.S.R. 510,000 11	Australia 302,549 7	Peru 285,928 6	Mexico 247,881 5
Asbestos	1964	st	3,543,000	Canada 1,419,851 40	U.S.S.R. 1,300,000 37	Republic of S. Africa 215,592 6	S. Rhodesia 153,451 4	China 130,000 4	U.S.A. 101,092 3
Uranium (U_3O_8 concentrates) (Free World)	1964	st	26,000	U.S.A. 11,847 46	Canada 7,285 28	Republic of S. Africa 4,445 17	France 1,910 7	Australia 370 1	Spain 50 -
Titanium concentrates (ilmenite)	1964	st	2,596,400	U.S.A. 1,001,132 39	Canada* 544,721 21	Australia 343,500 13	Norway 299,608 12	Malaysia 144,754 6	Finland 127,937 5
Gypsum	1964	'000 st	51,520	U.S.A. 10,684 21	Canada 6,361 12	Britain 5,052 10	U.S.S.R. 4,740 9	France 4,639 9	Spain 4,258 8
Lead (mine production)	1965	st	2,915,455	U.S.S.R. 460,000 16	Australia 390,300 13	Canada 302,952 10	U.S.A. 292,968 10	Mexico 187,492 6	Peru 162,148 6
Aluminum (primary metal)	1965	st	7,125,250	U.S.A. 2,754,476 39	U.S.S.R. 1,150,000 16	Canada 840,346 12	France 375,364 5	Japan 321,947 5	Norway 304,557 4
Platinum group metals (mine production)	1964	troy oz.	2,051,000	U.S.S.R. 1,000,000 49	Republic of S. Africa 606,000 30	Canada 376,238 18	U.S.A. 40,487 2	Colombia 23,345 1	Japan 4,074 -

Cobalt (mine production) (Free World)	1965	st	16,200	Republic of the Congo 9,000 56	Zambia 3,000 19	Canada 1,893 12	Morocco 1,500 9	Austria 20 -	
Gold (mine production)	1964	troy oz	46,100,000	Republic of S. Africa 29,136,542 63	U.S.S.R. 5,600,000 12	Canada 3,835,454 8	U.S.A. 1,469,000 3	Australia 963,300 2	Ghana 864,917 2
Cadmium (smelter production)	1965	'000 lb	26,747	U.S.A. 9,671 36	U.S.S.R. 4,189 16	Japan 2,678 10	Canada 2,009 8	Australia 1,197 4	Republic of the Congo 1,038 4
Iron ore	1965	'000 lt	589,231	U.S.S.R. 151,272 26	U.S.A. 87,430 15	France 59,166 10	Canada 35,526 6	China 30,510 5	Sweden 29,019 5
Magnesium	1965	st	179,000	U.S.A. 81,361 45	U.S.S.R. 36,000 20	Norway 25,000 14	Canada 11,133 6	Japan 8,763 5	U.K. 5,500 3
Silver (mine production)	1964	troy oz.	249,100,000	Mexico 41,943,247 17	Peru 37,043,217 15	U.S.A. 37,000,000 15	Canada 29,902,611 12	U.S.S.R. 27,000,000 11	Australia 18,275,000 7
Copper (mine production)	1965	st	5,430,418	U.S.A. 1,356,275 25	Zambia 756,321 14	U.S.S.R. 710,000 13	Chile 642,174 12	Canada 517,247 10	Republic of the Congo 317,833 6
Barite	1964	st	3,367,000	U.S.A. 816,706 24	W. Germany 487,884 14	Mexico 359,372 11	U.S.S.R. 220,000 7	Canada 169,149 5	Peru 145,934 4
Molybdenum	1964	st	47,175	U.S.A. 32,803 70	U.S.S.R. 6,600 14	Chile 4,297 9	China 1,650 3	Canada 612 1	Peru 431 1
Potash (K_2O equivalent)	1965	'000 st	14,881	U.S.A. 3,140 21	W. Germany 2,646 18	U.S.S.R. 2,535 17	E. Germany 2,094 14	France 2,071 14	Canada 1,430 10
Bismuth (mine production)	1965	st	3,813	Peru 900 24	Mexico 500 14	Japan 425 11	Bolivia 300 8	S. Korea 250 7	Canada 238 6

Sources: For Canada, Dominion Bureau of Statistics. For other countries, nickel, zinc, aluminum, lead, copper and magnesium, American Bureau of Metal Statistics; asbestos, platinum group metals, uranium, cobalt, cadmium, titanium concentrates, gypsum, gold, silver, barite, molybdenum, potash and bismuth, from U.S. Bureau of Mines, iron ore from American Iron and Steel Institute.

* United States Bureau of Mines.

TABLE 11

Net Value of Production in Canada of Commodity-Producing Industries, 1960-63
($ millions)

	1960	1961	1962	1963
Primary industries				
Agriculture	2,043	1,715	2,406r	2,665
Forestry	688	667	702	749
Fishing	100	110	131r	130
Trapping	12	12	10	12
Mining	1,453	1,562	1,748	1,856
Electric power	796	840	876	912
Total	5,092	4,906	5,873r	6,324
Secondary industries				
Manufacturing	10,380	10,690	11,741	12,568
Construction	3,635	3,701	3,788	3,980
Total	14,015	14,391	15,529	16,548
Grand total	19,107	19,297	21,402r	22,872

r Revised.

TABLE 12

Value of Exports of Crude Minerals and Fabricated Mineral Products by Main Groups, 1964 and 1965

	1964	1965	Increases or Decreases $ million	%
Ferrous				
Crude material	376.6	369.1	- 7.5	- 2.0
Fabricated material	246.4	251.7	+ 5.3	+ 2.2
Total	623.0	620.8	- 2.2	- 0.4
Nonferrous				
Crude material	426.8	493.1	+ 66.3	+15.5
Fabricated material*	868.5	959.3	+ 90.8	+10.5
Total	1,295.3	1,452.4	+157.1	+12.1
Nonmetals**				
Crude material	590.7	627.2	+ 36.5	+ 6.2
Fabricated material	75.2	81.9	+ 6.7	+ 8.9
Total	665.9	709.1	+ 43.2	+ 6.5
Total minerals** and products				
Crude material	1,394.1	1,489.4	+ 95.3	+ 6.8
Fabricated material	1,190.1	1,292.9	+102.8	+ 8.6
Total	2,584.2	2,782.3	+198.1	+ 7.7

* Includes gold refined and unrefined. ** Includes mineral fuels.

Note: Crude materials include materials in primary stages of processing such as ores, metallic concentrates, milled asbestos, etc. Metallic waste and scrap are also included. Fabricated materials include all materials of mineral origin which have been fabricated to such an extent that they can be incorporated into a structure, machine, etc. They are products not useful in themselves, but are for incorporation into end products.

TABLE 13

Value of Imports of Crude Minerals and Fabricated Mineral Products
by Main Groups, 1964 and 1965
($ millions)

	1964	1965	Increases or Decreases	
			$ millions	%
Ferrous				
Crude material	94.7	96.6	+ 1.9	+ 2.0
Fabricated material	432.7	550.0	+117.3	+27.1
Total	527.4	646.6	+119.2	+22.6
Nonferrous*				
Crude material	94.9	99.0	+ 4.1	+ 4.3
Fabricated material	174.3	232.5	+ 58.2	+33.4
Total	269.2	331.5	+ 62.3	+23.1
Nonmetals**				
Crude material	460.4	498.3	+ 37.9	+ 8.2
Fabricated material	258.4	313.5	+ 55.1	+21.3
Total	718.8	811.8	+ 93.0	+12.9
Total minerals** and products				
Crude material	650.0	693.9	+ 43.9	+ 6.8
Fabricated material	865.4	1,096.0	+230.6	+26.6
Total	1,515.4	1,789.9	+274.5	+18.1

* Includes gold, refined and unrefined. ** Includes mineral fuels.

Note: Crude materials include materials in primary stages of processing such as ores, metallic concentrates, milled asbestos, etc. Metallic waste and scrap are also included. Fabricated materials include all materials of mineral origin which have been fabricated to such an extent that they can be incorporated into a structure, machine, etc. They are products not useful in themselves, but are for incorporation into end products.

TABLE 14

Value of Exports of Crude Minerals and Fabricated Mineral Products in Relation to Total Export Trade, 1964 and 1965

	1964		1965	
	$ millions	% of Total	$ millions	% of Total
Crude material	1,394.1	17.2	1,489.4	17.5
Fabricated material	1,190.1	14.7	1,292.9	15.1
Total	2,584.2	31.9	2,782.3	32.6
Total exports*, all products	8,094.4[r]	100.0	8,523.0	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.
(See note bottom of Table 12.)

TABLE 15

Value of Imports of Crude Minerals and Fabricated Mineral Products in Relation to Total Import Trade, 1964 and 1965

	1964		1965	
	$ millions	% of Total	$ millions	% of Total
Crude material	650.0	8.7	693.9	8.0
Fabricated material*	865.4	11.5	1,096.0	12.7
Total	1,515.4	20.2	1,789.9	20.7
Total imports* all products	7,487.7[r]	100.0	8,633.4	100.0

* Includes gold, refined and unrefined.
[r] Revised from previously published figure.
(See note bottom of Table 12.)

TABLE 16

Value of Exports of Crude Minerals and Fabricated Mineral Products
by Main Groups and Destination, 1965
($ millions)

	Britain	United States	Other Countries	Total
Ferrous materials and products	45.5	460.9	114.4	620.8
Nonferrous* materials and products	425.1	602.4	424.9	1,452.4
Nonmetallic** mineral materials and products	19.1	560.0	130.0	709.1
Total	489.7	1,623.3	669.3	2,782.3
Percentage	17.6	58.3	24.1	100.0

* Includes gold refined and unrefined. ** Includes mineral fuels.
(See note bottom of Table 12.)

TABLE 17

Value of Imports of Crude Minerals and Fabricated Mineral Products
by Main Groups and Destination, 1965
($ millions)

	Britain	United States	Other Countries	Total
Ferrous materials and products	55.3	415.2	176.1	646.6
Nonferrous* materials and products	36.9	160.1	134.5	331.5
Nonmetallic** mineral materials and products	21.8	328.5	461.5	811.8
Total	114.0	903.8	772.1	1,789.9
Percentage	6.4	50.5	43.1	100.0

* Includes gold, refined and unrefined. ** Includes mineral fuels.
(See note bottom of Table 12.)

TABLE 18

Value of Exports of Crude Minerals and Fabricated Mineral Products from Canada by Commodity and Destination, 1965 ($000)

	U.S.A.	Britain	Other[1] EFTA Countries	EEC[2] Countries	Japan	Other Countries	Total
Iron ore	285,062	31,803	-	24,220	19,734	-	360,819
Primary ferrous metals	65,600	4,556	6	4,168	678	4,943	79,951
Aluminum	167,118	97,443	4,020	25,088	13,653	65,173	372,495
Copper	79,085	84,330	28,439	22,500	36,420	21,907	272,681
Lead	19,707	21,043	274	16,066	1,632	5,496	64,218
Nickel	206,769	110,000	52,683	14,383	5,354	8,011	397,200
Zinc	57,462	31,001	1,315	38,015	875	12,768	141,436
Uranium	14,749	38,949	-	-	-	-	53,698
Asbestos	66,370	11,885	6,776	32,677	9,040	33,929	160,677
Fuels	407,280	528	18	258	10,805	1,011	419,900
All other minerals[3]	254,121	58,192	5,179	32,228	7,675	101,803	459,198
Total	1,623,323	489,730	98,710	209,603	105,866	255,041	2,782,273

[1] Other European Free Trade countries: Norway, Sweden, Denmark, Switzerland, Austria and Portugal.
[2] European Economic Community (Common Market) countries: France, West Germany, Italy, Belgium, Luxembourg and the Netherlands. [3] Includes gold, refined and unrefined.
- Nil.
(See note bottom of Table 12 in respect to crude and fabricated materials.)

TABLE 19

Reported Consumption of Minerals in Canada and Relation to Production, 1964

	Unit of Measure	Consumption	Production*	Consumption as Per Cent of Production
Metals				
Aluminum	st	172,443	842,640	20.5
Antimony	lb	558,091	1,591,523	35.1
Bismuth	"	53,676	399,958	13.4
Cadmium	"	178,128	2,772,984	6.4
Chromium (chromite)	st	57,734	-	..
Cobalt	lb	365,851	3,184,983	11.5
Copper	st	185,044	486,900	38.0
Lead	"	82,736	203,717	40.6
Magnesium	"	3,762	9,353	40.2
Manganese ore	"	138,818	-	..
Mercury	lb	208,304	5,548	3,754.6
Molybdenum (Mo cont.)	"	1,261,454	1,224,712	103.0
Nickel	st	6,899	228,496	3.0
Selenium	lb	13,968	465,746	3.0
Silver	oz	18,775,307	29,902,611	62.8
Tellurium	lb	1,473	77,782	1.9
Tin	lt	4,822	157	3,071.3
Tungsten (W cont.)	lb	740,410	..	..
Zinc	st	91,052	684,513	13.3
Nonmetals				
Barite	st	13,537	169,149	8.0
Feldspar	"	7,493	9,149	81.9
Fluorspar	"	155,828	..	..
Mica	lb	3,432,000	1,198,162	286.4
Nepheline syenite	st	45,376	290,300	15.6
Phosphate rock	"	1,448,571	-	..
Potash	"	121,548	858,351	14.2
Sodium sulphate	"	244,592	333,263	73.4
Sulphur, elemental	"	544,392	1,788,165	30.4
Fuels				
Coal	st	24,977,432	11,319,323	220.7
Natural gas	Mcf	504,503,388	1,407,097,508	35.9
Petroleum	bbl	343,403,034	274,626,385	125.0

*Production for metals, in most cases, refers to production in all forms. This includes the recoverable metal content of ores, concentrates, matte, etc., exported 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.

- Nil; .. Not available or not applicable.

TABLE 20

Reported Consumption of Minerals in Canada and Relation to Production, 1965

	Unit of Measure	Consumption	Production*	Consumption as Per Cent of Production
Metals				
Aluminum	st	213,094	840,348	25.4
Antimony	lb	659,637	1,232,665	53.5
Bismuth	"	48,279	475,076	10.2
Cadmium	"	171,558	2,009,447	8.5
Chromium (chromite)	st	69,105	-	..
Cobalt	lb	366,036	3,798,740	9.6
Copper	st	190,736	517,247	36.9
Lead	"	90,168	286,811	31.4
Magnesium	"	4,473	11,133	40.2
Manganese ore	"	119,289	-	..
Mercury	lb	415,996	1,520	2,736.8
Molybdenum (Mo cont.)	"	1,702,589	10,165,370	16.7
Nickel	st	8,924	261,155	3.4
Selenium	lb	15,888	504,109	3.2
Silver	oz	30,170,097	32,964,299	91.5
Tellurium	lb	1,870	86,264	2.2
Tin	lt	4,892	183	2,673.2
Tungsten (W cont.)	lb	877,614	..	..
Zinc	st	97,345	831,902	11.7
Nonmetals				
Barite	st	12,186	203,025	6.0
Feldspar	"	10,419	10,830	96.2
Fluorspar	"	167,539	..	..
Mica	lb	3,186,000	886,550	359.4
Nepheline syenite	st	51,389	328,813	15.6
Phosphate rock	"	1,607,884	-	..
Potash (K_2O equivalent)	"	192,796	1,430,000	13.5
Sodium sulphate	"	275,620	346,000	79.6
Sulphur, elemental	"	585,441	1,907,723	30.7
Fuels				
Coal	st	26,774,718	11,588,616	231.0
Natural gas	Mcf	567,944,000	1,442,448,070	39.4
Petroleum, crude	bbl	352,839,269	296,418,914	119.0

*Production for metals, in most cases, refers to production in all forms. This includes the recoverable metal content of ores, concentrates, matte, etc., exported 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.
- Nil; .. Not available or not applicable.

TABLE 21

Apparent Consumption of Minerals in Canada and Relation to Production, 1964

	Unit of Measure	Apparent Consumption*	Production**	Consumption as % of Production
Asbestos	st	86,375	1,419,851	6.1
Cement	"	7,582,395	7,847,384	96.6
Gypsum (crude)	"	1,384,372	6,360,685	21.8
Iron ore	lt	8,979,217	34,219,484	26.2
Lime	st	1,455,175	1,540,727	94.4
Quartz (silica)	"	2,782,816	2,117,273	131.4
Salt	"	3,230,000[e]	3,988,598	81.0

* Production plus imports and less exports. Consumption of these commodities as reported by consumers is not readily available. **Producers' shipments.
[e] Estimated.

TABLE 22

Apparent Consumption of Minerals in Canada and Relation to Production, 1965

Minerals	Unit of Measure	Apparent Consumption*	Production**	Consumption as % of Production
Asbestos	st	60,806	1,380,210	4.4
Cement	"	8,129,703	8,426,971	96.5
Gypsum	"	1,539,755	6,210,960	24.8
Iron ore	lt	9,489,300	35,525,522	26.7
Lime	st	1,302,983	1,516,983	85.9
Quartz (silica)	"	3,109,906	2,831,555	109.8
Salt	"	3,324,000[e]	4,331,100	76.7

*Production plus imports less exports. Consumption of these commodities as reported by consumers is not readily available. **Producers' shipments.
[e] Estimated.

TABLE 23

Domestic Consumption of Principal Refined Base Metals[1] in Relation to Production[2] in Canada, 1956-65

(short tons)

	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
Copper										
Domestic consumption[3]	145,286	118,225	122,893	129,973	117,636	141,807	151,525	169,751	202,225	225,185
Production	328,458	323,540	329,239	365,366	417,029	406,359	382,868	378,911	408,509	433,552
% Consumption of production	44.2	36.5	37.3	35.6	28.2	34.9	39.6	44.8	49.5	51.9
Zinc										
Domestic consumption[4]	61,173	52,713	56,097	64,788	55,803	60,878	65,320	73,653	88,494	93,796
Production	255,564	247,316	252,093	255,306	260,968	268,007	280,158	284,021	337,728	358,779
% Consumption of production	23.9	21.3	22.3	25.4	21.4	22.7	23.3	25.9	26.2	26.1
Lead										
Domestic consumption	75,882	71,583	69,769	65,935	72,087	73,418	77,286	77,958	82,736	90,168
Production	147,865	142,935	132,987	135,296	158,510	171,833	152,217	155,000	151,372	186,484
% Consumption of production	51.3	50.1	52.5	48.7	45.5	42.7	50.8	50.3	54.7	48.4
Aluminum										
Domestic consumption[5]	91,869	77,984	101,886	114,344	120,831	135,575	151,893	166,909	172,059[r]	205,282
Production	620,321	556,715	634,102	593,630	762,012	663,173	690,297	719,390	842,640[r]	840,346
% Consumption of production	14.8	14.0	16.1	19.3	15.9	20.4	22.0	23.2	20.3	24.4

1 Refined metal of primary and secondary origins. 2 Refined metal from all sources, including metal derived from secondary materials at primary refineries. 3 Producers' domestic shipments. 4 Primary refined zinc only.
5 Producers' domestic shipments: primary aluminum to 1958; primary and secondary aluminum consumption for 1959 and thereafter. r Revised.

TABLE 24

Annual Averages of Prices of Main Minerals*, 1964 and 1965

	Unit of Measure	Average 1964	Average 1965	Increase or Decrease Cents or Dollars	Increase or Decrease %
Aluminum ingot, 99.5%	cents/lb	23.741	24.507	+ 0.766	+ 3.2
Antimony, RMM, f.o.b. Laredo, Tex.	cents/lb	40.311	44.000	+ 3.689	+ 9.2
Bismuth, ton lots, delivered	$/lb	2.350	3.426	+ 1.076	+45.8
Cadmium	cents/lb	305.000	262.956	- 42.044	-13.8
Calcium, commercial grade, f.o.b. Haley, Ont.	$/lb	.80	.85	+ 0.5	+ 6.2
Chromium metal, 98.5%, .05% C	$/lb	1.15-1.19	1.15-1.19	-	-
Cobalt metal, 500 lb lots	$/lb	1.500	1.625	+ 1.25	+ 8.3
Copper, U.S. domestic, f.o.b. refinery	cents/lb	31.960	35.017	+ 3.057	+ 9.6
Gold, Canadian dollars	$/troy oz	37.75	37.73	- 0.02	- 0.1
Iron ore, 51.5% Fe, Lower Lake ports					
Bessemer					
Mesabi	$/lt	10.70	10.70	-	-
Old Range	$/lt	10.95	10.95	-	-
Non-Bessemer					
Mesabi	$/lt	10.55	10.55	-	-
Old Range	$/lt	10.80	10.80	-	-
Lead, common, New York	cents/lb	13.596	16.000	+ 2.404	+17.7
Magnesium, ingot	cents/lb	35.250	35.250	-	-
Mercury	$ flask (76 lb)	314.787	570.726	+255.939	+81.3
Molybdenum metal	$/lb	3.35	3.35	-	-
*Molybdenite, 95% MoS_2, contained Mo	$/lb	1.51	1.55	+ 0.04	+ 2.6
Nickel, f.o.b. Port Colborne (duty incl)	cents/lb	79.000	78.673	- 0.327	- 0.4
Platinum	$/troy oz.	87.985	97.583	+ 9.598	+10.9
Selenium	$/lb	4.50	4.50	-	-
Silver, New York	cents/troy oz	129.300	129.300	-	-
Sulphur, Mexican export price	$/metric ton	20.000	22.575	+ 2.575	+12.9
Tin, Straits, New York	cents/lb	157.595	178.202	+ 20.607	+13.1
Titanium metal, 500 lb lots, 99.3%	$/lb	1.32	1.32	-	-
Titanium ore (ilmenite) 59.5% TiO_2	$/lt	23.00 to 26.00	22.50 to 25.50		
Tungsten metal	$/lb	2.75	2.75	-	-
Zinc, prime western, East St. Louis	cents/lb	13.568	14.500	+ 0.932	+ 6.9

* These prices, except those for gold and calcium are in United States currency and are from E & MJ Metal and Mineral Markets.

TABLE 25

Wholesale Price Indexes of Minerals and Mineral Products, Canada, 1955 and 1963-65
(1935-39 = 100)

	1955	1963	1964	1965
Iron and products	221.4	253.6	256.4	264.4
Pig iron	259.8	289.6	290.4	289.1
Rolling mill products	209.1	251.6	251.7	260.2
Pipe and tubing	231.6	273.2	271.0	281.8
Wire	248.2	274.0	274.9	288.2
Scrap iron and steel	301.1	243.0	269.4	300.5
Tinplate and galvanized sheet	220.0	238.3	238.2	248.9
Nonferrous metals and products				
Total (including gold)	187.6	197.5	205.9	217.7
Total (excluding gold)	259.3	270.0	284.9	306.1
Antimony	178.7	228.7	417.2	412.9
Copper and products	346.6	303.4	318.9	360.8
Lead and products	300.1	231.2	280.5	323.9
Silver	226.9	356.9	360.4	360.2
Tin	179.4	247.8	330.2	367.8
Zinc and products	294.7	278.3	307.5	329.3
Solder	196.5	226.9	299.4	335.7
Nonmetallic minerals and products	175.2	189.5	190.9	191.6
Clays and clay products	232.1	244.0	242.5	243.4
Pottery	153.7	227.2	225.5	240.4
Coal	172.1	200.2	201.6	200.9
Coal tar	213.7	219.6	211.6	229.4
Coke	225.8	260.6	263.9	265.5
Window glass	251.2	305.8	310.6	320.0
Plate glass	193.4	237.7	283.6	284.3
Petroleum products	165.8	160.6	159.8	159.8
Crude oil	n.a.	194.1	192.0	192.0
Gasoline	135.7	126.8	126.5	126.4
Coal oil	134.4	134.4	134.1	134.1
Asphalt	184.1	192.3	192.3	198.6
Asphalt shingles	142.9	111.5	106.1	92.1
Sulphur	201.3	225.6	226.2	226.2
Plaster	127.9	142.6	144.0	147.7
Lime	205.2	215.7	223.2	227.1
Cement	153.9	169.4	169.9	172.8
Sand and gravel	144.0	143.6	143.0	143.6
Crushed stone	160.4	171.6	159.0	158.3
Building stone	197.6	184.3	199.6	211.2
Asbestos and products	267.1	304.4	304.4	319.7
General wholesale price index (all products)	218.9	244.6	245.4	250.3

n.a. Not available.

TABLE 26

General Wholesale Price Index and Wholesale Price Indexes of Mineral and Nonmineral Industries, 1941-1965
(1935-39 = 100)

	Mineral Products Industries			Nonmineral Products Industries					
	Iron Products	Nonferrous Metal Products	Nonmetallic Mineral Products	Vegetable Products	Animal Products	Textile Products	Wood Products	Chemical Products	General Wholesale Price Index
1941	112.8	107.2	111.1	106.1	123.8	128.4	127.0	118.6	116.4
1942	116.0	107.2	114.5	114.9	137.1	131.2	132.3	127.9	123.0
1943	116.8	107.8	115.6	123.5	146.9	130.8	142.2	125.3	127.9
1944	117.8	107.8	114.3	129.1	146.6	130.7	151.6	124.9	130.6
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	315.8	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	264.4	217.7	191.6	218.5	270.7	246.8	333.3	200.0	250.3

TABLE 27

Industry Selling Price Indexes*, Mineral-
Based Industries
(1956 = 100)

	1962	1963	1964	1965
Iron and steel products industries				
Agriculture implements	115.2	117.1	116.8	117.4
Hardware, tools and cutlery	114.4	115.4	116.1	120.2
Heating and cooking apparatus	94.8	94.4	94.3	93.5
Machinery, household, office and store	98.0	99.2	99.5	99.9
Castings, iron	107.0	107.8	107.7	110.6
Pig iron	106.0	104.2	104.3	104.1
Steel ingots and castings	120.0	119.8	120.3	122.2
Rolled iron and steel products	106.6	106.4	106.1	108.8
Wire and wire goods	105.6	105.3	106.6	109.6
Nonferrous metal products industries				
Aluminum products	103.5	104.7	107.8	110.6
Brass and copper products	85.4	86.0	90.3	100.8
Jewellery and silverware	115.5	126.1	131.8	133.2
Nonferrous metal smelting and refining	99.1	101.2	109.7	112.9
White metal alloys	87.7	89.5	104.4	118.7
Nonmetallic mineral products industries				
Abrasives, artificial	114.4	116.1	115.8	115.9
Cement, hydraulic	108.4	110.8	112.3	115.4
Clay products from imported clay	106.8	106.8	107.7	112.1
Glass and glass products	109.0	109.2	110.1	109.3
Lime	110.6	110.7	111.8	114.6
Gypsum products	106.1	106.1	107.2	107.9
Concrete products	96.8	98.2	102.4	105.5
Clay products from domestic clay	108.6	109.3	109.6	111.0
Coke and gas products	111.7	111.2	111.8	112.3
Petroleum refining and products	98.5	94.7	95.1	93.2
Lubricating oils and greases	114.8	116.5	117.9	118.2
Fertilizer	101.2	103.5	105.8	107.5

* Industry selling price indexes are wholesale price indexes organized according to the Standard Industrial Classification.

TABLE 28

Principal Statistics of the Mineral Industry by Sectors, 1962

	Establishment	Employees	Salaries and Wages ($000)	Cost of Fuel and Electricity ($000)	Cost of Process Supplies, Ores Concentrates and Containers ($000)	Gross Value of Production ($000)	Net Value of Productio ($000)
Metallics							
Placer gold	39	231	1,341	102	14	2,161	1,990
Gold	133	15,220	64,579	6,982	18,495	129,496	102,318
Copper-gold-silver	191	11,046	53,489	6,873	16,233	218,036	142,917
Silver-cobalt	21	611	2,517	305	293	6,108	5,011
Silver-lead-zinc	59	4,532	23,546	2,791	7,947	111,258	59,099
Nickel-copper	37	13,342	74,050	4,479	16,753	115,549	90,942
Iron	55	9,215	60,354	10,837	23,707	257,966	185,452
Other	29	5,120	30,355	4,989	22,130	164,135	135,817
Total	564	59,317	310,231	37,358	105,572	1,004,709	723,546
Industrial minerals							
Asbestos	18	6,997	36,073	7,184	16,700	135,066	111,181
Feldspar, quartz, nepheline syenite	20	380	1,560	262	544	5,529	4,574
Gypsum	10	608	2,408	354	1,884	8,152	5,914
Salt	11	907	4,271	1,183	2,988	22,382	18,210
Sand and gravel	511	2,722	10,143	3,436	576	45,795	41,783
Stone	207	3,197	12,199	3,293	5,033	47,812	39,487
Clay products	93	3,693	14,794	5,406	5,645	37,054	26,772
Cement	20	3,320	18,225	17,719	16,221	116,706	83,622
Lime	22	896	3,777	2,505	2,153	14,503	9,792
Other	95	2,629	9,079	2,285	3,930	25,727	19,223
Total	1,007	25,349	112,529	43,627	55,674	458,726	360,558
Fuels							
Coal	101	9,470	34,385	3,818	10,045	68,260	54,397
Petroleum and natural gas	549	4,823	28,839	9,712	9,028	748,159	729,419
Total	650	14,293	63,224	13,530	19,073	816,419	783,816
Total mining industry	2,221	98,959	485,984	94,515	180,319	2,279,854	1,867,920
Nonferrous smelting and refining	23	29,303	159,439	45,703	915,967	1,549,049	582,653

Note: This table is a revision of Table 25, pages 706 and 707, Canadian Minerals Yearbook 1964.

TABLE 29

Principal Statistics of the Mineral Industry by Sectors, 1963

	Establishments	Employees	Salaries and Wages ($000)	Cost of Fuel and Electricity ($000)	Cost of Process Supplies, Ores, Concentrates and Containers ($000)	Gross Value of Production ($000)	Net Value of Productio ($000)
Metallics							
Placer gold	30	210	1,222	71	121	2,202	1,950
Gold quartz	122	15,120	63,095	6,734	19,147	126,903	99,259
Copper-gold-silver	176	11,536	58,514	7,010	19,882	229,873	150,193
Silver-cobalt	21	705	3,004	346	413	6,957	5,592
Silver-lead-zinc	61	4,636	24,886	3,721	8,689	125,778	70,253
Nickel-copper	26	12,110	68,080	4,220	17,414	112,121	85,524
Iron	48	9,993	65,647	14,150	32,621	305,372	215,044
Other	35	4,468	27,925	4,755	19,752	144,413	118,642
Total	519	58,778	312,373	41,007	118,039	1,053,619	746,457
Industrial minerals							
Asbestos	17	6,823	35,508	7,638	16,275	141,998	118,086
Feldspar, quartz, nepheline syenite	20	381	1,564	343	686	6,332	5,302
Gypsum	9	680	2,876	449	2,268	9,846	7,130
Salt	11	955	4,567	1,199	3,256	22,441	17,985
Sand and gravel	331	2,266	9,250	3,170	487	42,537	38,881
Stone	207	3,452	14,046	3,768	5,430	48,767	39,045
Clay products	89	3,519	14,319	5,406	4,966	37,587	27,572
Cement	20	3,566	20,559	17,920	16,292	122,179	87,881
Lime	21	886	4,058	2,427	2,211	14,914	10,365
Other	92	2,934	11,252	3,047	4,802	46,950	38,631
Total	817	25,462	117,999	45,367	56,673	493,551	390,878
Fuels							
Coal	97	8,903	35,624	3,731	13,011	71,295	54,553
Petroleum and natural gas*	634	5,840	36,397	10,533	10,775	811,101	789,783
Total	731	14,743	72,021	14,264	23,786	882,396	844,336
Total mining industry	2,067	98,983	502,393	100,638	198,498	2,429,566	1,981,671
Nonferrous smelting and refining	23	28,644	160,118	46,038	918,660	1,520,160	566,817

* Includes natural gas processing.

TABLE 30

Principal Statistics[1] of the Mining Industry[2], 1958-63

	Establishment	Employees	Salaries and Wages ($000)	Cost of Fuel and Electricity ($000)	Cost of Process Supplies, Ores, Concentrates and Containers ($000)	Gross Value of Production ($000)	Net Value of Production[3] ($000)
1958	2,502	106,434	460,446	86,872	164,552	1,742,742	1,364,924
1959	2,584	106,960	479,468	87,913[r]	175,544	1,961,335	1,547,793
1960	2,473	103,556	480,011	89,219	180,760	1,972,796	1,560,682
1961	2,483	99,644	469,983	87,792	162,717	2,057,452	1,671,549
1962	2,221	98,959	485,984	94,515	180,319	2,279,854	1,867,920
1963	2,067	98,983	502,393	100,638	198,498	2,429,566	1,981,671

[1] Commencing in 1960 certain changes in the industrial classification of industries were made by the Dominion Bureau of Statistics. The definition of establishment was changed to include only that establishment considered a separate accounting unit, capable of reporting employment, salaries and wages, etc., on a unit basis. This substantially reduced the number of establishments in comparison with previous years. Also, some companies formerly included in the mining industry were transferred to other industries (manufacturing, construction, etc.) if their main revenue-producing activity was not mining. [2] Does not include smelting and refining industries.

[3] Net value equals gross value of production less cost of process supplies, ores, concentrates, containers, treatment charges, freight, fuel and electricity.

[r] Revised.

Note: This table is a revision of Table 26, page 708, Canadian Minerals Yearbook 1964.

TABLE 31

Principal Statistics of the Nonferrous Smelting and Refining Industries, 1958-63

	Establish-ment	Employees	Salaries and Wages ($000)	Cost of Fuel and Electricity ($000)	Cost of Process Supplies, Ores, Concentrates and Containers ($000)	Gross Value of Production ($000)	Net Value of Production ($000)
1958	24	27,361	133,066	43,868	666,721	1,132,702	422,113
1959	23	28,172	139,320	47,341	788,218	1,283,938	448,380
1960	22	30,024	155,415	50,787	896,613	1,506,008	558,608
1961	24	29,527	157,475	49,000	891,951	1,471,048	530,097
1962	23	29,303	159,439	45,703	915,967	1,549,049	582,653
1963	23	28,644	160,118	46,038	918,660	1,520,160	566,817

Note: See footnotes to Table 30 for references to changes in statistical classification and definition of net value of production.

TABLE 32

Consumption of Fuels and Electricity in the Canadian Mineral Industry, 1962

	Unit	Metal Mining	Nonferrous Smelting and Refining	Total	Production of Industrial Minerals	Production of Crude Mineral Fuels	Total Mineral Industry
Coal and coke	st	123,523	1,000,279	1,123,802	890,889	42,380	2,057,071
	$	1,860,386	14,947,050	16,807,436	9,376,479	287,891	26,471,806
Gasoline and kerosene	gal.	3,622,335	928,942	4,551,277	11,047,346	7,378,765	22,977,388
	$	1,297,228	261,215	1,558,443	3,453,491	2,774,210	7,786,144
Fuel oil	gal.	62,538,468	58,911,405	121,449,873	99,260,416	2,940,746	223,651,035
	$	9,630,821	4,982,590	14,613,411	10,651,347	608,006	25,872,764
Liquefied petroleum gas	gal.	840,813	475,892	1,316,705	627,718	771,988	2,716,411
	$	195,140	105,665	300,805	173,384	137,280	611,469
Natural gas	Mcf	680,740	13,117,311	13,798,051	22,062,852	20,767,465	56,628,368
	$	343,160	4,443,010	4,786,170	6,803,333	2,041,707	13,631,210
Other fuels	$	409,377	79,789	489,166	227,711	121,761	838,638
Total fuels		13,736,112	24,819,319	38,555,431	30,685,745	5,970,855	75,212,031
Electricity purchased	million kwh	3,373	5,046	8,419	1,595	409	10,423
	$	23,621,502	20,883,574	44,505,076	12,940,965	7,559,338	65,005,379
Total value, fuels and electricity purchased	$	37,357,614	45,702,893	83,060,507	43,626,710	13,530,193	140,217,410
Electricity generated by industry for own use	million kwh	567	12,688	13,255	35	36	13,326

Note: This table is a revision of Table 27, page 709, Canadian Minerals Yearbook 1964.

TABLE 33

Consumption of Fuels and Electricity in the Canadian Mineral Industry, 1963

	Unit	Metal Mining	Nonferrous Smelting and Refining	Total	Production of Industrial Minerals	Production of Crude Mineral Fuels	Total Mineral Industry
Coal and coke	st	113,395	895,469	1,008,864	850,881	4,117	1,863,862
	$	1,788,706	13,495,225	15,283,931	8,907,179	33,964	24,225,074
Gasoline and kerosene	gal.	4,004,419	1,026,669	5,031,088	9,865,703	7,547,855	22,444,646
	$	1,454,530	300,569	1,755,099	3,321,066	2,350,271	7,426,436
Fuel oil	gal.	12,935,299	60,402,546	73,337,845	103,534,915	4,414,843	181,287,603
	$	11,580,263	5,159,394	16,739,657	11,290,960	870,813	28,901,430
Liquefied petroleum gas	gal.	285,845	674,247	960,092	246,149	1,068,170	2,274,411
	$	108,968	142,642	251,610	66,936	195,319	513,865
Natural gas	Mcf	651,323	14,736,545	15,387,868	23,839,128	23,088,699	62,315,695
	$	372,439	5,078,557	5,450,996	7,648,182	2,560,006	15,659,184
Other fuels	$	246,207	87,900	334,107	199,577	376,763	910,447
Total fuels		15,551,113	24,264,287	39,815,400	31,433,900	6,387,136	77,636,436
Electricity purchased	million kwh	3,711	5,215	8,926	1,766	602	11,294
	$	25,456,160	21,774,100	47,230,260	13,932,584	7,877,007	69,039,851
Total value, fuels and electricity purchased	$	41,007,273	46,038,387	87,045,660	45,366,484	14,264,143	146,676,287
Electricity generated by industry for own use	million kwh	432	13,735	14,167	36	47	14,250

TABLE 34

Cost of Fuel and Electricity Used in the Canadian Mining Industry *, 1955-63

		1955	1956	1957	1958	1959	1960	1961	1962	1963
Fuel**	$ million	39.9	47.0	53.1	53.1	53.1	48.8	46.3	50.4	53.3
Electricity purchased	million kwh	3,540	4,213	4,586	4,993[r]	5,164	5,195	5,084	5,377	6,079
	$ million	26.5	32.2	35.8	38.1	39.5	42.8	41.5	44.1	47.3
Total cost of fuel and electricity	$ million	66.4	79.2	88.9	91.2	92.6	91.6	87.8	94.5	100.6
Electricity generated for own use	million kwh	487	558	590	527	551	575	581	638	515
Electricity generated for sale	million kwh	47	12	14	16	17	33	29	31	33

* Excludes nonferrous smelting and refining. ** Coal, coke, fuel oil, gasoline, gas, wood.

Note: Total cost of fuel and electricity for years 1958 to 1960, inclusive, as shown in the above table do not agree with later revised totals for those years as shown in Table 30. The over-all costs of fuel and electricity were revised for those years, but the individual components (fuel and electricity) were not. It is, therefore, not possible to show the components, fuel and electricity, in a revised form for the years 1958 to 1960 incl. to agree with the totals reported in Table 30.

[r] Revised.

TABLE 35

Cost of Fuel and Electricity Used in the Nonferrous Smelting and Refining Industries, 1955-1963

		1955	1956	1957	1958	1959	1960	1961	1962	1963
Fuel*	$ million	24.3	29.9	27.3	23.4	26.3	26.9	27.2	24.8	24.2
Electricity purchased	million kwh	13,804	13,981	13,668	15,081	14,575	18,225	5,389	5,046	5,215
	$ million	32.6	35.0	32.2	40.1	36.0	36.3	21.8	20.9	21.8
Total cost of fuel and electricity purchased	$ million	56.9	64.9	59.5	63.5	62.3	63.2	49.0	45.7	46.0
Electricity generated for own use **	million kwh	1,132	1,121	1,037	1,038	1,060	1,146	12,851	12,688	13,735
Electricity generated for sale	million kwh	9	12	-	33	31	33	36	3	3

* Coal, coke, fuel oil, gasoline, gas, wood. ** Commencing in 1961 changes in statistical classifications account for decreases in electricity purchased and increases in electricity generated for own use.

Note: See footnote Table 34 for explanation of differences between total values of fuel and electricity 1958 to 1960 incl. as shown in above table and as reported in Table 31.

TABLE 36

Employment, Salaries and Wages in the Canadian Mineral Industry, 1944, 1949, 1954, 1959, 1962 and 1963

	1944		1949		1954		1959		1962		1963	
	Employees	$ million	Employees	$ million	Employees	$ million	Employees	$ million	Employees	$ million	Employees	$ million
Metal mining	34,559	71.9	46,181	132.3	51,599	195.2	63,871	306.9	59,317	310.2	58,778	312.4
Nonferrous smelting and refining	23,927	44.5	19,150	55.1	26,048	102.6	28,172	139.3	29,303	159.4	28,644	160.1
Industrial minerals	16,439	24.7	22,581	50.0	26,991	89.2	26,378	107.4	25,349	112.5	25,462	118.0
Fuels*	29,953	63.7	28,595	72.2	24,807	78.3	16,711	65.2	14,293	63.2	14,743	72.0
Total	104,878	204.8	116,507	309.6	129,445	465.3	135,132	618.8	128,262	645.3	127,627	662.5
Annual average of salaries and Wages ($)		1,953		2,658		3,595		4,579		5,031		5,488

* Coal, crude petroleum and natural gas (including natural gas processing after 1960).

TABLE 37

Number of Wage Earners - Surface, Underground, and Mill - Canadian Mining Industry*, by Sectors
1955-63

	1955	1956	1957	1958	1959	1960	1961	1962	1963
Metallics**									
Surface	15,540	16,706	18,532	16,602	16,697	16,039	15,815	15,197	14,615
Underground	26,522	27,679	29,382	29,712	31,384	30,774	28,975	27,959	26,334
Mill	4,664	5,624	6,168	6,541	6,573	6,162	6,047	6,504	7,802
Total	46,726	50,009	54,082	52,855	54,654	52,975	50,837	49,660	48,751
Industrial Minerals									
Surface	12,204	12,804	14,347	14,029	13,988	10,321	9,485	9,656	9,464
Underground	1,632	1,798	1,749	1,458	1,327	1,164	995	951	879
Mill	11,445	12,163	11,573	11,216	11,639	10,741	10,511	10,770	10,561
Total	25,281	26,765	27,669	26,703	26,954	22,226	20,991	21,377	20,904
Fuels									
Surface	8,886	9,622	8,683	7,887	7,537	6,715	5,786	5,585	5,537
Underground	11,439	11,065	10,043	9,247	8,022	8,257	7,439	6,678	6,276
Mill	-	-	-	-	-	-	-	-	-
Total	20,325	20,687	18,726	17,134	15,559	14,972	13,225	12,263	11,813
Total									
Surface	36,630	39,132	41,562	38,518	38,222	33,075	31,086	30,438	29,616
Underground	39,593	40,542	41,174	40,417	40,733	40,195	37,409	35,588	33,489
Mill	16,109	17,787	17,741	17,757	18,212	16,903	16,558	17,274	18,363
Total	92,332	97,461	100,477	96,692	97,167	90,173	85,053	83,300	81,468

* Does not include nonferrous smelting and refining. ** Includes placer operations.

TABLE 38

Labour Costs in Relation to Tons Mined from Metal Mines, 1944, 1954, 1962 and 1963

Types of Metal Mines	Number of Wage Earners	Total of Wage ($ millions)	Average Annual Wage ($)	Tons Mined (000 st)	Average annual tons mined per worker (st)	Wage Cost per ton mined ($)
1963						
Auriferous quartz	13,025	51.6	3,959	12,619	969	4.09
Copper-gold-silver	9,512	46.1	4,851	19,764	2,078	2.33
Nickel-copper	10,546	56.4	5,346	17,629	1,672	3.20
Silver-cobalt	585	2.4	4,034	307	525	7.69
Silver-lead-zinc	3,808	19.5	5,116	5,796	1,522	3.36
Iron ore	7,312	46.7	6,384	60,071	8,215	0.78
Miscellaneous	3,648	22.3	6,134	7,693	2,109	2.91
Total	48,436	245.0	5,058	123,879	2,558	1.98
1962						
Auriferous quartz	13,370	54.2	4,051	13,660	1,022	3.96
Copper-gold-silver	9,290	43.7	4,703	17,745	1,910	2.46
Nickel-copper	11,906	63.5	5,332	17,971	1,509	3.53
Silver-cobalt	520	2.1	4,075	235	451	9.03
Silver-lead-zinc	3,786	18.9	4,992	6,234	1,647	3.03
Iron ore	6,287	42.2	6,718	49,876	7,933	0.85
Miscellaneous	4,292	25.1	5,851	8,543	1,990	2.94
Total	49,451	249.7	5,050	114,264	2,311	2.19
1954						
Auriferous quartz	16,579	54.8	3,307	16,178	976	3.39
Copper-gold-silver	6,684	24.2	3,618	8,502	1,272	2.84
Nickel-copper	10,280	42.5	4,134	16,749	1,629	2.54
Silver-cobalt	680	2.2	3,310	289	425	7.79
Silver-lead-zinc	5,405	20.4	3,770	7,272	1,345	2.80
Iron ore						
Miscellaneous	5,712	21.5	3,767	10,025	1,755	2.15
Total	45,340	165.6	3,653	59,015	1,302	2.81
1944						
Auriferous quartz	15,260	31.2	2,041	10,790	707	2.89
Copper-gold-silver	4,553	8.9	1,965	7,396	1,624	1.21
Nickel-copper	7,133	13.2	1,857	12,954	1,816	1.02
Silver-cobalt	141	0.2	1,536	27	193	7.97
Silver-lead-zinc	2,395	4.9	2,042	2,912	1,216	1.68
Iron ore						
Miscellaneous	1,148	2.3	2,024	1,251	1,090	1.86
Total	30,630	60.7	1,984	35,330	1,153	1.72

TABLE 39

Man-hours Worked and Tons of Ore Mined and Rock Quarried, Metal Mines and Industrial Mineral Operations, 1955-63

	1955	1956	1957	1958	1959	1960	1961	1962	1963
Metal Mines[1]									
Ore mined (millions st)	69.2	77.4	84.3	78.8	99.1[r]	101.6	99.4	114.3	123.9
Man-hours worked[3] (millions)	116.6	126.4	135.7	133.6	133.3	130.5	124.9	124.4	123.1
Man-hours per ton mined (number)	1.68	1.63	1.61	1.70	1.35	1.28	1.26	1.09	0.99
Industrial Mineral Operations[2]									
Ore mined and rock quarried (millions st)	55.0	62.9	70.0	66.5	78.5[r]	86.0	94.6	100.9	119.0
Man-hours worked[3] (millions)	31.8[r]	32.8[r]	32.3[r]	29.3	29.3	27.5[r]	26.9	27.2	27.6
Man-hours worked per ton mined (number)	0.58	0.52	0.46	0.44	0.37	0.32	0.28	0.27	0.23

[1]Excludes placer mining. [2]Excludes salt, cement, clay products, stone for cement manufacture and stone produced for lime manufacture. [3]Includes man-hours worked by all employees both salaried and wage earners on surface, underground, mill and administration. [r] Revised.

TABLE 40

Basic Wage Rates per Hour in Canadian Metal Mining Industry on October 1, 1964 and 1965
($)

	Gold Mining		Iron Mining		Other Metal Mining	
	1964	1965	1964	1965	1964	1965
Underground workers						
Cage and shiptenders	1.66	1.75	..	..	2.33	2.42
Chute blaster	1.59	1.63	..	..	2.41	2.47
Deckman	1.57	1.61	..	..	2.08	2.19
Hoistman	1.77	1.85	..	..	2.51	2.59
Labourer	1.48	1.61	..	..	2.19	2.19
Miner	1.63	1.73	2.51	2.65	2.31	2.41
Miner's helper	1.50	1.56	2.41	2.57	1.92	2.04
Motorman	1.60	1.67	..	..	2.25	2.34
Mucking machine operator	1.55	1.64	..	..	2.28	2.37
Mucker and trammer	1.56	1.60	..	..	2.25	2.35
Timberman	1.68	1.78	..	..	2.38	2.42
Trackman	1.58	1.69	..	..	2.29	2.38
Open-pit workers						
Blaster	..	..	2.55	2.64	..	..
Bulldozer operator	..	..	2.69	2.71	..	..
Driller, machine	..	..	2.66	2.72	..	..
Dump-truck driver	..	..	2.80	2.76	..	..
Oiler	..	..	2.46	2.51	..	..
Shovel operator (power)	..	..	3.03	3.08	..	..
Surface and mill workers						
Blacksmith	..	..	..	..	2.40	2.55
Carpenter, maintenance	1.78	1.89	2.86	2.87	2.37	2.40
Crusher operator	1.58	1.68	2.45	2.56	2.22	2.25
Electrician	1.82	1.90	2.96	2.90	2.58	2.65
Filter operator	..	..	..	..	2.24	2.30
Flotation operator	..	..	..	..	2.20	2.23
Grinding-mill operator	..	..	2.58	2.69	2.23	2.32
Hoistman	..	..	2.45	2.48	..	..
Labourer	1.44	1.52	2.22	2.16	1.94	1.96
Machinist, maintenance	1.83	1.90	3.01	2.98	2.60	2.70
Mechanic, diesel	..	..	3.08	3.12	2.62	2.59
Mechanic, maintenance	1.77	1.86	2.89	2.70	2.45	2.54
Millman	1.68*	1.76*	..	..	..	..
Pipefitter, maintenance	1.73	1.79	2.77	2.79	2.35	2.43
Solution man	..	..	..	..	2.36	2.38
Steel sharpener	1.66	1.79	..	..	2.35	2.34
Tradesman's helper	1.56	1.64	2.40	2.42	2.14	2.21
Truck driver, light and heavy	1.57	1.68	2.49	2.57	2.04	2.19
Welder, maintenance	1.80	1.87	2.88	2.84	2.53	2.58
Millwright	..	..	2.85	2.98	..	..

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

TABLE 41

Index Numbers of Average Wage Rates* for Certain Main Industries, 1940-65
(1949 = 100)

		Mining		Manufacturing							
	Logging	Coal Mining	Metal Mining	All Manufacturing	Durable Goods	Non-durable Goods	Construction	Railways	Telephone	Personal Service	Genera Index
1940	48.5	52.1	56.9	47.9	46.6	48.8	56.7	58.8	66.9	54.1	50.8
1941	52.7	55.8	62.1	52.9	52.0	53.6	60.6	64.3	70.2	56.7	55.3
1942	58.2	57.7	65.7	57.6	57.7	57.5	64.4	67.5	73.9	59.7	59.9
1943	66.2	63.6	68.1	62.8	63.6	62.1	69.3	73.7	80.5	65.3	65.3
1944	67.6	74.5	69.2	64.9	65.6	64.4	70.4	73.7	80.8	66.1	67.4
1945	70.9	74.6	70.9	67.2	68.2	66.5	71.2	73.7	82.9	69.4	69.3
1946	77.4	74.8	75.1	74.1	74.5	73.8	78.1	82.0	82.6	75.6	75.9
1947	90.2	85.0	87.2	84.1	84.9	83.5	84.1	83.6	87.3	87.4	84.9
1948	101.2	98.4	95.7	94.5	94.7	94.4	95.7	100.0	92.7	92.7	95.7
1949	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1950	97.0	102.8	106.8	106.1	106.6	105.6	104.8	105.1	104.8	102.9	105.5
1951	109.6	111.1	121.6	120.3	121.7	118.8	118.6	121.9	115.7	110.6	119.1
1952	133.3	124.0	130.1	128.4	130.2	126.5	128.6	136.8	128.4	117.6	127.7
1953	135.5	124.0	132.3	134.6	136.3	132.8	136.2	137.2	136.6	123.3	133.6
1954	138.0	123.5	136.7	138.5	140.0	136.9	140.0	137.8	147.6	128.6	137.9
1955	138.2	122.8	140.3	142.2	143.7	140.7	145.4	137.8	152.8	132.3	141.7
1956	160.8	123.6	150.8	149.8	151.2	148.3	150.7	146.8	157.6	136.1	148.7
1957	168.4	137.4	156.2	158.6	160.7	156.3	160.7	153.3	165.9	138.9	156.5
1958	172.0	147.6	160.8	164.2	166.1	162.2	171.0	153.3	169.4	143.5	162.5
1959	176.2	147.3	164.3	168.9	170.8	167.0	180.7	165.7	175.3	146.1	168.8
1960	184.3	148.2	169.4	175.0	176.6	173.2	192.6	166.4	178.0	156.8	175.5
1961	190.8	154.5	173.9	179.5	180.3	178.7	196.3	176.5	188.0	158.8	180.0
1962	199.4	161.1	177.2	184.5	184.7	184.3	206.2	180.5	195.3	162.2	185.9
1963	208.2	155.6	182.0	190.5	190.6	190.4	214.1	185.9	200.2	171.1	192.5
1964	219.6	157.4	188.0	197.2	197.6	196.8	223.6	193.8	206.5	182.2	199.8
1965	239.0	166.7	195.0	207.0	207.8	206.0	235.2	201.3	212.3	195.4	210.1

* Average wage rate means the weighted average of straight-time rates paid on a time basis in an occupation.

TABLE 42

Average Weekly Wages and Hours of Hourly-rated Employees in Canadian Mining, Manufacturing and Construction Industries, 1959-65

	1959	1960	1961	1962	1963	1964	1965
Mining							
Average hours per week	41.5	41.7	41.8	41.7	42.0	42.2	42.5
Average weekly wage	84.80	87.26	89.08	91.22	94.12	97.61	103.09
Metals							
Average hours per week	41.7	41.9	42.2	41.9	41.9	42.1	42.3
Average weekly wage	88.73	90.89	92.83	94.43	96.92	100.22	106.27
Fuels							
Average hours per week	39.9	40.6	40.3	40.7	42.2	42.1	41.6
Average weekly wage	77.11	80.13	80.98	85.63	89.58	92.60	96.08
Nonmetals							
Average hours per week	42.2	42.2	42.3	42.3	42.4	43.1	43.9
Average weekly wage	76.87	79.62	82.60	83.82	87.70	92.00	97.29
Manufacturing							
Average hours per week	40.7	40.4	40.6	40.7	40.8	41.0	41.0
Average weekly wage	70.16	71.96	74.27	76.55	79.40	82.90	86.86
Construction							
Average hours per week	40.2	40.4	40.3	40.3	40.8	41.0	41.2
Average weekly wage	74.20	78.36	79.93	83.16	87.51	92.31	100.55

TABLE 43

Average Weekly Wages of Hourly-rated Employees in Canadian Mining Industry in Current and 1949 Dollars, 1959-65

	1959	1960	1961	1962	1963	1964	1965
Current Dollars							
All mining	84.80	87.26	89.08	91.22	94.12	97.61	103.09
Metals	88.73	90.89	92.83	94.43	96.92	100.22	106.27
Gold	68.95	70.81	73.34	75.76	77.38	80.27	85.12
Other	95.92	98.52	100.22	101.25	103.97	106.75	111.97
Fuels	77.11	80.13	80.98	85.63	89.58	92.60	96.08
Coal	67.00	69.36	70.36	73.82	79.26	80.84	80.68
Oil and Natural gas	92.74	96.57	95.66	102.35	105.83	110.61	116.44
Nonmetallics	76.87	79.62	82.60	83.82	87.70	92.00	97.29
1949 Dollars							
All mining	67.04	68.17	68.95	69.79	70.77	72.09	74.32
Metals	70.14	71.01	71.85	72.25	72.87	74.02	76.62
Gold	54.51	55.32	56.76	57.96	58.18	59.28	61.37
Other	75.83	76.97	77.57	77.47	78.17	78.84	80.73
Fuels	60.96	62.60	62.68	65.52	67.35	68.39	69.27
Coal	52.96	54.19	54.46	56.48	59.59	59.70	58.17
Oil and natural gas	73.31	75.45	74.04	78.31	79.57	81.69	83.95
Nonmetallics	60.77	62.20	63.93	64.13	65.94	67.95	70.14

TABLE 44

Industrial Fatalities in Canada per Thousand Paid Workers in Main Industry Groups[1] 1952-65

	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
Agriculture	0.94	1.00	0.82	0.83	1.03	0.95	1.00	0.92	0.62	0.61	0.56	0.48	0.72	0.48
Forestry	2.40	2.70	2.50	2.00	1.90	1.50	1.70	1.70	1.50	1.32	2.04	1.79	2.21	1.59
Fishing and Trapping	2.10	3.30	3.10	3.20	1.80	2.30	3.80	7.20	2.70	4.00	1.20	3.40	3.70	4.00
Mining[2]	2.30	2.00	2.00	1.60	2.10	1.50	2.20	2.00	1.92	1.73	1.89	2.33	1.87	1.24
Manufacturing	0.18	0.18	0.16	0.16	0.14	0.14	0.11	0.13	0.19	0.12	0.15	0.15	0.14	0.13
Construction	0.90	0.77	0.86	0.79	0.89	0.91	0.77	0.79	0.56	0.77	0.63	0.70	0.75	0.68
Transportation, Communication, Utilities and Other.	0.62	0.46	0.53	0.56	0.56	0.50	0.40	0.44	0.37	0.36	0.38	0.42	0.43	0.48
Trade	0.07	0.09	0.08	0.07	0.08	0.09	0.05	0.06	0.06	0.07	0.07	0.07	0.07	0.07
Finance, Insurance and Real Estate	0.06	0.02	0.01	0.03	0.05	0.01	0.02	0.01	0.09	0.05	0.08	0.04	0.08	0.01
Service[3]	0.12	0.09	0.08	0.07	0.06	0.07	0.07	0.06	0.07	0.06	0.06	0.09	0.07	0.05
Total	0.36	0.33	0.32	0.32	0.33	0.30	0.27	0.28	0.21	0.22	0.22	0.23	0.24	0.22

1 Includes quarrying and oil-well drilling. 2 Data for years 1961-65 were revised according to 1960 Standard Industrial Classification. 3 Includes Public Administration.

TABLE 45

Strikes and Lockouts by Industry, 1964 and 1965

	1964			1965		
	Strikes and Lockouts	Workers Involved	Duration in Man-days	Strikes and Lockouts	Workers Involved	Duration in Man-days
Agriculture	1	380	4,720	-	-	-
Forestry	5	1,162	12,150	3	1,199	54,460
Mines	12	6,560	69,640	25	8,402	58,460
Manufacturing	160	63,554	1,184,350	244	97,017	1,470,770
Construction	81	10,181	91,890	127	19,357	237,240
Transportation and Utilities	34	8,558	58,470	55	32,532	331,210
Trade	34	5,308	123,030	25	11,183	154,600
Finance	1	13	50	-	-	-
Service	11	2,728	16,120	20	2,101	42,070
Public Administration	4	2,091	20,130	2	79	1,060
All industries	343	100,535	1,580,550	501	171,870	2,349,870

- Nil.

TABLE 46

Ore Mined and Rock Quarried in the Canadian Mining Industry, 1962 and 1963
(short tons)

	1962	1963
Metallic ores		
Gold quartz	13,659,916	12,618,059
Copper-gold-silver	17,744,713	19,764,023
Silver-cobalt	234,621	307,095
Silver-lead-zinc	6,234,523	5,796,496
Nickel-copper	17,970,652	17,628,836
Iron	49,876,311	60,071,192
Miscellaneous metals	8,542,671	7,693,024
Total	114,263,407	123,878,725
Nonmetallics		
Asbestos	42,212,705	45,738,901
Feldspar, nepheline syenite	343,905	367,664
Quartz (exclusive of sand)	1,112,129	743,008
Gypsum	5,398,527	6,082,297
Talc, soapstone	67,069	64,712
Rock salt	1,867,584	1,751,436
Other nonmetallics	1,218,142	3,376,053
Total	52,220,061	58,124,071
Structural materials		
Stone, all kinds quarried	50,553,485	62,655,329
Stone used to make cement	9,294,196	9,384,412
Stone used to make lime	2,668,480	2,703,709
Total	62,516,161	74,743,450
Total ore mined and rock quarried	228,999,629	256,746,246

TABLE 47

Ore Mined and Rock Quarried, Canadian Mining Industry, 1930-63
(millions of short tons)

	Metal Mines	Industrial Mineral Operations	Total
1930	14.8	20.1	34.9
1931	15.2	15.0	30.2
1932	14.0	8.2	22.2
1933	15.0	6.4	21.4
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	39.3	20.2	59.5
1941	43.0	21.6	64.6
1942	42.5	21.8	64.3
1943	38.7	20.8	59.5
1944	35.3	19.5	54.8
1945	31.3	20.7	52.0
1946	28.9	24.8	53.7
1947	33.3	30.5	63.8
1948	36.9	33.6	70.5
1949	43.3	33.3	76.6
1950	45.9	41.8	87.7
1951	48.4	43.8	92.2
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	114.7	229.0
1963	123.9	132.8	256.7

TABLE 48

Cost of Prospecting by Metal-mining Industry, by Provinces and Types of Operations, 1962 and 1963
($)

1962	Placer Gold Operations	Gold Mines	Copper-gold-silver Mines	Silver-cobalt Mines	Silver-lead-zinc Mines	Nickel-copper Mines	Iron Mines	Miscellaneous Metal Mines	Total
Newfoundland	-	13,000	499,436	-	535,779	606	128,044	8,186	1,185,051
Nova Scotia	-	4,379	77,152	-	86,543	297	-	124,655	293,026
New Brunswick	28,000	34,125	361,098	-	162,842	-	48,340	10,227	644,632
Quebec	32,100	2,158,699	5,055,025	-	6,725,228	1,542,879	270,793	829,523	16,614,247
Ontario	-	1,800,075	1,694,626	47,553	353,178	3,840,373	1,175,207	496,893	9,407,905
Manitoba	-	119,485	1,685,544	-	58,563	3,309,538	193,484	8,083	5,374,697
Saskatchewan	-	156,295	209,081	-	68,622	267,005	-	52,211	753,214
Alberta	1,400	467	-	-	161,000	-	-	39,000	201,867
British Columbia	3,445	377,016	2,957,805	-	985,502	835,968	246,450	783,508	6,189,694
Yukon	35,890	171,745	482,685	-	206,887	20,000	720,000	398	1,637,605
Northwest Territories	-	159,979	330,956	-	163,144	603,729	80,000	150,395	1,488,203
Total, Canada	100,835	4,995,265	13,353,408	47,553	9,507,288	10,420,395	2,862,318	2,503,079	43,790,141
1963									
Newfoundland	3,304	84,625	88,601	-	483,702	-	223,576	14,294	898,102
Nova Scotia	-	12,201	117,184	-	58,142	-	-	88,881	276,408
New Brunswick	-	21,269	328,520	-	88,663	2,804	-	281,183	722,439
Quebec	3,299	2,787,178	7,925,089	1,925	493,307	2,408,984	752,551	1,419,179	15,791,512
Ontario	26,228	1,062,219	1,747,319	328,715	254,756	3,218,543	1,372,575	465,854	8,476,209
Manitoba	-	1,063	1,502,709	65,379	81,075	3,016,134	3,877	23,243	4,693,480
Saskatchewan	-	13,823	665,983	-	19,502	180,719	1,334	128,177	1,009,538
Alberta	-	18,850	55,892	-	201,204	-	-	88,433	364,379
British Columbia	174,989	285,223	4,442,302	114,572	1,928,269	659,548	253,247	672,036	8,530,186
Yukon	6,874	122,686	506,705	-	114,031	251,657	-	100,685	1,102,638
Northwest Territories	-	316,317	198,092	-	335,118	584,020	-	197,955	1,631,502
Total, Canada	214,694	4,725,454	17,578,396	510,591	4,057,769	10,322,409	2,607,160	3,479,920	43,496,393

Note: The amounts shown are the expenditures incurred by mining companies classified by their main type of metal-mining activity. These expenditures, however, apply to prospecting conducted by such companies in all sectors of the mineral industry. If, for example, a company whose chief activity is gold-quartz mining expends funds on prospecting for lead and zinc, such expenditures are included in the column headed Gold Mines in this table.

TABLE 49

Cost of Prospecting by Metal-mining Industry in Canada by Types of Operations, 1955-63
($)

	Placer Gold Operations	Gold Mines	Copper-gold -silver Mines	Silver-cobalt Mines	Silver-lead -zinc Mines	Nickel-copper Mines	Miscellaneous Metal Mines*	Total
1955	24,804	1,470,643	7,147,498	86,524	3,192,248	8,344,186	6,662,638	26,928,541
1956	31,620	4,264,955	18,315,885	111,102	3,571,201	13,310,337	8,795,159	48,400,259
1957	75,468	3,370,252	17,545,591	9,065	2,781,917	12,220,660	18,421,466	54,424,419
1958	91,461	2,246,360	10,239,495	10,396	1,351,065	13,894,699	4,673,610	32,507,086
1959	65,139	3,649,286	22,226,933	87,883	1,559,613	8,512,264	6,916,517	43,017,635
1960	118,805	3,814,541	19,105,258	26,808	5,602,547	9,411,381	5,474,270	43,553,610
1961	99,484	3,663,420	18,367,148	95,958	7,051,755	8,827,546	5,379,760	43,485,071
1962	100,835	4,995,265	13,353,408	47,553	9,507,288	10,420,395	5,365,397	43,790,141
1963	214,694	4,725,454	17,578,396	510,591	4,057,769	10,322,409	6,087,080	43,496,393

* Includes iron, uranium, molybdenum mining etc.

Note: see general footnote Table 48.

TABLE 50

Diamond Drilling on Canadian Metal Deposits by Mining Companies
with Own Equipment and by Drilling Contractors
(footage)

	Gold Quartz Deposits	Copper-gold-silver and nickel copper deposits	Silver-lead-zinc deposits	Other Metal-bearing deposits*	Total Metal Deposits
1950	3,640,265	4,080,713	1,425,812	273,012	9,419,802
1951	2,925,354	4,149,047	1,510,158	355,067	8,939,626
1952	2,651,722	3,894,437	1,496,542	183,833	8,226,534
1953	2,216,528	3,203,785	1,206,902	214,171	6,841,386
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

* Includes iron, chromite, litanium, uranium, molybdenum deposits.

TABLE 51

Exploration Diamond Drilling, Canadian Metal Deposits, 1950-63
(footage)

	By Mining Companies with Own Personnel and Equipment	By Diamond-Drill Contractors	Total
1950	790,768	3,434,375	4,225,143
1951	1,207,398	3,616,338	4,823,736
1952	1,366,363	3,120,419	4,486,782
1953	1,046,490	2,863,084	3,909,574
1954	969,858	3,641,220	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

TABLE 52

Contract Diamond-drilling Operations in Canada 1954-63

	Footage Drilled (ft)	Income from Drilling ($ millions)	Average Number of Employees (number)	Total of Salaries and Wages ($ millions)
1954	5,639,574	15.9	2,352	7.8
1955	6,443,641	21.4	2,840	9.9
1956	7,840,670	27.6	3,415	12.6
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

TABLE 53

Contract Drilling in Canada for Oil and Gas 1954-63

	Footage Drilled (feet)				Gross Income from Drilling	Average Number of Employees	Total Salaries and Wages
	Rotary	Cable	Diamond	Total	($ millions)	(number)	($ millions)
1954	9,609,140	457,480	-	10,066,620	58.8	4,559	18.1
1955	12,711,953	344,053	-	13,056,006	68.3	4,901	22.3
1956	15,424,310	376,663	-	15,800,973	93.3	5,793	28.8
1957	12,126,069	369,277	-	12,495,346	75.6	5,468	25.7
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

TABLE 54

Crude Minerals* Transported by Canadian Railways, 1964 and 1965 (thousands st)

	1964	1965
Coal		
Anthracite	790	774
Bituminous	10,160	10,595
Iron ore	35,807	38,906
Aluminum ores and concentrates	2,301	2,351
Copper ores and concentrates	1,214	1,297
Copper-nickel ores and concentrates	2,941	4,102
Lead ores and concentrates	413	791
Zinc ores and concentrates	1,736	2,146
Ores and concentrates, other	741	822
Barite	28	27
Clay and bentonite	537	522
Sand	932	1,072
Sand and gravel	6,210	6,228
Stone, crushed and ground	5,384	6,123
Stone, fluxing and dolomite	571	813
Stone, rough	45	34
Stone, dressed	22	20
Petroleum, crude	455	255
Salt	1,288	1,452
Phosphate rock	1,139	1,425
Sulphur	1,886	2,057
Asbestos	1,207	1,175
Gypsum, crude	4,889	4,710
Products of mines, other	1,580	1,512
Total	82,276	89,209
Total revenue freight moved by Canadian railways	198,337	205,197
Crude minerals as a percentage of total revenue freight moved by Canadian railways	41.5	43.5

* Domestic and imported.

TABLE 55

Crude Minerals* Transported by Canadian Railways, 1955-65
(millions of short tons)

	Total of Revenue Freight	Total of Crude Minerals	Crude Minerals as a % of Revenue Freight
1955	167.8	67.5	40.2
1956	189.6	75.7	39.9
1957	174.0	70.8	40.6
1958	153.4	57.8	37.6
1959	166.0	69.2	41.7
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

* Domestic and imported.

TABLE 56

Fabricated Mineral Products* Transported
by Canadian Railways, 1964 and 1965
('000 short tons)

	1964	1965
Aluminum: bar, ingot, pig, shot	504	599
Aluminum metal, other	107	118
Copper, ingot and pig	344	521
Copper, brass and bronze, other	442	249
Lead and zinc: bar, ingot, pig	516	549
Lead and zinc, other	7	8
Alloys for manufacture of steel	126	148
Metals and alloys, other	117	138
Iron, pig	238	309
Iron and steel: billet, bloom, ingot	375	549
Iron and steel: bar, rod, slab	858	539
Iron and steel, other	53	104
Matte	252	302
Furnace slag	255	455
Cement, natural and portland	1,719	1,973
Cement, other	67	59
Brick, common	88	98
Brick, other and building tile	141	158
Refractories	277	270
Artificial stone	59	82
Lime	636	635
Plaster, stucco and wall	86	91
Sewer pipe and drain tile	15	19
Broken brick and crockery	33	16
Gasoline	2,760	2,789
Fuel oil and petroleum oil	3,882	4,159
Lubricating oils and greases	342	360
Petroleum products, refined	1,131	1,469
Coke	1,764	1,941
Asphalt	326	330
Total	17,520	19,037
Total, all revenue freight	198,337	205,197
Fabricated minerals as a per cent of total freight	8.8	9.3

* Domestic and imported.

TABLE 57

Crude and Fabricated Minerals* Transported Through
Canadian Canals, 1963 and 1964
('000 short tons)

	1963	1964
Crude minerals		
Iron ore	20,815	28,911
Metallic ores and concentrates	239	395
Coal, bituminous	5,999	7,177
Crude petroleum	152	94
Clay and bentonite	286	302
Sand, gravel and crushed stone	1,249	1,306
Salt	634	683
Sulphur	172	170
Other crude materials	828	1,166
Total	30,374	40,204
Fabricated minerals		
Gasoline	562	661
Fuel oil	2,733	3,229
Lubricating oils and greases	217	172
Coke	475	530
Pig iron	265	511
Iron and steel: ingot, billet, etc.	358	539
Structural shapes and sheet piling	1,034	1,661
Iron and steel, other	440	357
Iron and steel, scrap	670	873
Cement	204	204
Total	6,958	8,737
Total crude and fabricated minerals	37,332	48,941
Total all freight transported	74,585	93,277
Per cent crude and fabricated minerals of total freight	50.1	52.5

* 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.

TABLE 58

Crude Minerals* and Fabricated Mineral Products*
Transported by Motor Transport **, 1964
('000 short tons)

	1964
Crude minerals	
Ores and concentrates	788
Coal	2,323
Sand and gravel	36,515
Stone, crude	7,535
Other crude nonmetallic minerals	6,290
Total	53,451
Fabricated minerals	
Gasoline	5,117
Fuel oil	5,007
Asphalt and road oil	3,904
Petroleum and coal products	5,850
Iron and steel and alloys and metal-fabricated basic products	4,380
Bricks, clay, building	53
Cement and concrete products	6,611
Miscellaneous nonmetallic mineral basic products	2,493
Total	33,415
Total crude and fabricated minerals	86,866
Grand total all products	183,190
Per cent crude and fabricated minerals of total freight	47.4

* Domestic and imported. ** Includes private and for hire intercity motor transport. Excludes freight carried by urban transport.

TABLE 59

Quantities* of Petroleum and Petroleum Products and
Gas (Manufactured and Natural) Transported by Pipeline

	Petroleum and Petroleum Products (millions of bbl)			Gas (000 Mcf)		
	Domestic Sales	Export Sales	Total	Domestic Sales	Export Sales	Total
1952	104.9	2.9	107.8	74,100e	7,958	82,058
1953	144.5	2.8	147.3	84,500e	9,408	93,908
1954	156.8	15.7	172.5	102,500e	6,984	109,484
1955	178.8	45.5	224.3	136,738	11,356	148,094
1956	215.6	59.3	274.9	163,764	10,828	174,592
1957	258.2	32.6	290.8	184,738	15,731	200,469
1958	239.3	35.5	274.8	211,751	86,973	298,726
1959	273.5	35.0	308.5	283,808	84,764	368,572
1960	274.2	41.8	316.0	326,212	91,046	417,258
1961	286.1	67.3	353.4	379,044	168,180	547,224
1962	300.9	86.6	387.5	421,631	319,566	741,197
1963	339.8	91.3	431.1	452,943	340,953	793,896
1964	355.7	104.2	459.9	505,145	404,143	909,288
1965	373.5	110.3	483.8	568,654	403,909	972,563

*Both domestic and imported. e Estimated.

TABLE 60

Taxes* Paid to Federal, Provincial and Municipal Governments in Canada by Six Important Divisions of the Mineral Industry, 1963
($)

	Federal Income Tax	Provincial Tax	Municipal Tax	Total
Auriferous-quartz mining	3,291,944	2,396,849	877,721	6,566,514
Copper-gold-silver mining	11,142,431	6,898,333	2,282,185	20,322,949
Silver-lead-zinc mining and smelting	12,148,708	6,977,108	1,394,896	20,520,712
Nickel-copper mining, smelting and refining	21,887,052	11,663,488	2,307,357	35,857,897
Iron mining	3,963,143	4,717,104	2,286,238	10,966,485
Asbestos mining	11,511,481	5,013,466	2,073,314	18,598,261
Total	63,944,759	37,666,348	11,221,711	112,832,818

* The above amounts refer only to payments actually made within the calendar year specified. These tax payments do not necessarily reflect the tax assessments of a calendar year. Included are taxes on non-operating revenue.

TABLE 61

Taxes* Paid by Six Important Divisions of the Canadian Mineral Industry 1958-63
($ millions)

	1958	1959	1960	1961	1962	1963
Auriferous-quartz mining	6.1	7.0	6.5	7.0	6.1	6.5
Copper-gold-silver mining	8.5	13.0	19.7	20.1	15.2	20.3
Silver-lead-zinc mining and smelting	10.8	12.2	15.3	15.7	17.7	20.5
Nickel copper mining, smelting and refining	22.4	12.1	41.0	38.2	51.6	35.9
Iron mining	7.1	4.4	6.6	5.6	7.5	11.0
Asbestos mining	11.4	12.1	14.2	16.8	18.4	18.6
Total	66.3	60.8	103.3	103.4	116.5	112.8

* The above amounts refer only to payments actually made within the calendar year specified. These tax payments do not necessarily reflect the tax assessments of a calendar year. Included are taxes on non-operating revenue.

TABLE 62

Federal Income Tax Declared by Companies
in Mining and Selected Related Manufacturing Industries
in Canada, Fiscal Years Ended March 31,
1962 and 1963
($ millions)

	1962	1963
Mining, quarrying and oil wells		
Gold mining	3.4	3.5
Other metal mining	50.6	55.4
Coal mines	0.6	0.8
Oil and natural gas	11.6	17.6
Other nonmetal mines	12.1	12.5
Quarries	1.3	1.5
Mining, unclassified	0.1	.2
Prospecting and contract drilling	2.8	4.2
Total	82.5	95.7
Metallurgical and metal-fabricating industries		
Iron and steel mills	32.0	40.5
Iron foundries	3.1	3.6
Metal smelting and refining	11.5	8.4
Boilers and fabricated structural material	1.6	2.5
Metal stamping, pressing, coating	8.2	10.1
Wire and wire products	3.8	4.0
Miscellaneous metal-fabricating	5.6	7.1
Total	65.8	76.2
Nonmetallic mineral products		
Cement, clay and stone products	17.4	17.4
Glass and nonmetallic minerals	10.3	9.7
Fertilizers and industrial chemicals	13.9	15.6
Total	41.6	42.7
Petroleum and coal products		
Petroleum refineries	39.7	30.6
Other petroleum and coal products	7.1	0.6
Total	46.8	31.2
Total mining and related industries	236.7	245.8
Grand total, all industries	1,363.3	1,446.7

TABLE 63

Capital and Repair Expenditure of the Canadian Mining Industry
($ million)

Metal	1964			1965[p]			1966[f]		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
Gold mines	7.1	9.6	16.7	6.1	8.4	14.5	5.8	8.0	13.8
Silver-lead-zinc mines	45.6	5.6	51.2	42.2	5.6	47.8	34.2	6.2	40.4
Iron mines	143.7	47.2	190.9	62.7	61.4	124.1	124.2	58.0	182.2
Other metal mines*	43.4	39.7	83.1	78.5	43.7	122.2	152.1	46.6	198.7
Total, metal mines	239.8	102.1	341.9	189.5	119.1	308.6	316.3	118.8	435.1
Nonmetal mines									
Quarries and sandpits	17.9	16.5	34.4	10.4	16.0	26.4	18.1	14.8	32.9
Other nonmetallic minerals	63.8	24.6	88.4	84.9	23.7	108.6	143.1	24.2	167.3
Total, nonmetal mines	81.7	41.1	122.8	95.3	39.7	135.0	161.2	39.0	200.2
Mineral fuels									
Coal mines	7.8	4.7	12.5	4.0	4.6	8.6	1.9	9.2	11.1
Petroleum and gas wells	262.7	24.6	287.3	364.7	25.0	389.7	402.3	23.6	425.9
Natural gas processing plants	40.6	5.1	45.7	33.7	5.3	39.0	54.0	5.4	59.4
Total, mineral fuels	311.1	34.4	345.5	402.4	34.9	437.3	458.2	38.2	496.4
Total, mining	632.6	177.6	810.2	687.2	193.7	880.9	935.7	196.0	1,131.7

* Includes copper-gold-silver, nickel-copper, silver-cobalt, uranium and other metal mines.
[p] Preliminary; [f] Forecast.

TABLE 64

Capital Investment in the Canadian Petroleum and Natural Gas Industries[1]
(millions of dollars)

	Exploration	Development and Production	Oil[5] Pipelines	Gas Transmission Pipelines	Gas Processing	Petroleum Refining	Marketing		Capital Investment in Canada	
							Oil[3]	Gas[4]	Petroleum and Natural Gas Industry	All Industries
1947	2	9.5	2.6	-	-	25.7	14.9	2.5	55.2	2,440
1948	2	37.3	4.3	-	-	32.6	9.7	3.8	87.7	3,087
1949	2	45.0	7.7	-	-	21.6	11.3	4.3	89.9	3,539
1950	2	53.9	55.0	-	-	24.1	16.7	6.6	156.3	3,936
1951	2	72.1	10.7	-	-	50.9	18.1	6.8	158.6	4,739
1952	59.8	101.6	91.9	2.7	1.3	60.5	25.0	6.3	349.1	5,491
1953	59.1	107.2	75.7	3.8	0.7	66.1	36.7	11.2	360.5	5,976
1954	55.1	126.8	63.5	1.6	8.5	83.9	46.3	9.7	395.4	5,721
1955	67.4	201.6	28.5	17.5	2.9	102.9	56.5	9.4	486.7	6,244
1956	73.7	252.4	43.5	133.6	10.5	79.1	68.5	46.6	707.9	8,034
1957	77.3	237.8	68.0	242.1	34.5	81.5	74.9	69.8	885.9	8,717
1958	62.4	181.5	23.6	214.8	40.1	94.9	63.6	79.4	760.3	8,364
1959	51.0	191.9	10.7	48.5	24.4	95.0	73.1	89.8	584.4	8,417
1960	50.4	209.1	18.3	80.6	19.4	59.2	68.1	62.9	568.0	8,262
1961	47.7	182.4	49.3	115.5	76.6	31.2	56.0	59.3	618.0	8,172
1962	53.9	182.7	20.8	51.4	21.8	64.8	47.7	69.3	512.4	8,715
1963	58.9	216.2	26.0	81.9	53.6	44.2	53.0	84.1	617.9	9,393
1964	59.7	262.7	29.0	135.1	40.6	23.9	48.3	68.3	667.6	10,944
1965[p]	58.4	364.7	50.3	60.5	33.7	38.2	56.7	73.9	736.4	12,798
1966[f]	59.2	402.3	37.8	65.4	54.0	69.1	84.8	83.3	855.9	14,546

[1]The petroleum and natural gas industries in this table include all companies engaged in whole or in part in oil and gas industry activities. The investment data under Petroleum and Natural Gas in Tables 65, 66, 67 apply only to companies whose main revenues are derived from oil and gas activities. [2]Capital investment in exploration prior to 1952 is included in the Development and Production column. [3]Capital investment in this item includes chiefly outlets reported by major companies. [4]Capital expenditures in gas marketing are for gas-distribution pipelines. [5]Capital investment in oil pipelines includes small expenditures for rail and water transport.
[p]Preliminary; [f]Forecast; - Nil.

TABLE 65

Ownership of Canadian Mining and Metallurgical Industries, Year's End 1961-63
($ millions)

	Estimated Total Investment	Investment Owned In Canada	U.S.A.	U.K.	Other
1961					
Petroleum and natural gas*	6,428	2,399	3,444	296	289
Mining, other	2,428	870	1,400	86	72
Smelting and refining non-ferrous ores	968	432	421	62	53
Iron and steel mills	873	614	165	65	29
1962					
Petroleum and natural gas*	6,922[r]	2,538[r]	3,662[r]	355	367[r]
Mining, other	2,595[r]	875[r]	1,562[r]	95	63[r]
Smelting and refining non-ferrous ores	1,042	465	436	89	52
Iron and steel mills	938	691	151	59	37
1963					
Petroleum and natural gas*	7,295	2,592	3,945	380	378
Mining, other	2,743	949	1,639	77	78
Smelting and refining non-ferrous ores	1,066	513	415	84	54
Iron and steel mills	874	696	70	65	43

[r] Revised

* Data apply to companies whose main revenues are derived from oil and gas activities.

TABLE 66

Estimated Book Value and Ownership of
Capital Employed in Selected Canadian Industries
1954 and 1961-63
($ billions)

	1954	1961	1962	1963
Total capital employed				
Manufacturing	8.3	12.7	13.1	13.7
Petroleum and natural gas*	2.5	6.4	6.9	7.3
Other mining and nonferrous smelting and refining	1.9	3.4	3.6	3.8
Railways	4.1	5.4	5.4	5.3
Other utilities	5.3	10.3	10.6	12.2
Merchandising and construction	6.1	9.4	9.5	9.8
Total	28.2	47.6	49.2	52.1
Resident owned capital				
Manufacturing	4.4	5.9	6.0	6.2
Petroleum and natural gas*	1.0	2.4	2.5	2.6
Other mining and nonferrous smelting and refining	0.9	1.3	1.3	1.5
Railways	2.7	4.0	4.1	4.1
Other utilities	4.6	9.0	9.2	10.6
Merchandising and construction	5.5	8.5	8.5	8.8
Total	19.1	31.1	31.8	33.8
Nonresident owned capital				
Manufacturing	3.9	6.8	7.1	7.4
Petroleum and natural gas*	1.5	4.0	4.4	4.7
Other mining and nonferrous smelting and refining	1.0	2.1	2.3	2.3
Railways	1.4	1.4	1.3	1.2
Other utilities	0.7	1.3	1.3	1.5
Merchandising and construction	0.6	0.9	1.0	1.0
Total	9.1	16.5	17.4	18.3

* The investment data under Petroleum and Natural Gas apply only to companies whose main revenues are derived from oil and gas activities.

Note: Owing to rounding, figures do not add to totals in all cases.

TABLE 67

Foreign Capital Invested in the Canadian Mineral Industry, Selected Years (End of Year) 1930-63
($ millions)

	Owned by All Non-residents		Owned by United States Residents	
	Mining and Nonferrous Smelting and refining	Petroleum and Natural Gas*	Mining and Nonferrous Smelting and refining	Petroleum and Natural Gas*
1930	311	150	234	147
1945	356[r]	160[r]	280	149
1955	1,121	1,854	975	1,716
1956	1,330	2,275	1,129	2,063
1957	1,570	2,849	1,307	2,570
1958	1,657	3,187	1,386	2,866
1959	1,783	3,455	1,513	3,108
1960	1,977	3,727	1,701	3,184
1961	2,094	4,029	1,821	3,444
1962	2,297[r]	4,384[r]	1,998[r]	3,662[r]
1963	2,347	4,703	2,054	3,945

* Data apply only to companies whose main revenues are derived from oil and gas activities. [r] Revised.

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