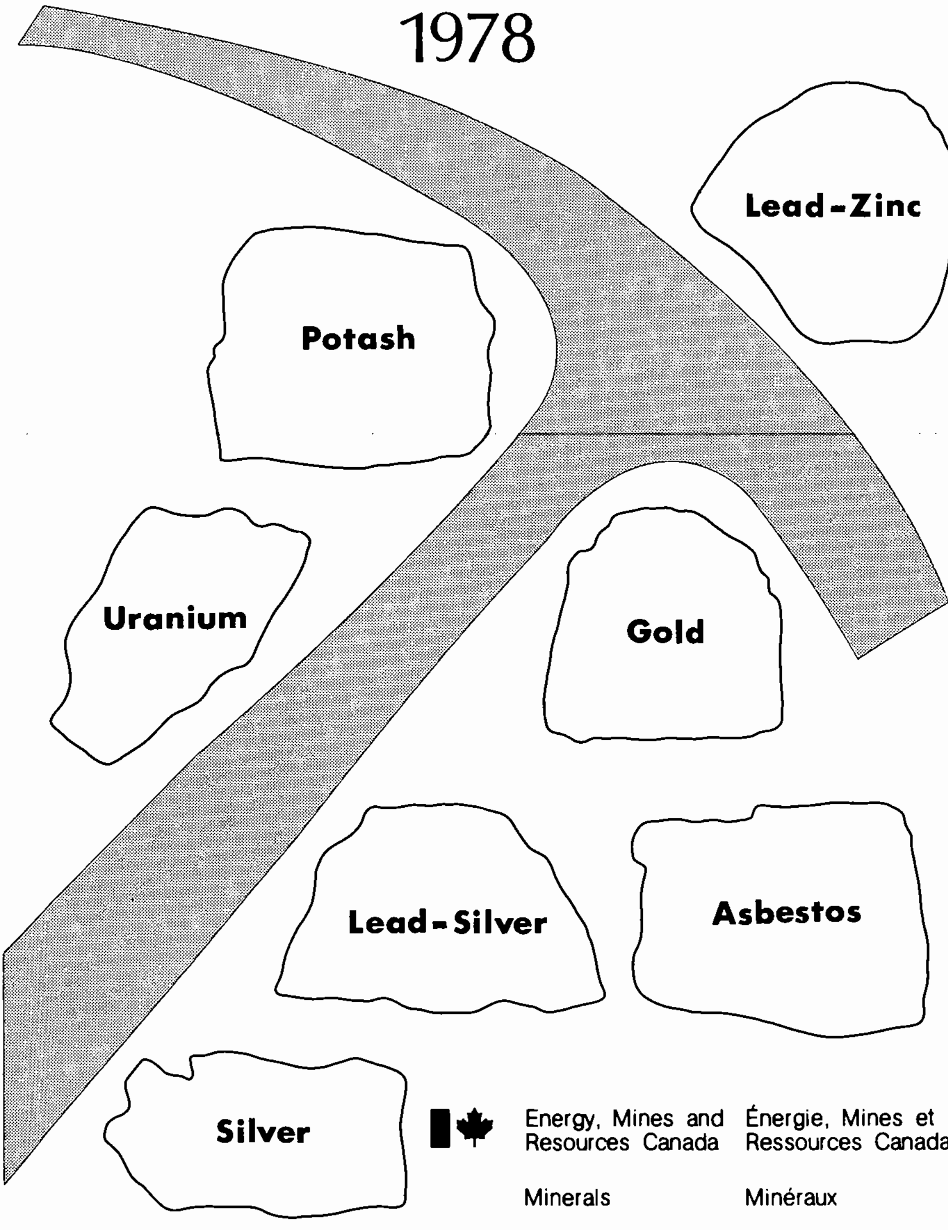
MINERAL REPORT 28

CANADIAN MINERALS YEARBOOK 1978



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

Minerals / Minéraux

Some metallic and nonmetallic ores that are mined in Canada.
Photos by Geological Survey of Canada.

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Foreword

This issue of the Canadian Minerals Yearbook is a comprehensive report of developments in the mineral industry during 1978. In order to provide information as early as possible to all interested persons, the 52 chapters dealing with individual commodities and all other chapters except the General Review were issued previously as Annual Mineral Reviews, 1978. The General Review deals with the main events and trends in the Canadian economy during the year, as well as overall developments in the mineral industry. The Company Index lists the accurate full names of all companies mentioned in the text and the page number of each mention, thus providing a complete cross-reference to the activities of companies engaged in the Canadian mineral industry. The text is also supported by pocket map 900A, Principal Mineral Areas of Canada.

The Canadian Minerals Yearbook has been published under that title, or other titles, since 1886 and is the permanent official record of the mineral industry in Canada. Those wishing to refer to previous Yearbooks or reports should consult departmental catalogues, available in most libraries.

The basic statistics on Canadian production, trade and consumption were collected by the Information Systems Division, Energy, Mines and Resources Canada, and by Statistics Canada, unless otherwise stated. Company data were obtained by the authors directly from company officials though surveys or correspondence, or from corporate annual reports. Market quotations are mainly from standard marketing reports.

Energy, Mines and Resources Canada is grateful to all those who contributed information necessary to compile this report.

October, 1980

Editor: R.B. Abbott
Assistant Editor: N.G. Bruce
Graphics and Cover: N. Sabolotny

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Readers wishing more recent information than that contained in this volume should obtain the 1979 series of mineral reviews: a complete set costs $48 in Canada and $57.60 in other countries, while individual copies sell for $1.00 in Canada and $1.20 in other countries. They may be ordered from Canadian Government Publishing Centre, Supply and Services Canada, Hull, Quebec Canada K1A 0S9. Prices subject to change without notice.

Front End Leaf
Located on Lake Ontario near Pickering, Ontario, the Pickering A and B nuclear generating stations of Ontario Hydro are important contributors to the province's pool of electrical energy. (Ontario Hydro photo).

Frontispiece
A huge bucket-wheel excavator of Great Canadian Oil Sands Limited (GCOS) digs tar sand from an open-pit bank at its operation near Fort McMurray, Alberta. The supply belt in front transports the material to the extraction plant visible in the background where the oil is separated from the sand. (Alberta Government Services photo).

Contents

Conversion Factors

Imperial units to Metric (SI) Units

Ounces to grams	x	28.349 523
Troy ounces to grams	x	31.103 476 8
to kilograms	x	.031 103 476
Pounds to kilograms	x	.453 592 37
Short tons to tonnes	x	.907 184 74
Gallons to litres	x	4.546 09
Barrels to cubic metres	x	.158 987 220
Cubic feet to cubic metres	x	.028 316 85

Source: *Canadian Metric Practice Guide*.

General Review

L.K. TIBBO

The Canadian Economy in 1978

While economic activity continued to expand throughout the world, that rate of expansion or growth was below the level achieved in the 1960s. All major Western industrialized countries were faced with high levels of unemployment, sharply rising energy costs and other strong inflationary pressures, effectively restraining any surge in economic activity.

The Canadian economy, heavily dependent on the industrialized world for external trade, experienced the negative impact associated with slow growth in the rest of the world. At the close of 1978 foreign markets had not yet

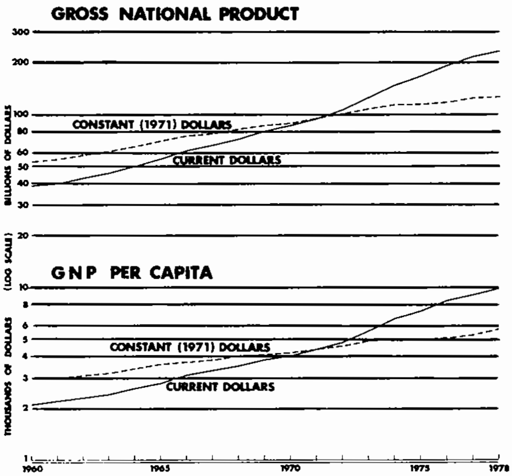


Figure 1

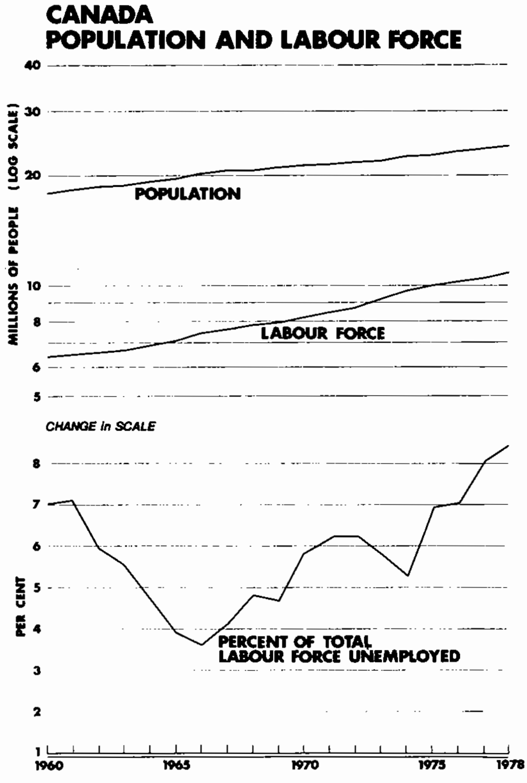


Figure 2

Statistical data were compiled by the Information Systems Division, Mineral Policy Sector, Energy, Mines and Resources Canada, from information provided by Statistics Canada.

fully recovered from the 1974-75 recession and most economists agreed that average annual growth rates of 5 to 6 per cent achieved in Canada during the 1961-74 period would not be reached in the next few years. The rate of growth for Gross National Product in constant 1971 dollars was 3.3 per cent, an improvement over the 1977 rate of 2.3 per cent but much lower than the 5.1 experienced in 1976. In current dollars, GNP reached $230 billion in 1978, which on a per capita basis represented $9,810, up from $9,000 the previous year. Real Domestic Product (RDP), a measure of the physical volume of output in constant dollars, indicated modest levels of growth in the major sectors of manufacturing, construction and agriculture but a decline in mining. The index for the total economy rose from 129.7 in 1977 to 134.3 in 1978, a change of 3.4 per cent, while mining at 106.9 was at its lowest level since 1972.

Another indicator of a weak economic performance in 1978 relative to the years prior to the energy crisis was the rising level of unemployment. Of a total labour force of 10.9 million, 8.4 per cent were unemployed, almost double the rate ten years earlier.

Total exports of goods and services climbed to $52.5 billion during the year – an encouraging sign – but closer examination revealed a poor performance on the services side. Even though the total merchandise trade surplus reached more than $3 billion, the nonmerchandise trade balance showed a deficit of almost $9 billion. Nonmerchandise imports continued a steady increase, almost doubling the level of equivalent exports, contributing to a dangerously high balance-of-payments deficit on the current account. That deficit was $1.5 billion in 1974 compared with $5.3 billion in 1978.

Total investment in the Canadian economy in 1978 amounted to $64.4 billion, an increase of 10.7 per cent from 1977. Of that total, the manufacturing sector showed a value of $9.6 billion, (up 7.3 per cent) agriculture and fishing, $4.3 billion, (up 16.2 per cent) and mining, quarrying and oil wells $5.1 billion, (down 4.2 per cent)

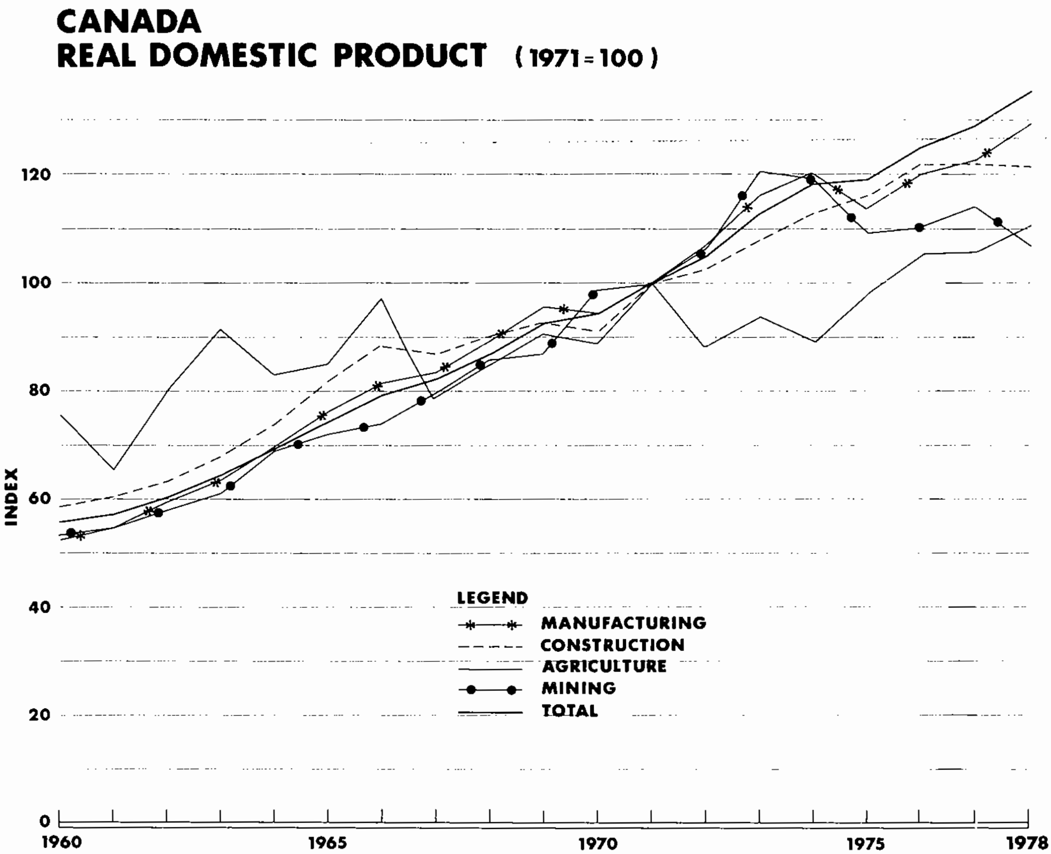
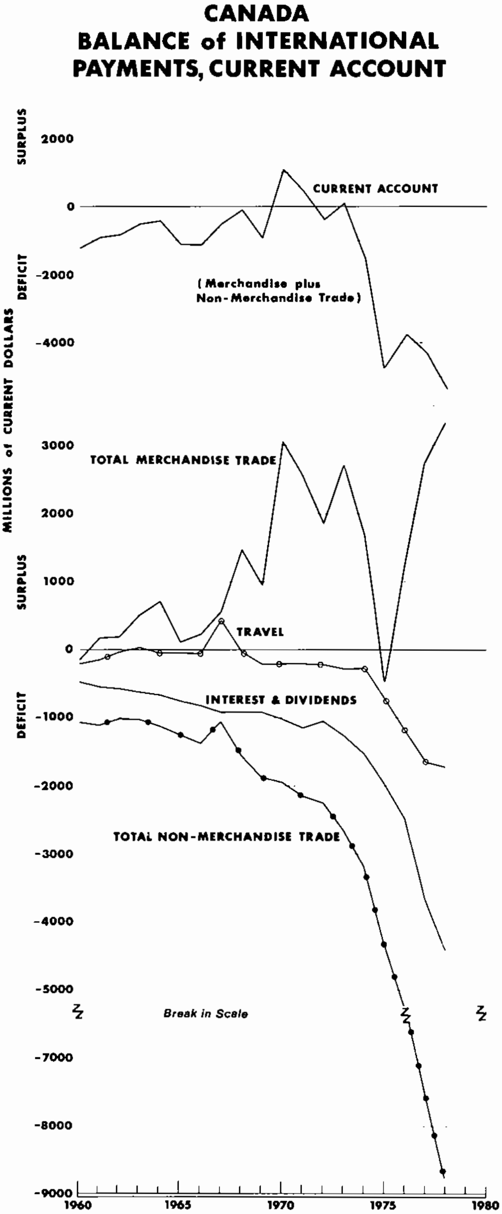


Figure 3

from the previous year.

In general, the economy did show improvement over 1977 in most sectors but recovery from the 1974-75 recession has not been fully achieved, nor can it be expected to show strength while other industrial countries suffer from similar problems of unemployment, inflation and balance-of-payments deficits. Recovery paths appeared to be slow



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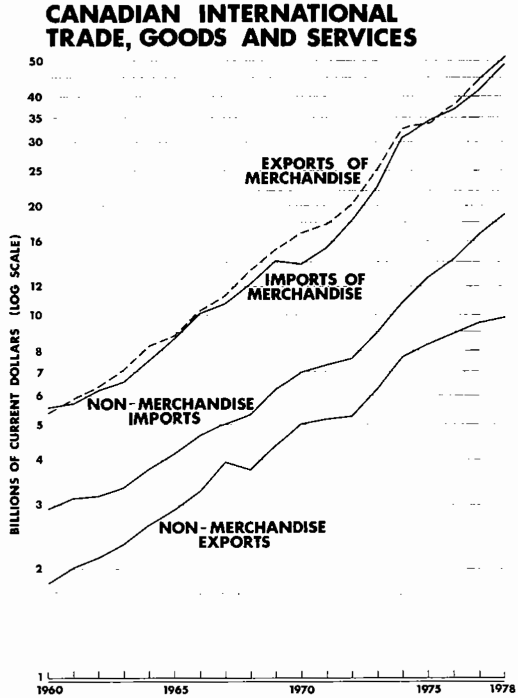

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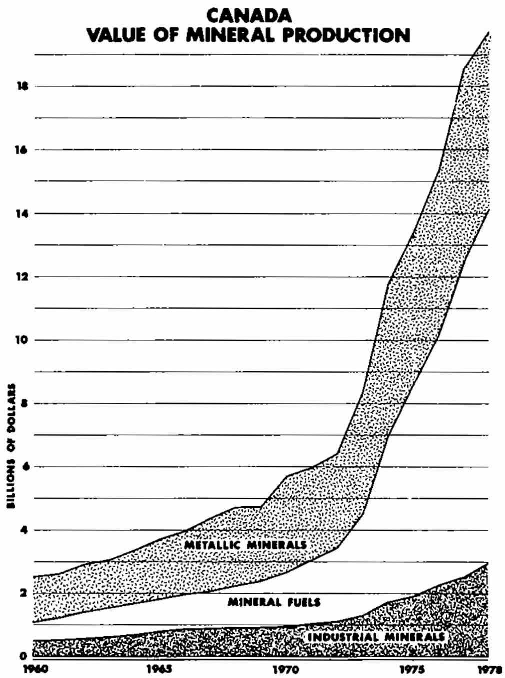


Figure 6

throughout the world with no strong stimulus foreseen in the near future.

The Canadian Mineral Industry in 1978

Compared with other sectors of the economy, mining had a somewhat dismal year. Total value of mineral production was $19.7 billion, up from $18.5 billion in 1977, with the increase attributable to the fuel component. The value of metallic mineral production declined 7.8 per cent from the previous year; from $5,988 million to $5,520 million in 1978. Nonmetallic mineral production increased 14.1 per cent to $1,554 million and structural materials increased 8.5 per cent to $1,355 million. The nonfuel mining industry showed an overall decline of 2 per cent in value of output during the year. On the fuel side, value of output increased substantially. Coal, natural gas and crude oil recorded increases in value of 20.3 per cent, 13.4 per cent and 16.2 per cent, respectively, even though volume of production was down in natural gas (3.7 per cent) and crude oil (2.6 per cent). Of the major metallic commodities, copper showed a decrease of 13.4 per cent in volume and 7.2 per cent in value, iron ore was down 26.1 per cent in volume and 16.4 per cent in value, nickel was down 44.0 per cent in volume and 46.2 per cent in value and zinc was down 3.6 per cent in volume and 5.7 per cent in value. Contributing factors to these declines included a serious world over-supply of these

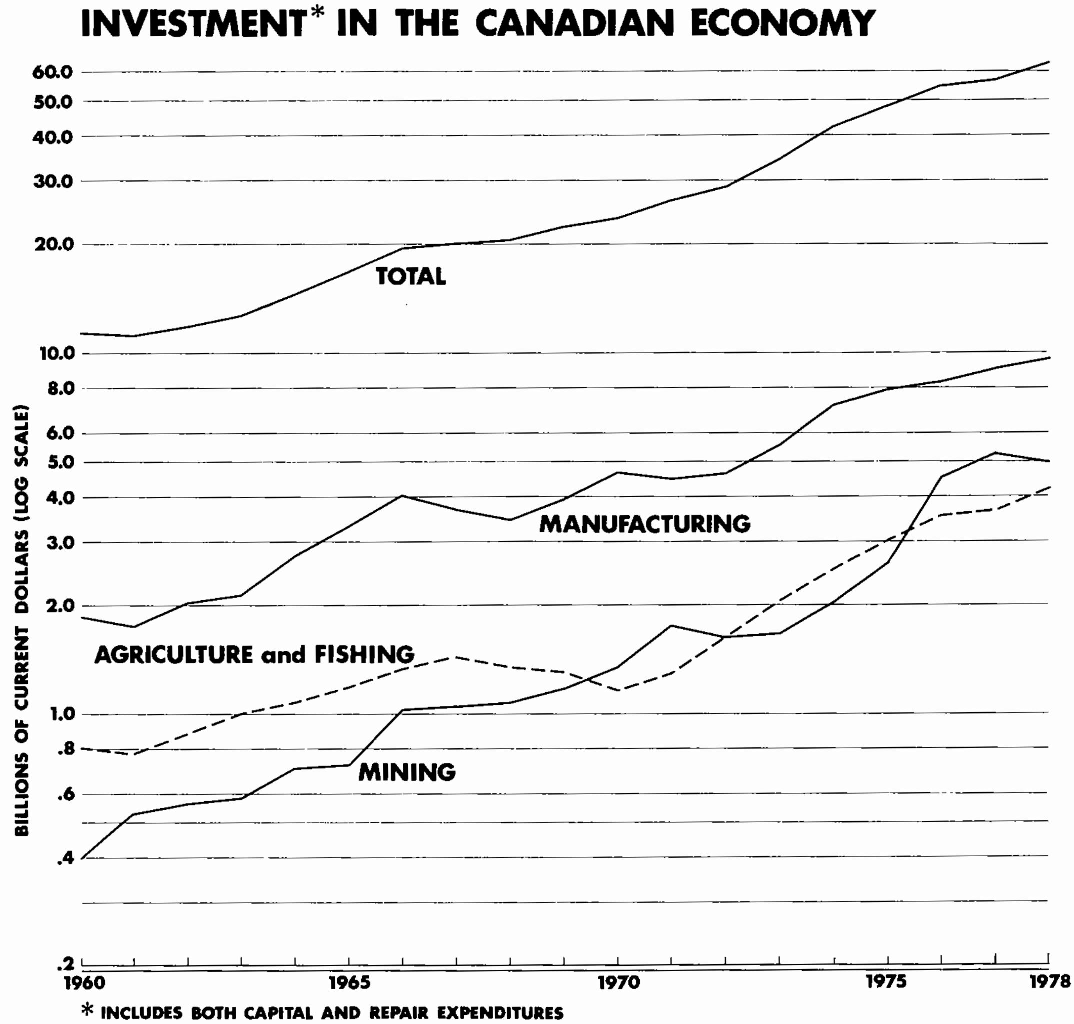
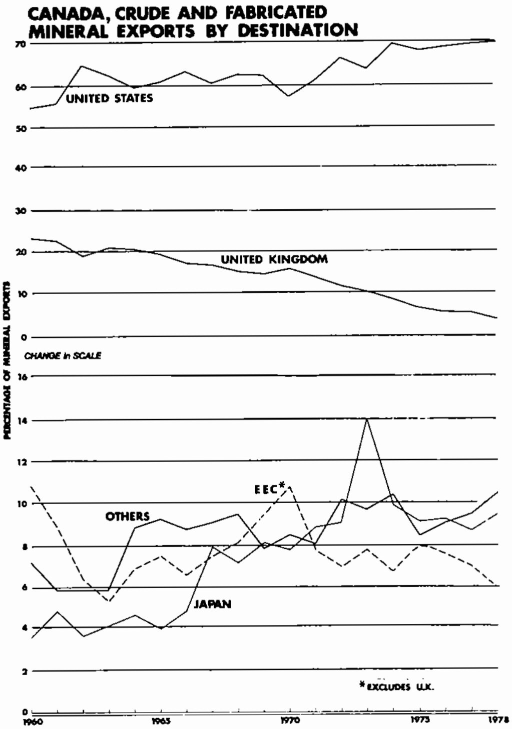


Figure 7

commodities at the beginning of the year, causing drastic downward fluctuations in prices, and industry-wide labour disputes in some of the major mining operations. In the copper industry there were voluntary production cutbacks to correct the position of over-supply, while strikes at Inco Limited's Sudbury operations and Gaspé Copper Mines, Limited resulted in large production losses by the end of the year. The nickel and zinc industries were plagued by similar problems, being subjected to wide price fluctuations on world markets. Canadian zinc producers, some of the largest in the world, suffered through a very difficult period from mid-1977 to mid-1978, operating at a loss at some points.

Production of iron ore was sharply reduced to 39 622 000 tonnes in 1978 compared with almost 54 000 000 tonnes the previous year, due mainly to a four-month labour dispute at the Quebec-Labrador mines and shipping problems through the Great Lakes.

Of the metallic minerals, the lead industry was one of the few in which depressed conditions did not prevail. For the third consecutive year world demand for lead exceeded supply. Canadian mine production increased 14 per cent, reaching its highest level since 1970. The precious metals also showed improvement over the period with prices rising. Volume did not increase significantly but the price of gold at $U.S. 243.65 was a record high in the last quarter of 1978. The price of platinum reached a high of



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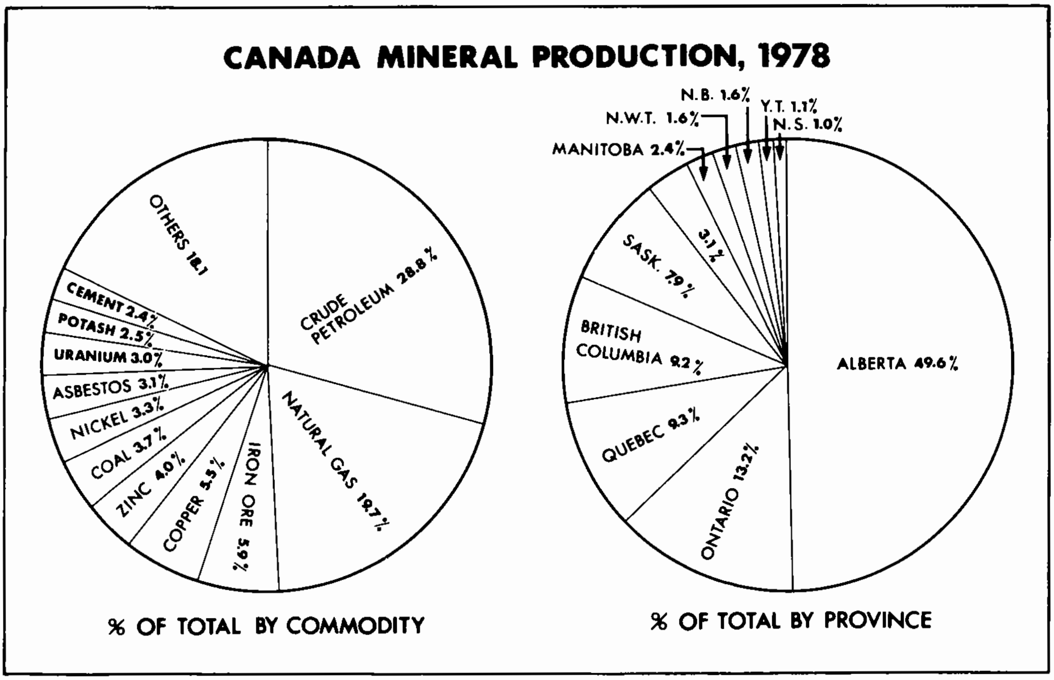

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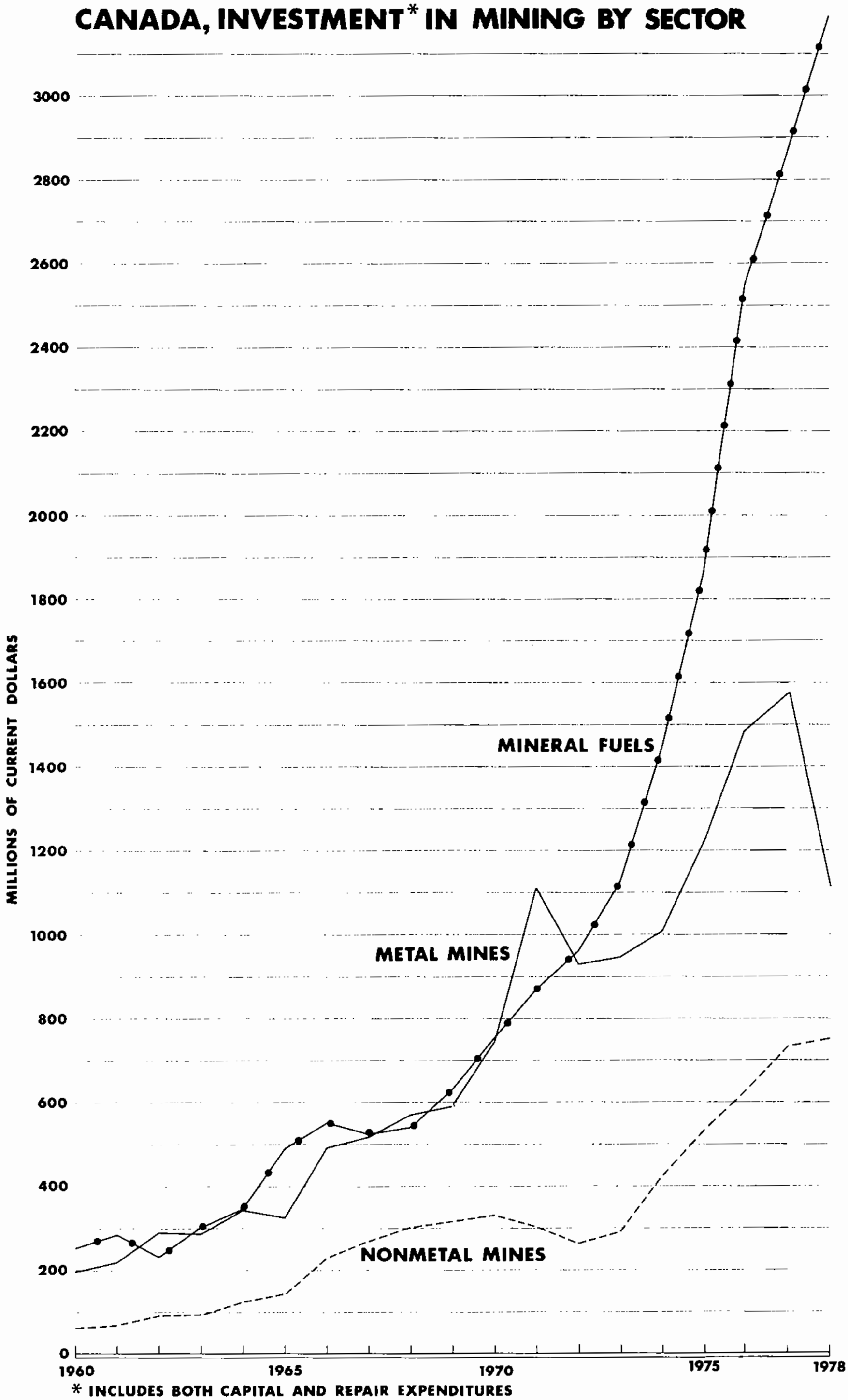


CANADA, INVESTMENT* IN MINING BY SECTOR
MILLIONS OF CURRENT DOLLARS
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
MINERAL FUELS
METAL MINES
NONMETAL MINES
1960
1965
1970
1975
1978
* INCLUDES BOTH CAPITAL AND REPAIR EXPENDITURES

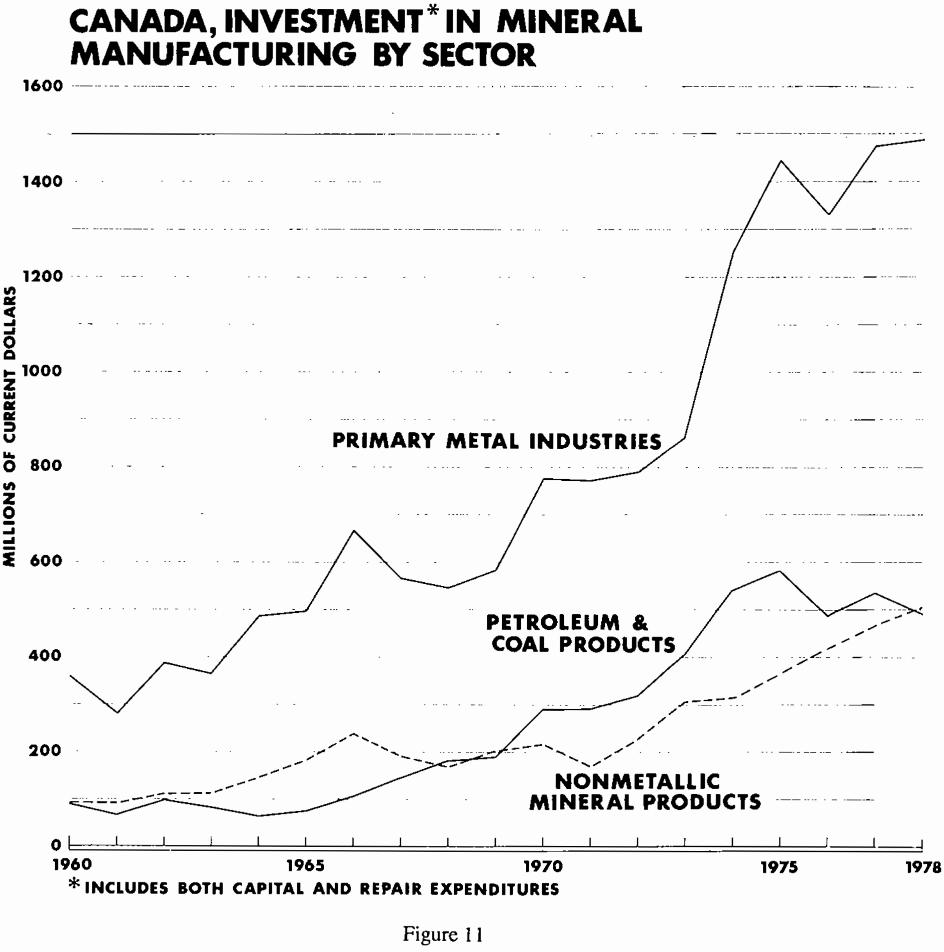
Figure 10

$U.S. 372.00 per ounce during the same period and silver reached more than $U.S. 6.00 by the end of the year.

On the nonmetallic side, the output of potash was up 10 per cent from the previous year, reaching 6 375 000 tonnes. Potash Corporation of Saskatchewan, through acquisitions in the province, became the largest producer in Canada. Volume of asbestos output was down in 1978 and the industry was affected by inquiries and proposals by various governments throughout the world concerning health hazards and pollution problems. The industry could face serious difficulties in the near future as new technology provides substitutes for the commodity.

In the world markets, Canadian exports of crude and fabricated materials increased slightly over 1977, from $13,158.8 million to $14,502.6 million. Crude mineral exports were down, due to labour and supply problems but domestic producers and exporters were able to maintain their share of world mineral markets overall. Exports of fabricated products were up, contributing to the total increase. At the same time, imports of equivalent goods increased considerably; from $7,498.8 million in 1977 to $8,733.5 million in 1978.

Faced with an environment of increased competition from abroad for all mineral-based commodities from crude ore to fully fabricated products, coupled with a decline in overall worldwide demand for minerals, the Canadian industry more than survived and did show modest growth. However, in order to maintain this competitive position and improve on it, much higher levels of spending will be necessary in areas of exploration and development. The nonfuel mining industry was one major sector of the economy that did not attract higher levels of investment in 1978. This year did see a sharp reduction in inventories for most major commodities, clearing the way for rising prices in the near future. A turn-around in world economic conditions could bring improvement in demand for minerals and the potential exists to provide much greater returns to mining and the Canadian economy as a whole.



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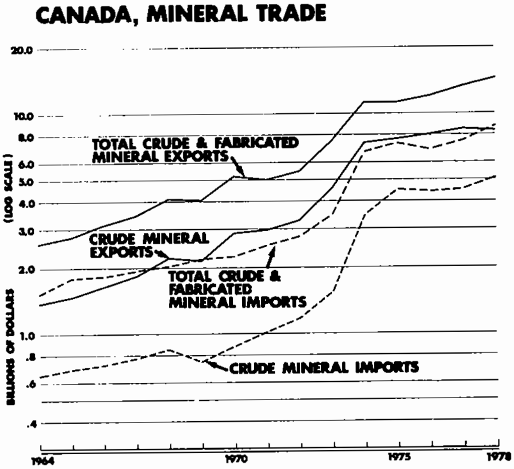

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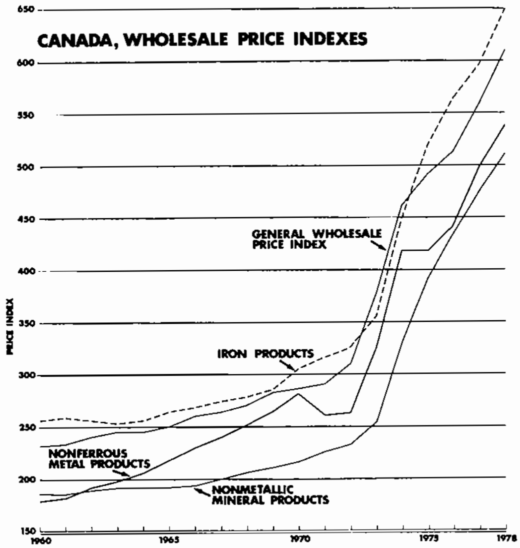

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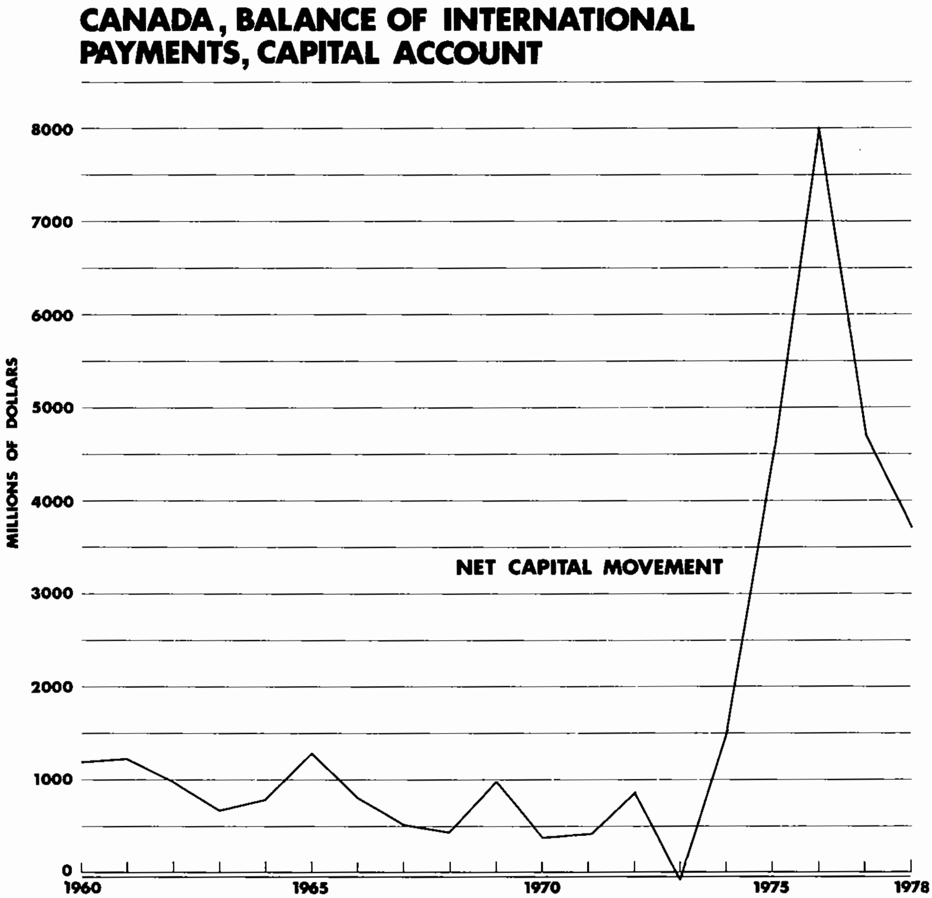

Figure 14

Regional Review
Canadian Mineral Industry

P.W. ANDREWS

Mining contributes substantially to the Canadian economy. The value of mining production, including fuels, over the past five years has averaged about 8 per cent of Gross National Product (GNP). The value of domestic mineral production for 1978 was $19.6 billion, equivalent to 8.3 per cent of GNP. Mineral exports (including fuels) valued at $14.6 billion accounted for just over 27.6 per cent of the value of all exports in 1978. Mineral imports for the year amounted to $8.1 billion, 16.2 per cent of all imports in 1978.

For the same five-year period, in terms of direct employment creation, the contribution of the mineral industry, including primary processing, was at just under 3 per cent of total Canadian employment. In a regional context, however, mining is an important source of work and the industry may often be the primary or sole creator of jobs in a particular area.

Provincial mineral activities

Newfoundland and Labrador

Leading minerals	Value of 1978 production	% change from 1977
	($ million)	
Iron ore	505.0	−32.0
Zinc	41.1	+1.1
Copper	18.2	+30.3

Among the provinces, Newfoundland is second only to Alberta in its dependency on minerals for its economic well-being. A substantial portion of the province's total employment is dependent on mining – more specifically, iron ore mining.

A four-month strike in 1978 (affecting about 11 000 workers in the Quebec-Labrador iron ore mines) caused Newfoundland's iron ore production to fall almost one-third in value from the previous year.

Other producers were also affected by labour disputes. In February, 510 workers at Advocate Mines Limited asbestos operations at Baie Verte went on strike in support of health and safety demands. The conflict received national attention and was resolved on May 20, 1978.

At St. Lawrence early in the year the Aluminum Company of Canada, Limited terminated its fluorspar mining operation which was the town's major employer. At its peak the mine employed about 400 workers.

At Buchans, another single-industry mining community, ASARCO Incorporated's lead-zinc mine continued to wind down its operations throughout the year. Established 50 years ago, the mine is scheduled to close in 1979. About 510 people are employed. In summary, mining employment in Newfoundland in 1978 was at the lowest level it has been over the past five years.

In response to mine closures the government announced its intention to introduce an amendment to the Mineral Act which would provide for mining rights to revert to the Crown either five years after production has ceased or by December 31, 1982 whichever is later.

In order to generate further mining activity within the province, funding of geological mapping and geochemical surveys under the Canada/Newfoundland Mineral Development Subsidiary Agreement continued throughout 1978.

A resumption of offshore exploration for oil and gas took place in 1978. No activity had been permitted in 1977 while the province prepared its position. In 1978, the Minister of Mines and Energy issued a set of guidelines and procedures his department will follow in the administration of certain sections of the oil and gas regulations. The resumption of exploration could create as many as 500 local jobs.

Prince Edward Island

Leading minerals	Value of 1978 production	% change from 1977
	($ million)	
Sand and gravel	1.9	+2.0

Prince Edward Island continues to be the smallest mineral producer in Canada. Sand and gravel was the sole contributor to the province's mining industry in 1978.

The region's economy was the least dependent on mineral resources of all the provinces.

Nova Scotia

Leading minerals	Value of 1978 production	% change from 1977
	($ million)	
Coal	113.6	+46.4
Gypsum	23.6	+13.6
Salt	19.2	+10.3
Sand and gravel	18.5	+1.5

The development of Nova Scotia's coal resources received a high priority during the year reflecting its option to use coal as the chief fuel for future electrical generation. Coal dominated the province's mining industry in 1978, accounting for 55.8 per cent of the value of total mineral output.

The Cape Breton Development Corporation (Devco), which accounts for roughly 95 per cent of the province's coal production, obtained approval in principle from the federal cabinet for a five-year, $265 million plan to develop a new coal mine in the Donkin area (where offshore drilling has indicated extensive coal seams), to rehabilitate the No. 26 colliery at Glace Bay, and to improve coal transportation, shipping and storage facilities. Final approval is subject to the results of feasibility studies launched early in 1978.

Devco's coal production at the Prince Colliery, which started only two years ago, was terminated because of technical problems. The 300 affected workers were offered employment at other Devco operations.

The provincial Crown corporation, Sydney Steel Corporation (Sysco) arranged for a series of sales agreements in 1978 which may add a new impetus to this financially hard-pressed company and help create much-needed employment in Cape Breton.

Esso Minerals Canada announced during the year that it will begin developing a zinc-lead mine at Gays River, 48 kilometres northeast of Halifax. At its peak the $27 million project will employ more than 200 construction workers and the permanent workforce is expected to be around 150. The project will be completed in the fall of 1979 and will be the province's first major metal mining operation in 30 years.

Exploration for coal received renewed emphasis both onshore and offshore in the final years of the 1974-79 Canada-Nova Scotia Subsidiary Agreement for Mineral Development. Mining employment in Nova Scotia reached a five-year high during 1978.

New Brunswick

Leading minerals	Value of 1978 production	% change from 1977
	($ million)	
Zinc	131.5	−10.8
Lead	57.5	+49.3
Silver	35.4	+47.4
Copper	17.6	−4.6

Depressed markets for zinc, the province's dominant commodity (accounting for 42.9 per cent of its mineral production value in 1978), dampened growth in mineral revenues to only 5.8 per cent. Mining employment has remained relatively stable in New Brunswick during the past five years.

New Brunswick's mining industry is diversifying away from its traditional nonferrous commodities. Potash Company of America is developing the country's first potash mine outside Saskatchewan, and the International Minerals & Chemical Corporation (Canada) Limited announced that it had confirmed high grade potash deposits at its Salt Springs exploration project.

The announcement by Consolidated Durham Mines & Resources Limited that uranium was found in association with its antimony-bearing veins resulted in a flurry of exploration activity in 1978.

Mineral development activity continued to be supported by the $11.3 million Canada-New Brunswick Subsidiary Agreement for Minerals and Fuels (1976-81). The main objective of the program is to build up a geoscientific data base and to develop appropriate methods for processing the complex base metal deposits found in New Brunswick.

Quebec

Leading minerals	Value of 1978 production	% change from 1977
	($ million)	
Asbestos	509.4	+22.4
Iron ore	338.9	+0.2
Stone	183.6	+3.8
Copper	145.5	−13.4

The relatively good performance of Quebec's mineral industry in 1978 was due to substantial increases from 1977 values in the production of minor commodities such as titanium dioxide (42 per cent), gold (35 per cent) and cement (19 per cent).

Major developments during 1978 focussed, however, on asbestos and iron ore. In seeking a greater share of the benefits associated with its asbestos resources, the Quebec government passed Bill 70 which created la Société nationale de l'amiante. This Crown corporation is to become involved in research, development, exploitation, marketing, manufacturing and commercial activities related to the further processing of fibre in Quebec. To provide the groundwork for the société, the Bureau de l'Amiante was created and officially began to function as of January 1978. The Quebec government supported various research and pilot projects related to asbestos product manufacturing.

In December 1978, Finance Minister Parizeau tabled a bill in the National Assembly that would give the government the power to expropriate the assets of the province's largest nonintegrated asbestos producer, Asbestos Corporation Limited, and its Quebec subsidiaries.

During 1978 most of Quebec's asbestos producers were affected by strikes. While most companies were shut down a relatively short time (one week), employees of Carey-

Canadian Mines Ltd. remained off the job from April to August.

The installation of environmental control equipment continued in most asbestos mills throughout the year.

Labour disputes were also responsible for the closure of the large iron ore mines and pelletizing plants in the northeast part of the province. Over 11 000 workers in the Quebec-Labrador iron mining district were off the job for four months during the year, creating strains on the region's economy, the revenues of the affected companies and mineral export earnings.

Other significant labour disputes took place at The Steel Company of Canada, Limited's (Stelco's) Contrecoeur steel plant, Gaspé Copper Mines, Limited at Murdochville, Alcan Smelters and Chemicals Limited's Beauharnois operations, and Alcan's Arvida works.

Weak markets for copper and zinc during 1978 prompted the Quebec government to provide financial assistance to Orchan Mines Limited and Campbell Chibougamau Mines Ltd. to permit continued production and employment.

At Mattagami Lake Mines Limited, Matagami, ore reserves, output, and employment continued to fall in 1978. No new discoveries have been made recently and the number of workers declined from a peak of about 470, to 370 in May 1978.

In contrast, the high price of gold during 1978 provided the incentive for mining companies to assess the feasibility of bringing back into production previously abandoned gold mines. Two such mines; Darius Gold Mines Inc. and Thompson Bousquet Gold Mines, Ltd., which together employ about 150 workers, started production in the Cadillac area. The Chadbourne property near Noranda is also being prepared for production startup in 1979 and it is expected that about 50 jobs will be created.

In summary, Quebec's mining employment in 1978 was at its lowest level of the past five years. In order to stimulate further mineral resource developments in the province's northwest, the Quebec government initiated a five-year, $65-million support program in fiscal year 1977-78. The program has supported mining road construction as well as geoscientific work. In addition, funds were available for joint exploration agreements, development projects, and assistance to prospectors and small exploration companies.

Another support program is the five-year, $28.6 million, Canada-Quebec Sub-Agreement for Mineral Development focussing on access road construction and geoscientific works.

Ontario

Leading minerals	Value of 1978 production	%change from 1977
	($ million)	
Nickel	489.6	−47.2
Uranium	341.1	+36.1
Copper	318.8	−25.5
Iron ore	295.4	+2.7
Zinc	195.3	−15.6

With the exception of uranium, Ontario's mining industry had a lacklustre year, due largely to a strike at Inco Limited's (Inco's) Sudbury operations involving some 11 500 workers. The walkout, which started in mid-September 1978, was not resolved at year-end. The shutdown in Sudbury forced a temporary closure of Inco's Shebandowan mining and concentrating operation, directly affecting about 215 jobs.

The northern Ontario town of Atikokan faces a precarious future because its two major employers; Steep Rock Iron Mines Limited (550 workers in September 1978) and Caland Ore Company Limited (475 workers in September 1978), have announced plans to close down all, or part, of their operations sometime in 1979. The Ontario iron mining industry was dealt a further setback with the closure of the Marmoraton Mining Company Ltd. operations at Marmora at the end of March 1978, with about 275 jobs being eliminated.

In March 1978, the Langmuir mine of Noranda Mines Limited, located near Timmins, suspended operations because of high nickel inventories. About 110 employees were affected.

In contrast, Texasgulf Canada Ltd. announced that it will complete the $400 million mine-concentrator expansion and new copper smelter-refinery complex at Kidd Creek. The No. 2 mineshaft was completed in November 1978 and a 35 per cent increase in mine output is expected by 1981. At that time the concentrator expansion and construction of the smelter-refinery will be finished and about 275 additional workers will be employed.

At Elliot Lake, Rio Algom Limited and Denison Mines Limited have undertaken major expansion projects to increase uranium production to meet long-term contract obligations. It is anticipated that more than 3 500 jobs will be created by 1984 when the expansions are completed.

The province's gold mines enjoyed a prosperous year in 1978 due to high prices for the precious metal. The value of Ontario's gold production increased almost 35 per cent from 1977, to $156.5 million. Gold properties in the northeast enjoyed renewed activity and many are being examined for production possibilities.

In spite of these positive developments, employment in Ontario's mining industry reached a five-year low in 1978 due to weak market conditions and labour-related problems.

In other developments, the Ontario Workmen's Compensation Board granted the world's first compensation for larygeal cancer to an 18-year employee of Inco's Copper Cliff operations.

Manitoba

Leading minerals	Value of 1978 production	% change from 1977
	($ million)	
Nickel	162.4	−43.0
Copper	99.4	+7.9
Zinc	43.9	−8.9
Crude petroleum	43.6	+7.9

Mining continued to remain a sluggish sector of the Manitoba economy during 1978 due to continued weakness in markets for nickel, copper and zinc. Among the communities that rely on mining, Thompson underwent some stress due to the substantial reduction in the workforce at Inco (achieved through attrition) of some 650 employees in the latter part of 1977 and early 1978. The mines were also closed for a two week period in July to reduce inventories.

On a positive note: near Flin Flon, Hudson Bay Mining and Smelting Co. Limited officially opened its new West Arm Mine (copper-zinc), as well as a new concentrator in the Snow Lake area.

Manitoba opened provincial Crown-owned oil and gas exploration rights to sale by tender in an effort to stimulate increased exploration. The province produced 593 000 cubic metres (m^3) of crude petroleum in 1978, down about 37 700 m^3 from 1977. However, the value of production increased by almost 8 per cent in 1978 compared with 1977.

The Manitoba government regulation which required exploration companies to file their proposals was suspended. The government no longer enjoys the option of entering into joint venture agreements with the private sector.

Saskatchewan

Leading minerals	Value of production	% change from 1977
	($ million)	
Crude petroleum	688.3	+18.5
Potash	493.0	+22.1
Uranium	247.6	+151.3

The impact of the mineral industry on the provincial economy continues to intensify. Mining employment has increased from 4 900 in 1973 to 6 900 in 1978. Value of minerals production tripled over the same period. All of Canada's potash and just over 40 per cent of its uranium originates in Saskatchewan.

Saskatchewan production of crude petroleum declined slightly in 1978 to 9.66 million m^3 from 9.77 million m^3 in 1977. However, price increases caused the value of that production to increase by 18.5 per cent.

The Potash Corporation of Saskatchewan (PCS) purchased two more mines in 1978; AMAX Potash Limited and APM Operators Ltd. These acquisitions increased the Crown corporation's share of provincial potash capacity to nearly one-half. PCS also announced intentions to expand facilities at its Cory, Rocanville and Lanigan divisions. At Lanigan, the mill will be shut down for about six months but all employees will be retained.

In a suit launched originally by Central Canada Potash Co. Limited against Saskatchewan, the Supreme Court of Canada ruled on October 3, 1978 that the province's prorationing scheme was unconstitutional. In another legal dispute, five companies have challenged the constitutionality of the province's potash reserve tax. Judgment has been reserved.

Following the release of a report by the Cluff Lake Board of Inquiry headed by Justice E.D. Bayda, Premier Blakeney announced that the mining and milling of uranium ores could proceed at Cluff Lake in northern Saskatchewan, subject to strict conditions related to environmental protection, the health and safety of workers, and employment and business opportunities for northern residents. A $130 million project by Amok Ltd. is expected to begin producing by 1980 at an initial rate of 1 000 tonnes* of elemental uranium, increasing to an eventual annual rate of 1 500 tonnes.

A consortium headed by Uranerz Exploration and Mining Limited is proceeding rapidly with the development of a uranium property at Key Lake, with production planned for early 1982.

In the fall of 1978 the Imperial Oil Limited group announced the discovery of what may be the world's largest uranium deposit at Midwest Lake in northern Saskatchewan. More than 25 companies have been exploring for uranium in this region.

The expansion of existing mining and milling facilities at Eldorado Nuclear Limited's Beaverlodge operations continued during the year. The company's goal is to increase capacity by 75 per cent by 1981.

In September the Saskatchewan government released its coal policy which reaffirmed the province's commitment to coal as an energy source. In developing its resources the government will pay special attention to maximizing benefits to the province by the realization of five basic objectives: (1) security of energy supply; (2) economic benefits; (3) social benefits; (4) environmental protection; (5) research and development.

Alberta

Leading minerals	Value of 1978 production	% change from 1977
	($ million)	
Crude petroleum	4 784.5	+16.6
Natural gas	3 557.8	+14.4
Natural gas byproducts	928.6	−1.3
Coal	240.6	+14.4

Alberta was the most dependent of all the provinces on mineral production in 1978 in terms of revenue and employment. Value of mineral production grew remarkably over the last five years – from $2 760 million in 1973 to $9 749 million in 1978. The growth in mining employment was also substantial, with 38 500 employed in 1978, compared with 23 600 in 1973. The province accounts for most of Canada's crude petroleum and natural gas output. Both crude petroleum and natural gas production declined slightly in volume in 1978 compared with 1977, but the value of this production showed substantial increases. Coal production was relatively insignificant compared with other

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

hydrocarbons, accounting for 2.5 per cent of the province's total value of mineral output in 1978. In national terms, however, Alberta is a major coal province, producing about one-third of Canada's total output.

Demand for coking coal was sluggish during the year due to decreased world demand. Activity in thermal coal, on the other hand, remained high.

Only one new coal mine was opened in 1978 – Luscar Sterco Ltd.'s Coal Valley mine which employs about 300 workers. Most of its production is sold to Ontario Hydro and is shipped by rail to a new terminal at Thunder Bay and from there by lake vessel to Nanticoke on Lake Erie.

The Alberta Energy Resources Conservation Board (AERCB) granted conditional approval for a new thermal coal mine near Forestburg to supply Alberta Power Limited's plant at Battle River. Mining will start in 1981 and about 70 people will be employed at this highly mechanized operation.

Manalta Coal Ltd.'s Whitewood Mine at Wabamun and its Highvale Mine at Seba Beach have been expanding production facilities to meet future demand from Calgary Power Ltd.

British Columbia

Leading minerals	Value of 1978 production	% change from 1977
	($ million)	
Copper	450.5	+6.8
Coal	351.8	+19.3
Natural gas	261.8	+3.7
Molybdenum	160.7	+13.5

British Columbia's mining industry performed moderately well during 1978 in spite of weak markets for copper, its most important commodity (British Columbia produces almost 42 per cent of Canada's copper output). Coal and molybdenum on the other hand, contributed more substantially to the province's mineral wealth in 1978 than in 1977. Almost half of Canada's coal production and almost all of its molybdenum output originates in British Columbia.

Mine closures and labour disputes were common in the province's mining industry in 1978. On June 30, Newmont Mines Limited ceased production at its Granduc mine near Stewart, eliminating about 320 jobs. Granby Mining Corporation closed its Phoenix Copper Division, Greenwood, resulting in a loss of 90 jobs. In September, Cominco Ltd. closed its H.B. mine near Salmo, affecting 110 employees.

Production at Gibraltar Mines Ltd. at Williams Lake was halted on May 26 due to a labour dispute. Five hundred employees had not resumed work as of the end of 1978. During the year Gibraltar workers set up pickets and halted production temporarily at the Endako mine and at Craigmont Mines Limited, two other Placer Development Limited interests.

A strike at Cassiar Asbestos Corporation Limited that started in September and involved most of the 650 workers was still in progress at year-end. As a consequence, the province's value of asbestos production fell by almost one-third (to $47.3 million) during 1978 compared with 1977 output.

In a dispute involving work practices, about 1 250 workers at Kaiser Resources Ltd.'s Sparwood coal mine walked off the job for nine days in mid-March.

New mine developments include Climax Molybdenum Corporation of British Columbia, Limited's plans to reopen and expand the open-pit molybdenum mine near Kitsault. Production will start in 1982 with a workforce of about 500. In the construction phase, 450 jobs will be created for two years.

The industry's contribution to the provincial economy was further bolstered by the opening of Teck Corporation's new Afton mine and smelter complex near Kamloops. The project, which attained its rated production capacity in mid-1978, employs about 325 workers.

At its Trail lead-zinc smelter, Cominco continued its $425 million, eight year expansion and modernization program. The company plans to improve efficiency and working conditions and to eliminate undesirable plant jobs through automation. The latter objective is partially the result of the company's anticipation of a labour shortage in the 1980s.

The provincial government stimulated exploration for coal in 1978 by lifting the moratorium on the issuance of new licences which had been in effect since 1972. Also, with the aim of creating jobs, developing new deposits and attracting investment to the province, the Accelerated Mineral Development Program was introduced in 1978. The program would achieve its aims by expanding prospectors' assistance, supporting mine road construction, enhancing mine site reclamation, and funding geochemical surveys and potentially viable exploration and development projects.

Yukon Territory

Leading minerals	Value of production	% change from 1977
	($ million)	
Zinc	75.5	−6.3
Lead	65.5	+37.5
Asbestos	32.4	−31.8
Silver	29.4	+45.9
Copper	18.1	+101.8

Mining is a major basis of the Yukon economy, with four mines contributing to the Territory's mineral production. During 1978 one of these mines, the Clinton Creek operation of Cassiar Asbestos Corporation, closed due to the exhaustion of reserves. The mine had been in production since 1967 and employed 300 workers.

The future economic health of mining in the Yukon was further threatened by the announcement of a possible closure of the historic, narrow-gauge White Pass and Yukon Railway if federal subsidies are not provided. A government decision on the matter is expected in 1979.

Other operations also face an uncertain future. Whitehorse Copper Mines Ltd., which employs about 200 workers, announced during the year that it expects to close by 1980 or 1981. United Keno Hill Mines Limited, which employs about 250 workers, is also searching for new sources of ore.

Parks Canada announced during the year that a 38 850 square kilometre (km^2) area of the northern Yukon would be withdrawn from further resource development pending land-use studies and public hearings on establishing a wilderness park in all, or part, of the area.

Major exploration programs, where new deposits are being found or further explored, have been continuing in the MacMillan Pass and Faro areas.

It is estimated that exploration expenditures in the Yukon Territory in 1978 amounted to about $18.0 million. While exploration work has focussed mainly on base metals, the results of exploration for natural gas in the Kotaneelee field of the southeastern Yukon were reported by Columbia Gas Development of Canada Ltd. to be "exceeding expectations". A pipeline has been built to the field, with production being imminent; an important "first" for the Yukon.

Of major interest to both the Yukon and Northwest Territories have been the recent announcements of the appointment of a special mineral adviser from industry to the Minister of Indian and Northern Affairs and of the preparation of a new northern mineral policy, for which the viewpoints of the mining industry will be sought.

Northwest Territories

Leading minerals	Value of 1978 production	% change from 1977
	($ million)	
Zinc	148.8	+18.9
Lead	56.8	+39.3
Gold	44.5	+42.2

Like the Yukon Territory, the Northwest Territories depend heavily upon mining to sustain their economy. Mining contributes about one-half of the Northwest Territories' production of goods and services. Eight metal mines are in operation, with the major producer being the Pine Point lead-zinc mines controlled by Cominco Ltd. Other important mines are operated by Canada Tungsten Mining Corporation Limited, Canada's only tungsten producer; and Nanisivik Mines Ltd. on Baffin Island.

One development of interest to the mineral industry during 1978 was the agreement in principle regarding land claims reached by the federal government and the Committee for Original Peoples' Entitlement (COPE), representing the Inuit of the northwest District of Mackenzie and Western Arctic Islands. Outright ownership of 10 900 km^2, surrounding six Inuit communities, will be transferred to the Inuit, along with surface rights to an additional 83 000 km^2. The government announced that the final settlement, which will also include provisions for financial and economic concessions, should act as a guideline for other native land claim agreements.

The federal government ban on all exploration in the Baker Lake area was lifted in April 1978, when an interim court injunction laid down new land-use guidelines. These restrict exploration to periods timed with the spring and summer movements of the caribou in the region. The final solution to the land-use problems of Baker Lake await the outcome of a suit by the Baker Lake Inuit against the federal government, which is expected to be heard early in 1979.

Added problems for those with mining interests in the area were the 1978 announcements by the federal government that the land around Bathurst Inlet would be considered for withdrawal from development to become a wilderness park, and that special studies would be made on the caribou populations covering most of the North District of Mackenzie to determine whether parts of the region should be declared land management zones.

During 1978 talks were continued between the federal government and Cominco over the development of Arvik Mines Ltd.'s zinc-lead deposit on Little Cornwallis Island. Major problems blocking agreement concerns limits on the export of mineral concentrates from this high-grade deposit and the phasing of production to processing facilities in Canada.

A major discovery of uranium near Baker Lake was announced by Urangesellschaft Canada Limited during the year. One deposit has been partially outlined and other prospects remain to be tested. The company's estimate for its properties' potential is between 13 605 and 45 350 tonnes of uranium oxide. The company intends to continue exploration, with a $4 000 000 program planned for 1979.

Federal-provincial agreements

Since 1970 the federal government has been actively involved with several provinces in agreements designed essentially to stimulate development in the mineral industry. All the agreements have specifically worded objectives, but in effect they aim at the use of the potential for extracting and processing minerals in a region to assist in achieving socio-economic benefits.

In 1974 Canada entered into General Development Agreements (GDAS) with all the provinces except Prince Edward Island, generally with the purpose of alleviating regional disparities. Since then all mineral development agreements have been subsidiary to the GDAS. The Department of Regional Economic Expansion (DREE) is the signatory of the GDAS on behalf of Canada, and it and the Department of Energy, Mines and Resources (EMR) represent the federal interest in the mineral development agreements.

The programs carried out under the mineral development agreements are varied, according to the requirements of a province or an area in a province. They are made up in large measure of geological, geochemical and geophysical surveys, mineral deposit studies and mineral inventory development in order to build up the geoscientific data base and thus provide assistance to industry in making decisions about exploration programs. They may also include process development, mineral commodity studies and mineral economic studies, which may be useful to a province in its management of its mineral resources.

Newfoundland. The Canada-Newfoundland Mineral Development Subsidiary Agreement came into being on December 17, 1976. The estimated total cost is $12 458 000, with a federal-provincial sharing ratio of 90:10 over the five-year period from January 1, 1977 to December 31, 1981. Nearly 60 per cent of this cost was planned for regional detailed geological mapping; much of the balance was for regional lake sediment geochemical surveys, the development of a mineral occurrence inventory and for various mineral commodity assessments. By the end of 1978 two field seasons had elapsed and good progress had been realized in the geological and geochemical surveys. Also, an aggregate resources inventory has been started, and both the manual and computerized parts of the mineral occurrence inventory were well advanced.

Nova Scotia. The Canada-Nova Scotia Mineral Development Subsidiary Agreement has been under way since April 1, 1974. The original estimated cost was $6 338 000 over a five-year period, with a sharing ratio of 80:20. The program involved geological, geochemical and geophysical surveys, a mineral deposits inventory and mineral evaluation surveys, including an inventory of coal. In 1977 the coal project was expanded to provide for more extensive work onshore and for offshore drilling in the Sydney basin. In the two fiscal years to March 31, 1979, $7 500 000 was added to the agreement. The offshore drilling identified potentially mineable coal off Donkin in the southeasterly extension of seams that are known and being mined near Glace Bay.

New Brunswick. The Canada-New Brunswick Subsidiary Agreement on Minerals and Fuels was signed in June 1976. The estimated total cost is $11 313 000 over a five-year period, with a sharing ratio of 80:20. The agreement covers a wide variety of projects. In 1978 work continued on inventories of coal, uranium, peat and aggregates. Seismic and gravity studies were made on parts of the Carboniferous basin, and regional detailed geological mapping of the west-central part of the province and detailed follow-up geological mapping in selected areas in the northern and southern parts was carried out. Research was supported on the development of processing technology that would allow higher recoveries from the complex base metal assemblages in deposits located in the northeast.

Quebec. The Canada-Quebec Subsidiary Agreement for Mineral Development began on April 1, 1976. The estimated total cost is $28 600 000 over a four-year period, with a federal-provincial sharing ratio of 60:40. Much of the program is concerned with access roads to mining and mineral-potential areas, geoscientific surveys, including some aimed at possible deposits of oil and gas; and research and development on processing and products. In 1978 work continued on roads in northern and northwestern Quebec and on a wide-ranging selection of geological, geophysical and geochemical surveys in various parts of the province.

Ontario. Under the six-year Canada-Ontario Community and Rural Resource Subsidiary Agreement, $491 000 was allotted for geoscientific surveys and mineral deposit studies in Renfrew County, southeastern Ontario. Work on these continued in 1978.

Manitoba. The four-year Canada-Manitoba Subsidiary Agreement on Mineral Exploration and Development entered its final year on April 1, 1978. The estimated total cost was $8 500 000, with a sharing ratio of 50:50. The program was designed to have a large measure of base metal exploration and smaller components relating to uranium reconnaissance, regional geological surveys and studies of industrial minerals and pegmatite minerals. By 1978 a change in policy resulted in a reduced and redesigned project on base metals. The other projects continued.

Saskatchewan. The four-year Canada-Saskatchewan Subsidiary Agreement on Mineral Exploration and Development in Northern Saskatchewan terminated on March 31, 1978. It was replaced by an Interim Subsidiary Agreement on Mineral Development, which was to run for two years at a total estimated cost of $2 469 500, with the same federal-provincial cost-sharing ratio of 50:50. The program was designed to continue reconnaissance for Precambrian and Quaternary geological mapping in the northern part of the province, metallogenic studies of uranium and base metals and the development of data systems for mineral deposits and geochemical results. In addition, a peat evaluation was begun.

Table 1. Canada, mineral production and employment by province, 1978

	Nfld.	P.E.I.	N.S.	N.B.	Quebec	Ontario	Manitoba	Sask.	Alberta	B.C.	Yukon	N.W.T.	All Canada
Value of mineral production (millions of dollars)	611	2	204	306	1 822	2 595	464	1 554	9 749	1 818	228	308	19 661
Change from 1977	−29.5%	2.0%	28.3%	5.9%	8.8%	−12.9%	−17.7%	28.7%	13.7%	7.8%	8.6%	20.3%	6.4%
Proportion of total Canadian output													
Metals	10.5%	—	—	4.5%	14.1%	36.0%	6.0%	4.8%	—	15.5%	3.6%	5.0%	100.0%
Nonmetals and structurals	1.2%	0.1%	3.1%	1.6%	35.8%	19.9%	3.1%	19.1%	8.2%	6.8%	1.1%	—	100.0%
Fuels	—	—	1.0%	0.1%	—	0.2%	0.4%	6.5%	84.7%	6.8%	—	0.3%	100.0%
Employment in mining[1] (persons)	5 800	...	4 700	2 700	21 200	23 400	5 400	6 900	38 500	12 700	1 100	1 500	139 700
Change from 1977	−4.9%	na	2.2%	—	−4.9%	−25.2%	−11.5%	9.5%	20.7%	−3.1%	na	na	
Employment in mining as a proportion of total provincial employment	8.9%	na	3.9%	2.6%	1.8%	1.2%	2.8%	6.3%	10.0%	2.7%	0.3%	0.3%	1.7%

[1] Statistics Canada Catalogue 72-008, Estimates of Employees by Province and Industry.
— Nil; ... Insignificant; na Not applicable.

Table 2. Per cent contribution by provinces to Canada's total value of mineral production, selected years, 1965, 1970 and 1975-78

	1965	1970	1975	1977	1978[p]
			(%)		
Alberta	20.5	24.4	43.1	46.4	49.7
Ontario[1]	26.8	27.8	17.6	16.1	13.2
British Columbia	7.5	8.6	9.7	9.1	9.3
Quebec	19.3	14.0	9.3	9.1	9.3
Saskatchewan[1]	8.8	6.6	6.5	6.5	7.9
Newfoundland	5.6	6.2	4.1	4.7	3.1
Manitoba	4.9	5.8	4.0	3.1	2.4
New Brunswick	2.2	1.8	1.7	1.6	1.5
Northwest Territories	2.1	2.4	1.5	1.4	1.5
Yukon	0.4	1.4	1.7	1.1	1.1
Nova Scotia	1.9	1.0	0.8	0.9	1.0
Prince Edward Island	0.02	0.01	0.01	0.01	0.01
Total Canada %	100.0	100.0	100.0	100.0	100.0
Millions of $	3 714.9	5 722.1	13 345.4[r]	18 472.5	19 601.3

Source: Statistics Canada.
[1] Does not include uranium prior to 1977.
[p] Preliminary; [r] Revised.

Canadian Reserves of Selected Mineral Commodities

(data available as of 1978)

R.T. WHILLANS

Any assessment of future supply of a given mineral commodity from Canadian mines requires information on current working inventories, i.e., on the amounts of ore known to be present in operating mines and on additional known tonnages in deposits that are close to being mineable profitably. The tonnages that – in 1978 – were fairly well delineated and judged to be economically mineable are reported below as "reserves". The limits of what is included in reserves are further specified in each case.

(A)	**Copper**	16 470 600 tonnes[1]
	Nickel	7 388 900 tonnes
	Lead	8 934 400 tonnes
	Zinc	26 907 600 tonnes
	Molybdenum	383 600 tonnes
	Silver	29 085 tonnes
	Gold	366 421 kilograms

The quantities of the metals listed above are contained in ore economically recoverable from producing mines and from deposits that had been committed for production up to January 1, 1978. These quantities represent measured and indicated tonnages and exclude inferred tonnages[2].

(B) Iron 2 400 million tonnes

This is the quantity of iron contained in known crude ore in producing mines and properties under development[3]. Ore in undeveloped deposits is not included.

[1]The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

[2]D.A. Cranstone and R.T. Whillans, MR 185, *Canadian Reserves of Copper, Nickel, Lead, Zinc, Molybdenum, Silver and Gold, as of January 1, 1978*, Energy, Mines and Resources Canada, 1979.

[3]Energy, Mines and Resources Canada, MR 170, *A Summary View of Canadian Reserves and Additional Resources of Iron Ore*, 1977.

(C) Asbestos 33 million tonnes

This represents the quantity of fibre recoverable (3.5 per cent) from economically mineable ore reserves — largely described as "probable" — in producing mines.

(D) Potash 14 000 million tonnes (K_2O equivalent), corresponding to 23 000 million tonnes KCl product (standard fertilizer – exported product).

This amount would be recoverable by conventional mining (to a depth of about 1 100 metres) from known potash deposits. At least an additional 42 000 million tonnes (K_2O equivalent) would be recoverable from known deposits by solution mining at depths beyond 1 100 metres; this would represent 69000 million tonnes of KCl product.

(E) Uranium

Mineable at uranium prices:	"Reasonably Assured" Measured	"Reasonably Assured" Indicated
up to $Cdn. 125/kg U:	76 000	139 000
	tonnes U	
$125 to $175/kg U:	4 000	16 000
	tonnes U	

The tonnages refer to uranium contained in recoverable ore. Unless otherwise specified, uranium "reserves" in Canada refer to the tonnages mineable at uranium prices up to $125/kg U[4].

[4]Energy, Mines and Resources Canada, *1978 Assessment of Canada's Uranium Supply and Demand*, EP 79-3, 1979.

(F) Coal

— *Bituminous*	1 607 million tonnes (of which 1 263 million tonnes could be used for metallurgical purposes)
— *Sub-bituminous*	2 182 million tonnes
— *Lignitic*	2 117 million tonnes

These represent tonnages that could be recovered as run-of-mine coal, with current technology and at current market prices, from measured and indicated coal in deposits that are legally open to mining. For the purpose of making these estimates, it was assumed that coal sales are to cover the costs of any required infrastructure not already in place[5].

[5]Energy, Mines and Resources Canada, *Coal Resources and Reserves of Canada*, ER 79-9, 1979.

Lightweight Aggregates

D.H. STONEHOUSE

Despite a recognized need for energy conservation, demand for lightweight aggregates and insulation materials has not increased at rates predicted earlier. In view of increasing energy costs greater amounts of insulation materials can now be economically installed in new housing units and, in fact, in older homes as well. During 1978 insulation materials were available in adequate quantities in Canada but some producers feel that the private sector requires motivation, perhaps even by legislation, to use more insulation. A major market, with great potential, lies in the fields of industrial and institutional building construction.

Technology

Aggregates commonly used to provide bulk in concrete and concrete products are sand, gravel and crushed stone. These commodities have an average unit weight of approximately 2 000 kilograms per cubic metre (kg/m^3). Until the mid-1940s comparatively little attention was paid to designing concrete products to meet a specific requirement other than a certain predetermined strength and setting time. At that time increased housing demand accentuated the need for prefabricated structures and techniques of construction were developed which could utilize structural sections and panels. It soon followed that panels, beams and trusses of much lighter unit weight could be fabricated with no sacrifice in strength by utilizing lightweight aggregates, a variety of rock and mineral materials weighing in the neighbourhood of 1 300 kg/m^3.

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

The use of lightweight concrete in commercial and institutional projects has facilitated the construction of taller buildings and the use of longer clear spans in bridges and buildings. Additional advantages from the use of lightweight aggregates lie in the fact that they supply thermal and acoustical insulation, fire resistance, good freeze-thaw resistance, low water absorption and a degree of toughness to the concrete product. Disadvantages stem from the fact that in production of both manufactured and ultra-lightweight aggregates heat processing is required. As the cost of fuel increases the competitiveness of these types will be reduced unless the insulation values more than offset the heat units consumed in processing.

All types of lightweight aggregates are used in Canada, but only expanded clays, shale and slag are produced from materials of domestic origin. Vermiculite is imported mainly from Montana, U.S.A., although a small amount is brought in from the Republic of South Africa. Perlite is imported mainly from New Mexico and Colorado, and pumice is imported from Oregon and Greece. Most processed lightweight aggregate is utilized in the construction industry, either as loose insulating material or as aggregate in the manufacture of lightweight concrete units. The scope of such applications has not yet been fully investigated.

Any lightweight material with acceptable physical and chemical characteristics could substitute for the mineral commodities generally used. The most significant substitute for vermiculite, for instance, is styrofoam or polyurethane, which offers insulating value and comparable strength. However, these materials are petroleum-based and higher fuel prices could limit their use. Mineral wool is a competitive insulation material but its manufacture requires a pyroprocessing stage, as does the production of perlite and vermiculite. Transportation costs for high-bulk, lightweight materials are high; those materials, such as perlite and vermiculite, that can be transported to a consuming centre prior to expansion, have obvious advantages.

There are as yet no Canadian Standards Association (CSA) specifications for the lightweight aggregates. Production and application are based on the American Society for Testing and Materials (ASTM) designations as follows: ASTM Designations C 332-66 – Lightweight Aggregates for Insulating Concrete; C 330-75a – Lightweight Aggregates for Structural Concrete; and C 331-69 – Lightweight Aggregates for Concrete Masonry Units.

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Table 1. Canada, imported raw materials purchased, 1977 and 1978

	1977		1978	
	(tonnes)	($)	(tonnes)	($)
Pumice	34 555	698 125	40 361	859 200
Perlite and vermiculite	66 563	7 162 713	52 109	6 665 038
Total	101 118	7 860 838	92 470	7 524 238

Source: Company data.

Perlite. Perlite is a variety of obsidian or glassy volcanic rock that contains 2 to 6 per cent of chemically combined water. When the crushed rock is heated rapidly to a suitable temperature (760°C to 980°C) it expands to between 4 and 20 times its original volume. Expanded material can be manufactured to weigh as little as 30 to 60 kg/m^3, with attention being given to preblending of feed to the kiln and retention time in the kiln.

In Canada, imported perlite is expanded and used mainly by gypsum products manufacturers in plaster products such as wallboard or drywall, and in fibre-perlite roof insulation board, where its value as a lightweight material is augmented by its fire-resistant qualities. It is also used as a loose insulation and as an insulating medium in concrete products. Perlite, vermiculite, and expanded shale and clay are becoming more widely used in agriculture as soil conditions and fertilizer carriers.

Imports of crude perlite for consumption in Canada are from New Mexico and Colorado deposits, worked by such companies as Johns-Manville Corporation, United States Gypsum Company, United Perlite Corp. and Grefco Inc. In 1978 seven companies at nine locations in Canada reported production of expanded perlite.

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

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

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

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

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

Table 2. Canada, production of lightweight aggregates, 1977 and 1978

	1977		1978	
	(m^3)	($)	(m^3)	($)
From domestic raw materials				
Expanded clay, shale and slag	576 637	6 919 646	520 752	6 892 181
From imported crude materials				
Expanded perlite and exfoliated vermiculite[1]	620 305	15 108 723	449 061	11 982 841
Total	1 196 942	22 028 369	969 813	18 875 022

Source: Company data.
[1] Grouped to protect individual company confidentiality.

Table 3. Canada, consumption of slag, percentage by use, 1976-78

Use	1976	1977	1978
Concrete block manufacture	72.0	63.0	64.0
Ready-mix concrete	3.0	3.0	2.0
Loose insulation	1.0	1.0	1.0
Slag cement	24.0	33.0	33.0

Source: Company data.

Vermiculite. The term vermiculite refers to a group of micaceous minerals, hydrous magnesium-aluminum silicates, that exhibit a characteristic lamellar structure and expand or exfoliate greatly upon being heated rapidly. Mining is normally by open-pit methods, and beneficiation techniques include the use of hammer mills, rod mills, classifiers, screens, dryers and cyclones. Exfoliating is done in oil- or gas-fired, vertical or inclined furnaces, usually close to the consuming facility to obviate the higher costs associated with shipping the much-bulkier expanded product. Required temperatures can vary from 1 100°C to 1 650°C depending on the type of furnace in use. A controlled time and temperature relation is critical in order to produce a product of minimum bulk density and good quality.

The expansion process has been improved technologically to enable production of various grades of expanded vermiculite as required. The uses to which the product is put depend on its low thermal conductivity, its fire-resistance and, more recently, on its lightweight qualities.

Canadian consumption is mainly as loose insulating material, with smaller amounts being used as aggregate in the manufacture of insulating plaster and concrete. The energy situation will undoubtedly result in continued increases in domestic fuel costs, and greater use of insulation in both new construction and older buildings will continue to tax the production capability of manufacturers for some time.

Table 4. Canada, consumption of expanded clay and shale, percentage by use, 1976-78

Use	1976	1977	1978
Concrete block manufacture	70.7	72.4	72.5
Precast concrete manufacture	10.8	4.9	5.5
Ready-mix concrete	12.7	18.1	19.4
Horticulture and miscellaneous uses	5.8	4.6	2.6

Source: Company data.

The major producer of vermiculite is the United States. The principal company supplying Canada's imports is W.R. Grace and Company, from operations at Libby, Montana and from the Enoree region of South Carolina. Canada also imports crude vermiculite from the Republic of South Africa, where Palabora Mining Co. Ltd., is the major producer. At both the Grace and Palabora operations milling limitations have necessitated new mill installations in an effort to keep up with demand. Minor amounts of vermiculite are produced in Argentina, Brazil, India, Kenya and Tanzania.

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

Three companies operated a total of eight vermiculite-processing plants in Canada during 1978.

Clay, shale and slag. Common clays and shale are used throughout Canada as raw material for the manufacture of lightweight aggregates. Although the Canadian industry began in the 1920s in Ontario, it did not evolve significantly until the 1950s when it grew in support of demands from the construction industry. The raw materials are usually quarried adjacent to the plant sites at which they are expanded. Clays receive little beneficiation other than drying before being introduced to the kiln in which they are heated. Shales are crushed and screened before burning. Seven plants in Canada produced lightweight aggregates from clay and shale during 1978, each using a rotary kiln process. Production data was obtained from six operations only.

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

Although Canada does not produce large amounts of fly ash, the technology of fly-ash processing and utilization is well advanced. The largest single use for fly ash is as a cementitious material, in which application its pozzolanic qualities are utilized. Use of fly ash as a lightweight aggregate could become increasingly important. Ontario Hydro produces over 400 000 tonnes* of fly ash a year from three coal-fired stations. Experimentation continues towards successful utilization of this material at the Lakeview plant in the production of pozzolan, iron oxide and lightweight pellets. Disposal costs of $2 to $3 per tonne add incentive to such programs.

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 5. Canada, consumption of expanded perlite, percentage by use, 1976-78

Use	1976	1977	1978
Insulation			
– in gypsum products	13.9	27.0	15.9
– in other construction materials	68.3	57.0	57.3
Horticulture	8.5	13.0	17.9
Loose insulation and miscellaneous uses	9.3	3.0	7.2

Source: Company data.

World review

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

The major producers of pumice include the United States, Italy, West Germany and Greece, although production is recorded from other countries. As with other low-cost, lightweight material, transportation costs are the main factor in determining the competitiveness of pumice. Prices have not varied greatly in recent years.

The use of fly ash should increase with the added incentives provided by environmental control. Using only about 20 per cent of ash production, industry in North America falls far short of European enterprises which use as much as 80 per cent of production.

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

The unit price of lightweight aggregates has shown a steady but unspectacular rate of increase during the past few years and is likely to continue to do so in pace with a steady increase in demand and inflationary conditions, each of which could have as its main contributing influence increased costs of energy, particularly the fossil fuels.

Table 6. Canada, consumption of exfoliated vermiculite, percentage by use, 1976-78

Use	1976	1977	1978
Insulation			
– loose	71.9	75.1	69.9
– in concrete and concrete products	7.3	4.7	4.6
– in gypsum products	2.0	1.4	3.7
Horticulture	8.8	10.0	6.2
Miscellaneous uses	10.0	8.8	15.6

Source: Company data.

Table 7. Lightweight aggregate plants in Canada, 1978

Company	Location	Product
Atlantic Provinces		
Avon Aggregates Ltd.	Minto, N.B.	Expanded Shale
Quebec		
F. Hyde & Company, Limited	Montreal	Vermiculite
Laurentide Perlite Inc.	Charlesbourg West	Perlite
Masonite Canada Ltd.	Gatineau	Perlite
Perlite Industries Reg'd.	Ville St. Pierre	Perlite
Vermiculite Insulating Limited	Lachine	Vermiculite
Ontario		
Canadian Gypsum Company, Limited	Hagersville	Perlite
Johns-Manville Canada Inc.	North Bay	Perlite
Domtar Inc.	Caledonia	Perlite
	Mississauga	Expanded Shale
	Cornwall	Perlite
W.R. Grace & Co. of Canada Ltd.	St. Thomas	Vermiculite
	Ajax	Vermiculite
National Slag Limited	Hamilton	Slag
Prairie Provinces		
Aerlite Products Limited	Namao, Alta.	Expanded Clay
Cindercrete Products Limited	Regina, Sask.	Expanded Clay
Genstar Limited	Calgary, Alta.	Expanded Shale
Domtar Inc.	Calgary, Alta.	Perlite
Genstar Limited, Edcon Block Division	Edmonton, Alta.	Expanded Clay

W.R. Grace & Co. of Canada Ltd.	Winnipeg, Man.	Vermiculite
	Edmonton, Alta.	Vermiculite
Kildonan Concrete Products Ltd.	St. Boniface, Man.	Expanded Clay
Northern Perlite & Vermiculite Limited	St. Boniface, Man.	Vermiculite
British Columbia		
W.R. Grace & Co. of Canada Ltd.	Vancouver	Vermiculite
Westroc Industries Limited	Vancouver	Perlite

Source: Company data.

Table 8. Rock- mineral- and glass-wool producers, Canada, 1978

Company	Location	Remarks
Atlantic Provinces		
Fiberglas Canada Limited	Moncton, N.B.	New 1975, $4 million, 15 000 tonnes per year. Limestone, dead-burned magnesia, silica, borax
Quebec		
Fiberglas Canada Limited	Candiac, P.Q.	Expanded 1977, $6 million
Ontario		
Fiberglas Canada Limited	Sarnia	Expanded 1978, $6 million. New electric furnace is largest of kind
	Toronto	New plant by 1979, $25 million
Johns-Manville Canada Inc.	West Hill (Toronto)	Using imported glass balls
Canadian Gypsum Co. Ltd.	Mount Dennis (Toronto)	Using slag from Hamilton
Spun Rock Ltd.	Thorold	Boiler blankets, etc. from argillaceous dolomite
Holmes Insulation	Sarnia	Slag – Detroit
Bishop Building Materials	Toronto	Slag – Hamilton
Graham Fiber Glass Ltd.	Erin	New by 1979, $10 million, 10 000 tonnes per year
Prairie Provinces		
Fiberglas Canada Limited	Clover Bar, Alta. (Edmonton)	Expanded 1977, $5 million
Johns-Manville Canada Inc.	Innisfail, Alta.	New 1978, $11-$18 million, 6 000 tonnes per month. New energy-efficient mechanical fiberizing technology
British Columbia		
Fiberglas Canada Limited	Mission	New for 1980, $25 million, 45 000 tonnes per year

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.

Table 9. Canada, value of construction by province, 1977-79

	1977[1]			1978[2]	1979[3]
	Building Construction	Engineering Construction	Total	Total	Total
	(millions of dollars)				
Newfoundland	390.0	233.1	623.1	664.0	838.1
Nova Scotia	522.2	392.3	914.5	1 015.8	1 066.8
New Brunswick	449.3	424.4	873.7	921.8	977.5
Prince Edward Island	78.6	40.4	119.0	144.8	150.7
Quebec	5 223.3	3 366.6	8 589.9	8 736.2	9 199.2
Ontario	7 078.4	3 535.2	10 613.6	10 914.5	11 758.3
Manitoba	854.2	543.4	1 397.6	1 532.3	1 546.1
Saskatchewan	976.3	587.7	1 564.0	1 663.2	1 840.7
Alberta	2 940.9	3 183.9	6 124.8	7 387.8	8 316.2
British Columbia, Yukon Territory and Northwest Territories	2 793.6	2 189.6	4 983.2	5 404.7	5 821.3
Canada	21 306.8	14 496.6	35 803.4	38 385.1	41 514.9

Source: Statistics Canada.
[1]Actual. [2]Preliminary. [3]Forecast.
Note: Data for the preliminary and forecast years are not available by type of construction.

Aluminum

G. NINACS

The world aluminum industry enjoyed a steady strengthening in demand and increased profits during the year. World consumption increased 5.6 per cent, and although the industry operated at capacity where feasible, stocks were reduced to working levels. Power shortages in the United States and the noncompetitiveness of the Japanese industry limited non-communist world production to 88 per cent of theoretical capacity. Further plans were made for significant new production to come on stream during the early 1980s, but the short-term emphasis was in improving existing facilities and applying new technology. Higher metal prices and greater cash flows resulted in the strengthening of balance sheets.

A price spread of over 4 cents per pound on primary aluminum ingot existed during most of 1978, but it narrowed to a range of 55 to 57.5 cents by year-end. This was a 2 to 4.5 cent increase over prices one year earlier.

Canada

No economic deposits of bauxite, the predominant ore of aluminum, have been found in Canada. Bauxite is imported from tropical countries for the production of alumina, an aluminum oxide, which is reduced in electrolytic cells to aluminum metal. Approximately 4.5 tonnes* of bauxite are refined to produce 2 tonnes of alumina, which in turn are smelted to obtain 1 tonne of aluminum. The electric power requirements in the production of aluminum are high; from 7 to 8 kilowatt hours (kWh) per pound of aluminum produced. For this reason, Canada's aluminum smelters have been advantageously located near large low-cost power sources. Also, because transportation is an important cost factor the smelters have been located near ocean shipping ports.

Production. Canadian primary aluminum output in 1978 was 1 048 469 tonnes, compared with 973 106 tonnes in 1977. Two companies operate primary smelters in Canada; the Aluminum Company of Canada, Limited (Alcan), a subsidiary of Alcan Aluminum Limited of Montreal (also referred to as Alcan) and Canadian Reynolds Metals Company, Limited, a subsidiary of Reynolds Metals Company of Richmond, Virginia.

Alcan operates aluminum smelters at Jonquiere, Isle-Maligne, Shawinigan and Beauharnois, all in Quebec and one in Kitimat, British Columbia. Combined rated capacity of the smelters is 894 000 unalloyed tonnes per year. Canadian Reynolds Metals Company, Limited's only smelter is located at Baie Comeau in the province of Quebec and has a rated annual capacity of 158 800 tonnes.

Alcan's Beauharnois smelter experienced an 11-day work stoppage during October that resulted in an ingot production loss of 5 500 tonnes. All other Canadian smelting operations were normal. However, various labour strikes occurred at Alcan's Canadian fabrication plants. The most serious stoppage lasted 15 weeks at the Kingston sheet and extrusion plant before settlement was reached on October 20.

Foundations were poured and steel erection began on the site of Alcan's new smelter complex located at Grande Baie about 30 kilometres (km) east of Jonquiere, Quebec. The first phase includes the building of a 57 000-tonne-per-year potline, together with the major segments of the basic facilities and electrode making machinery for two additional potlines. The capital cost of the first phase is estimated to be $200 million and is scheduled for completion by the end of 1980. Construction of a second 57 000-tonne phase costing an additional $90 million was approved in December and is to begin in the spring of 1979 with a tentative completion date in 1981.

Some 2 432 552 tonnes of bauxite were imported from Guinea, Guyana, Surinam, Australia and elsewhere to produce alumina at Alcan's refinery at Jonquiere (formerly Arvida), Quebec, the only alumina refinery in Canada. The capacity of the refinery is 1 225 000 tonnes per year and it supplies Alcan's four smelters in Quebec. Alumina for Alcan's Kitimat smelter in British Columbia is imported mainly from Australia. The Reynolds Metals Company's smelter in Quebec imports alumina from Jamaica and the United States.

Canadian exports of aluminum, mainly in ingot form, but also including further fabricated materials were 902 472 tonnes, an increase of 29 per cent over the 698 798 tonnes exported in 1977. The United States was by far the major market for Canadian aluminum, accounting for 58 per cent of the Canadian exports followed by Japan, with 18.7 per

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, aluminum production and trade, 1977 and 1978

	1977		1978p	
	(tonnes)	($ 000)	(tonnes)	($ 000)
Production	973 106	. .	1 048 469	. .
Imports				
Bauxite ore				
Guinea	1 244 348	22 679	1 053 335	23 677
Guyana	531 229	6 082	813 917	15 265
Surinam	254 188	11 707	105 758	9 961
Australia	19 203	1 554	54 550	4 874
Sierra Leone	333 667	3 909	329 630	4 783
United States	25 723	2 749	28 947	2 865
Trinidad and Tobago	329 980	3 064	46 415	859
Other countries	16 916	721	—	—
Total	2 755 254	52 465	2 432 552	62 284
Alumina				
Australia	500 791	69 213	445 358	73 116
Jamaica	164 700	30 949	334 518	59 477
United States	32 852	7 730	163 700	38 401
West Germany	73 880	14 141	92 578	20 736
France	49 368	5 449	20 048	2 144
Other countries	6	3	6	5
Total	821 597	127 485	1 056 208	193 879
Aluminum and aluminum alloy scrap	16 126	10 936	27 162	10 927
Aluminum paste and aluminum powder	6 472	8 287	5 639	7 920
Pigs, ingots, shots, slabs, billets, blooms and extruded wire bars	20 789	22 298	11 480	13 914
Castings	1 092	4 494	1 089	4 625
Forgings	427	2 651	439	3 129
Bars and rods, nes	1 858	4 084	2 780	6 524
Plates	9 300	15 490	12 984	25 683
Sheet and strip up to 0.025 inch thick	21 003	31 129	19 807	37 232
Sheet and strip over 0.025 inch up to 0.051 inch thick	7 232	13 543	12 554	27 640
Sheet and strip over 0.051 inch up to 0.125 inch thick	20 435	28 979	21 679	39 689
Sheet over 0.125 inch thick	23 959	33 013	24 355	42 719
Foil or leaf	365	780	661	1 445
Converted aluminum foil	. .	7 072	. .	9 925
Structural shapes	2 002	5 071	2 446	8 727
Pipe and tubing	1 276	3 272	1 600	4 275
Wire and cable not insulated	1 571	3 389	1 672	4 163
Aluminum and aluminum alloy fabricated materials, nes	. .	28 809	. .	30 776
Total aluminum imports	. .	223 297	. .	279 313

Table 1. (cont'd)

	1977		1978[p]	
	(tonnes)	($ 000)	(tonnes)	($ 000)
Exports				
Pigs, ingots, shot, slabs, billets, blooms and extruded wire bars				
United States	454 659	499 080	489 687	608 462
Japan	59 371	42 517	168 822	200 902
People's Republic of China	9 996	10 306	76 598	89 999
Brazil	8 987	9 326	19 044	22 161
Israel	7 572	8 994	33 757	17 461
Spain	6 455	6 557	13 970	16 981
Thailand	10 387	12 259	12 329	16 027
Hong Kong	14 646	13 527	12 103	15 953
Pakistan	5 033	5 789	5 891	7 893
Colombia	5 422	6 061	6 068	7 688
Portugal	785	953	5 113	6 468
Other countries	71 939	83 432	19 222	52 331
Total	655 252	698 801	862 604	1 062 326
Castings and forgings				
United States	651	6 072	1 516	10 176
West Germany	16	950	30	2 417
United Kingdom	14	925	14	1 124
France	10	774	5	493
Other countries	10	490	22	564
Total	701	9 211	1 587	14 774
Bars, rods, plates, sheets and circles				
United States	10 294	15 913	20 979	33 566
Venezuela	7 370	10 198	1 877	4 145
Pakistan	4 769	5 958	1 549	2 229
South Korea	239	393	941	1 388
India	—	—	994	1 218
Barbados	44	175	160	440
United Kingdom	49	265	65	417
Mexico	—	—	137	302
Peru	45	47	135	266
Trinidad and Tobago	—	—	120	231
Other countries	4 363	5 782	1 280	1 249
Total	27 173	38 731	28 237	45 451
Foil				
United States	223	510	763	1 708
Venezuela	586	1 275	29	59
Trinidad and Tobago	32	63	4	10
Guyana	—	—	2	6
United Kingdom	—	—	2	5
Other countries	20	37	1	5
Total	861	1 885	801	1 793

Table 1. (cont'd)

	1977		1978ᵖ	
	(tonnes)	($ 000)	(tonnes)	($ 000)
Exports (cont'd)				
Fabricated materials, nes				
United States	11 228	14 701	6 595	10 486
Venezuela	45	118	627	1 903
United Kingdom	253	581	412	983
Pakistan	351	547	536	818
Iran	5	24	294	517
Norway	125	281	194	393
Ivory Coast	336	613	121	193
Other countries	2 468	3 956	464	925
Total	14 811	20 821	9 243	16 218
Ores and concentrates				
United States	19 885	4 557	26 679	7 340
Italy	736	183	1 712	482
United Kingdom	631	149	1 411	435
France	283	71	837	322
Venezuela	701	155	701	209
Spain	993	297	586	180
Other countries	842	262	733	302
Total	24 071	5 674	32 659	9 270
Scrap				
United States	38 844	28 663	42 935	34 531
Japan	8 765	6 872	11 893	11 203
West Germany	1 439	753	1 112	674
Brazil	598	439	403	370
Italy	158	82	637	237
Spain	403	210	368	194
South Korea	30	19	109	86
South Africa	—	—	61	50
Other countries	500	221	184	48
Total	50 737	37 259	57 702	47 393
Total aluminum exports	..	812 382	..	1 197 225

Source: Statistics Canada.
ᵖ Preliminary; — Nil; .. Not available; nes Not elsewhere specified.

cent. Canada's exports to Japan were more than twice that of 1977. Japan increased her reliance on imports as domestic primary production was being reduced.

The value of aluminum exports from all sources in 1978 was $1 197 225 000, compared with $812 382 000 in 1977. These increased exports include 45 500 tonnes of toll-based metal for Nippon Light Metal Company Ltd., a Japanese affiliate of Alcan under a 24-year contract signed in 1974.

Consumption. Consumption in Canada was an estimated 380 290 tonnes for 1978, compared with 332 393 tonnes in 1977.

World review

World production of bauxite was 84.1 million tonnes in 1978, about 1 per cent less than the 84.8 million tonnes produced in 1977. Australia, the world's largest producer, produced 24.3 million tonnes, compared with 26.1 million tonnes in 1977. Guinea and Jamaica were the next largest producers with 12.1 million and 11.7 million tonnes, respectively.

World primary aluminum production for 1978 increased by 3.0 per cent, from 14.2 million tonnes in 1977 to 14.6 million tonnes in 1978. Non-communist world stocks at the end of 1978 were 2.0 million tonnes, down from 2.5 million tonnes at the end of 1977. Non-communist world consump-

Table 2. Canada, primary aluminum production, trade and consumption, 1965, 1970, 1975-78

	Production	Imports	Exports	Consumption[1]
		(tonnes)		
1965	753 421	6 300	641 844	193 316
1970	962 541	12 179	761 671	250 150
1975	878 056[r]	18 302	512 050[r]	293 280
1976	628 137[r]	22 556[r]	507 936[r]	322 206
1977	973 106	20 789	655 252	332 393
1978[p]	1 048 469	11 480	862 604	380 290

Source: Statistics Canada.
[1]Excluding aluminum metal used in the production of secondary aluminum.
[p]Preliminary; [r]Revised.

tion rose by 5.7 per cent to 12.0 million tonnes in 1978, up from 11.4 million tonnes in 1977.

In the United States apparent consumption of aluminum metal increased to a new record of almost 5.4 million tonnes, according to the United States Bureau of Mines. Domestic production of primary metal rose 6 per cent to 4.4 million tonnes. Production during the early part of 1978 was adversely affected by labour strikes in the eastern coal industry and by drought conditions which limited electricity availability in the northwest. Demand was strong in the U.S., particularly for plate and sheet. As a result, numerous expansions of rolling capacity have come on stream. A limited amount of expanded smelter capacity is also under way. These expansions are being approached cautiously due to environmental and future power supply factors, as well as the possible near-term emergence of improved production technology.

Alumax, Inc. is still committed to construction of its $400 million, 179 000-tonne smelter near Charleston, South Carolina, with a planned startup date of mid-1980. However, plans for a third potline (90 000 tonnes) at Frederick, Maryland were shelved when Potomac Edison advised it would be impossible to supply the required power.

Aluminum Division of Atlantic Richfield Company continued with its 54 500-tonne smelter expansion at Seebree, Kentucky, scheduled for completion in 1979. This will raise the smelter capacity to 163 000 tonnes per year.

The Aluminum Company of America's (Alcoa) 13 600-tonne expansion of its Palestine, Texas smelter to 27 200 tonnes is planned to be operational early in 1979. The smelter uses Alcoa's new smelting process based on chlorination of the alumina and its subsequent reduction in a chloride bath. This process is reported to use 30 per cent less energy than conventional technology. Alcoa also plans to spend $60 million modernizing and expanding its alumina production facilities at Mobile, Alabama. The annual capacity of this alumina hydrate plant is to be increased by 68 000 tonnes.

The Japanese aluminum smelting industry has become progressively noncompetitive against imports, due to increases in costs of raw materials, labour, the appreciation of the yen and rapidly escalating power costs. The Japanese aluminum industry is dependent on oil-fired power for 72 per cent of its power requirement. A government authorized production cartel was established for the period September 1, 1978 to March 31, 1979 to reduce smelter inventories from 230 000 tonnes to 146 000 tonnes. This will be done by reducing production to 58 per cent of existing capacity, scrapping 275 000 tonnes of capacity and freezing another 255 000 tonnes of capacity. The planned 1.1 million tonnes of capacity that will remain will be further rationalized where possible. A Tariff Quota System that diverts part of the duties normally paid on imported aluminum to a fund is now in effect. The fund will be used to assist the rationalization and restructuring of the existing Japanese industry. During December, the domestic industry reached agreement with users to raise primary aluminum prices to about U.S. 71 cents per pound by the end of February 1979 – some 5 per cent above the price of imported aluminum. The Japanese government continued domestic purchases of primary aluminum for its own buffer stockpile, which now contains some 22 000 tonnes.

By 1985, Japanese aluminum demand is forecast at 2.15 million tonnes, of which 1.15 million will be supplied domestically, the remainder will be imported mainly from offshore projects partially owned by Japanese interests.

Two major new alumina production facilities are planned in Australia. Alcoa recently won formal approval to proceed with a 200 000 tonne alumina refinery at Wagerup, Western Australia, costing $400 million. Construction will start early in 1979, and provision will be made to ultimately increase capacity to 2 million tonnes per year. Alcoa will also add a third potline to its Point Henry smelter in Victoria, raising capacity to 157 000 tonnes per year. Construction will commence during early 1979 and production will start in 1981.

The Alwest alumina project, also to be built in Western Australia, is now estimated to cost $700 million. Initial output of 1 million tonnes alumina per year will eventually be increased to 2 million tonnes. Construction of the facility is scheduled to begin late in 1979 and will take 3 1/2 years to complete. The two original partners, the Reynolds Metals Company and the Broken Hill Proprietary Company Limited (BHP), have been joined by the Anaconda Company, Billiton B.V., and Kobe Alumina Associates.

A 212 000-tonne-per-year aluminum smelter is planned in Queensland adjacent to the Gladstone alumina refinery. The cost of the plant will be $540 million (Australian) and ingot production should start during 1984. Ownership will be: Comalco Limited, 30 per cent; Kaiser Aluminum & Chemical Corporation, 20 per cent; and a Japanese group, 50 per cent.

The Indonesian government has formed a consortium, including Klockner INA, KHD and Alcoa, to examine the feasibility of a $450 million, 600 000-tonne-per-year

Table 3. Canada, consumption of aluminum at first processing stage, 1975-78

	1975	1976	1977	1978p
		(tonnes)		
Castings				
Sand	1 292	1 142	1 277	1 496
Permanent mould	13 152	17 116	21 836	14 483
Die	17 310	20 899	16 413	23 234
Other	49	16	65	65
Total	31 803	39 173	39 591	39 278
Wrought products				
Extrusions including tubing	77 989	83 814	84 019	87 625
Sheet, plate, coil and foil	106 175	134 527	134 278	159 720
Other wrought products (including rod, forgings and slugs)	64 469	53 889	61 318	81 833
Total	248 633	272 230	279 615	329 178
Other uses				
Destructive use (deoxidizer), nonaluminum base alloys, powder and paste	12 844	10 803	13 187	11 834
Total consumed	293 280	322 206	332 393	380 290
Secondary aluminum[1]	31 201	52 246	51 260	44 627

	Metal entering plant		On hand December 31	
	1977	1978	1977	1978
Primary aluminum ingot and alloys	294 924	345 589	81 839	88 633
Secondary aluminum	36 887	35 575	2 434	3 297
Scrap originating outside plant	52 534	52 150	13 971	15 340
Total	384 345	433 314	98 244	107 270

Source: Statistics Canada.
[1] Aluminum metal used in the production of secondary aluminum.
[p] Preliminary.

alumina refinery. This facility is planned to convert Indonesia's nonexport grade bauxite into feed for the 225 000-tonne Asahan smelter. The Asahan smelter is now under construction and scheduled to begin production by 1982.

In Brazil bauxite and aluminum production capacity is being rapidly expanded with the help of government involvement.

The large Trombetas bauxite project is scheduled to commence production during 1979. Initial output will be 1.4 million tonnes per year bauxite, increasing to 3.3 million tonnes in 1980 and eventually reaching 5.3 million tonnes. The Brazilian government (Companhia Vale do Rio Doce (CVRD)) and private interests hold 51 per cent of the project; Alcan, 19 per cent and six other aluminum producers, 30 per cent.

Table 4. World primary aluminum production and consumption, 1977 and 1978

	Production		Consumption	
	1977	1978[e]	1977	1978[e]
	(000 tonnes)			
United States	4 117.7	4 358.1	4 756.0	4 975.9
Europe[1]	3 467.3	3 526.8	3 493.9	3 582.2
Japan	1 188.2	1 057.7	1 418.7	1 655.0
Canada	973.1	1 048.5	332.4	380.3
Australia and New Zealand	392.7	414.7	198.6	207.3
Asia (excluding Japan and People's Republic of China)	444.7	454.2	602.6	672.1
Africa	368.3	336.3	125.7	139.0
America (excluding United States and Canada)	362.2	405.6	441.5	396.2
Subtotal	11 314.2	11 601.9	11 369.4	12 008.0
Central economy countries	2 905.8	3 039.6	3 013.9	3 174.1
Total	14 220.0	14 641.5	14 383.3	15 182.1

Sources: World Bureau of Metal Statistics; for Canada, Statistics Canada; for United States production, U.S. Bureau of Mines, Mineral Commodity Summaries.
[1] Includes Yugoslavia.
[e] Estimated.

A feasibility study on the extensive Vera Cruz bauxite deposits is under way. This proposed mining facility is estimated to cost $300 million and is expected to produce 2 million tonnes of bauxite per year.

The Trombetas and Vera Cruz bauxite deposits are planned to supply the $400-million Alumina do Norte S.A. (Alunorte) refinery, which is scheduled to produce 800 000 tonnes of alumina per year. Brazil holds a 60.8 per cent interest in Alunorte and Japan 39.2 per cent. The Alunorte refinery, in turn, will supply feed for two new smelters – the Aluminio Brazileiro Ltd. (Albras) smelter and the Valesul smelter. Albras will be 51 per cent Brazilian-owned and 49 per cent Japanese. Albras' eventual production will be 290 000 tonnes per year at a capital cost of $955 million, although initial production will only be 36 000 tonnes per year commencing in 1981. Aluminio do Sul S.A. (Valesul) will start production in mid-1981 with a capacity of 86 000 tonnes per year. Total cost of Valesul will approximate $300 million, with the Shell group holding 35 per cent interest, Reynolds International Inc. 5 per cent, and Brazilian interests 60 per cent.

Brazil currently imports 100 000 tonnes of aluminum metal annually but by the early 1980s should be a net exporter.

Brazil will have to compete with Venezuela's Venalum smelter, which started production during September. Venalum's current capacity is 64 000 tonnes with a planned capacity of 250 000 tonnes by 1982. Some 145 000 tonnes of this output are destined for Japanese consumption. Venezuela has an 80 per cent interest in the smelter and Japan 20 per cent.

Financing arrangements were completed for the $500 million alumina plant in County Limerick, Ireland. Ownership will be 40 per cent Alcan, 35 per cent Billiton and 25 per cent Anaconda. Production should start in 1982 at a capacity of 800 000 tonnes of alumina per year. Bauxite for the facility will be imported from Guinea, West Africa and Brazil.

Following the 1977 agreement between Reynolds Metals Company and the Jamaican government, Alcan and Jamaica signed a joint venture agreement in September. Jamaica will purchase all Alcan's mining lands and 7 per cent of the operating assets, based on book values. All operating assets will be combined into the joint venture (Jamaican) from which Jamaica will receive 7 per cent of the production. In return Alcan is granted a 40 year mining lease, ensuring a secure bauxite supply base. Alcan will also pay a production levy (fixed until the end of 1983) equal to 7.5 per cent of the realized ingot price.

China's increasing normalization with the western world extended to aluminum during 1978. China has been importing aluminum metal to cover some 50 per cent of its 400 000-tonne-per-year consumption. The Chinese have reported sizeable bauxite reserves and are negotiating with Japanese aluminum producers for the construction of an 80 000-tonne smelter in China.

In Spain, construction is well advanced on an 800 000-tonne-per-year alumina plant and 160 000-tonne smelter in San Ciprian. Initial ingot production should start during 1979.

Table 5. Canada, aluminum production facilities, 1978

	Annual Rated Capacity
	(tonnes)
Alumina plant locations	
Aluminum Company of Canada, Limited (Alcan)	
Quebec	
Vaudreuil (Jonquière)	1 225 000
Smelter locations	
Aluminum Company of Canada, Limited (Alcan)	
Quebec	
Jonquière	422 000
Isle-Maligne	75 000
Shawinigan	83 000
Beauharnois	46 000
British Columbia	
Kitimat	268 000
Total (Alcan) smelter capacity	894 000
Canadian Reynolds Metals Company, Limited	
Quebec	
Baie-Comeau	158 800
Total Canadian smelter capacity	1 052 800

Source: Compiled from various company reports by the Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.

Table 6. Estimated world production of bauxite, 1978

	Production
	(million tonnes)
Australia	26.5
Guinea	12.0
Jamaica	11.4
Surinam	5.0
Guyana	3.0
Greece	3.0
United States	1.7
India	1.5
Other non-communist countries	7.7
Total non-communist countries	71.8
Communist countries	12.2
World total	84.0

Source: United States Bureau of Mines, Mineral Commodity Summaries, January 1979.

Prices and trade

The year began with official prices posted at U.S. 53 cents per pound for primary ingot and dealer prices in the U.S. 46 to 47 cent range. As the year progressed demand strengthened for fabricated products, inventories declined and prices firmed. In February, Kaiser increased its flat rolled product prices by over U.S. 5 cents per pound, and during May it raised the primary ingot price to U.S. 57 cents. Consolidated Aluminum Corporation followed with an increase to U.S. 57.5 cents. Other major producers did not follow, resulting in a split pricing system. In June, Alcan raised its export prices 2 cents to U.S. 53 cents cif major ports and to U.S. 54.5 cents elsewhere. Anaconda, Revere Copper and Brass Incorporated, and Howmet Aluminum Corporation raised their U.S. ingot price 3 cents to U.S. 56 cents. Other major producers stayed at U.S. 53 cents for ingot but effected numerous price increases for their fabricated products. At this point in time, dealer ingot prices had increased to around U.S. 51 cents. In September, Alcan and Kaiser raised export ingot prices a further 3 cents per pound, and Alcan raised its North America price to U.S. 55 cents. In mid-December, Alcoa announced a 2.5 cent ingot price increase to U.S. 55.5 cents and Reynolds advised customers of an identical increase. At this time, fabricated products were subjected to price increases generally ranging from 6 to 9 per cent. By year-end, dealer prices had risen to the 55.5-56.5 cent range.

On October 2, the London Metal Exchange entered into aluminum trading with a three-month forward contract unit of 25 tonnes, 99.5 per cent minimum purity. Trading has been modest and has had little impact on world markets. Year-end warehouse stocks were 3 075 tonnes in preparation for physical deliveries and spot sales, which will commence January 2, 1979.

Technology

Global reserves of bauxite are enormous but they are scarce in developed countries where aluminum consumption is high. Thus, strategic considerations plus fears of cartel pricing by the International Bauxite Association (IBA) have resulted in efforts to develop alternate raw materials. Alcan and Pechiney Ugine Kuhlmann Corporation completed a test program on a new process to extract alumina from sources such as clay. The companies have commenced an 18-month feasibility study on constructing a 50 000 to 100 000 tonne per year alumina plant that will use the new process. The Canada Centre for Mineral and Energy Technology (CANMET), a research arm of the Canadian government, is examining potential domestic raw material sources – promising candidates include coal mining wastes, anorthosite and ash from coal-fired power plants.

Rising costs of electricity and higher costs of construction have resulted in efforts to improve the output and efficiency of existing aluminum facilities. The new Alcoa chloride process represents a significant step toward this objective, although some problems remain to be overcome.

Noteworthy events in the usage of aluminum in 1978 were the development of a method to combine lithium with aluminum (yielding a potentially superior family of alloys) and the apparent decision by the auto industry to use aluminum engine blocks in future models.

Outlook

The industry will enter 1979 with a lean stock position and a world demand growth probably in excess of 5 per cent. Average 1979 use in new automobiles is expected to be 57.6 kilograms (kg) as opposed to 51.7 (kg) in 1978 and could exceed 68 kg by the 1980s. In 1979 emphasis will continue to be placed on maximizing production from existing facilities by modernization and adopting technological improvements. Major producers will show increasing interest in scrap recycling as a way to augment their production. Higher power costs will be used as justification for raising ingot prices to around 60 cents per pound – prices on fabricated products will probably rise at a faster rate.

Tariffs

Canada

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

United States

Item No.		
417.12	Aluminum compounds: hydroxide and oxide (alumina)	free
601.06	Bauxite	free
618.01	Unwrought aluminum in coils, uniform cross section not greater than 0.375 inch, per pound	1.2¢
618.02	Other unwrought aluminum, excluding alloys, per pound	1.0¢
618.04	Aluminum silicon, per pound	1.0¢
618.06	Other aluminum alloys, per pound	1.0¢
618.10	Aluminum waste and scrap, per pound [1]	0.7¢

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978), ITC Publication 843.
Various tariffs are in effect on more advanced fabricated forms of aluminum.
[1] Duty on waste and scrap temporarily suspended.
na Item does not qualify under the General Preferential Tariff.

Antimony

J.J. HOGAN

Antimony produced in Canada in 1978 was obtained as a byproduct of lead smelting operations and from the treatment of antimonial ores. The value of the antimony content of primary antimonial-lead alloy produced in 1978 was $2 057 000, compared with $2 519 739 in 1977. The value of antimony contained in ores and concentrates produced in 1978 was $5 590 000, compared with $6 639 005 in 1977. The quantity of antimony contained in antimonial ores and concentrates, as reported by Statistics Canada, is withheld to protect the confidentiality of the sole producer.

Imports of antimony oxide in 1978 totalled 906 686 kilograms (kg) of which the United Kingdom supplied 84 per cent, the United States 11 per cent and Belgium and Luxembourg 4 per cent.

Cominco Ltd., which operates a lead smelter and refinery at Trail, British Columbia, is the main producer of primary antimonial lead in Canada. It can produce antimonial lead with an antimony content ranging up to 23 per cent, depending on customer requirements. Antimony contained in antimonial-lead alloy produced by Cominco in 1978 was reported at 454 tonnes*, compared with 596 tonnes in 1977. The only other primary producer of antimonial lead is Brunswick Mining and Smelting Corporation Limited, Smelting Division, which operates a lead plant at Belledune, New Brunswick. The antimony is contained in a slag produced from the recovery of lead. Secondary smelters recovered antimonial lead from scrap metal but no recent statistical data are available concerning this production.

Domestic sources and occurrences

Most of the antimonial lead produced at Trail is a byproduct of the lead concentrate obtained from ores of Cominco's Sullivan mine at Kimberley, British Columbia. Other sources are the lead-silver ores and concentrates shipped to Trail from other Cominco mines and from custom shippers. The lead bullion produced from the smelting of these ores and concentrates contains about 1 per cent antimony, which is recovered in anode residues from the electrolytic refining of the lead bullion and furnace drosses. These residues and drosses are treated to yield antimonial-lead alloy, to which refined lead may be added to produce marketable products of the required grade. At Belledune, the Brunswick Mining and Smelting plant has facilities for producing antimonial-lead alloys of varying grades to suit market requirements.

Consolidated Durham Mines & Resources Limited operates Canada's only antimony mine. It mines low-angle dipping veins containing stibnite (Sb_2S_3) at its Lake George property near Fredericton, New Brunswick. Underground development on the 213 metre (m) level, the lowest level in the mine, was completed in the fiscal year ending June 30, 1978. To explore for further ore reserves an extensive diamond-drilling program was carried out to test the more favorable zones on the property. At year-end this work was continuing. Drilling will be done to investigate the deposit below the present mining area. Ore reserves at the end of the fiscal year 1978 were 275 000 tonnes, containing 3.44 per cent antimony per tonne. During the fiscal year the concentrator, rated at a capacity of 360 tonnes of ore per day, treated 82 300 tonnes of ore to produce about 3 520 tonnes of concentrates, averaging 65.6 per cent antimony. The concentrates were of premium quality and were shipped to Europe, the United Kingdom, Japan and the United States.

Placer Development Limited will obtain control of Equity Mining Corporation's Sam Goosly silver-copper property near Houston, British Columbia. Placer purchased from Kennecott Copper Corporation its 30 per cent net profit interest in the property for $5 100 000. Under an agreement with Equity, Placer will acquire a 70 per cent interest in Equity Silver Mines Limited, a company to be formed to take over ownership of the property, for the payment of $2 300 000 to Equity. Placer will have the responsibility for bringing the property into production and for its operation. The property will be brought into production at an expected rate of 4 500 tonnes per day. There are two separate ore zones on the property but the Southern Tail, the smaller zone, which contains an estimated 6 800 000 tonnes grading 92.6 grams (g) of silver and 1.2 g of gold per tonne and 0.42 per cent copper and 0.087 per cent antimony, will be brought into production first. Metallurgical tests have indicated that the antimony

*The term "tonne" refers to the metric ton of 2 204.6 pounds avoirdupois.

Table 1. Canada, antimony production, imports and consumption, 1977 and 1978

	1977		1978[p]	
	(kilograms)	($)	(kilograms)	($)
Production				
Antimonial lead alloy	596 210	2 519 739	454 000	2 057 000
Antimony in ores and concentrates	. .	6 639 005	. .	5 590 000
Total	. .	9 158 744	. .	7 647 000
Imports				
Antimony oxide				
United Kingdom	553 881	1 827 000	741 170	2 831 000
Belgium-Luxembourg	33 929	108 000	119 476	364 000
United States	35 380	133 000	34 836	125 000
France	2 994	15 000	11 204	42 000
Total	626 184	2 083 000	906 686	3 362 000

	1977			1978[p]		
	Antimony Metal	Antimonial Lead Alloy[1]	Total	Antimony Metal	Antimonial Lead Alloy[1]	Total
		(kilograms)			(kilograms)	
Consumption[2]						
Antimony used for, or in the production of:						
Antimonial lead	254 385	na	254 385	212 134	na	212 134
Babbitt	18 660	6 268	24 928	27 132	6 412	33 544
Batteries	na	1 067 298	1 067 298	. .	878 415	. .
Solder	17 929	15 518	33 447	22 907	. .	. .
Type metal	16 976	115 190	132 166	. .	. .	126 761
Other commodities	62 917	142	63 059	71 348	. .	. .
Total	370 867	1 204 416	1 575 283	347 906	1 000 732	1 348 638
Held by consumers on December 31[2]	27 932	132 262	160 194	101 814	91 049	192 863

Source: Statistics Canada.
[1] Antimony content of primary and secondary antimonial lead alloys. [2] Available data, as reported by consumers.
[p] Preliminary; . . Not available due to confidentiality; na Not applicable.

contained in the concentrates can be extracted economically and it should be an important source of byproduct antimony.

World review

Increasing use of the lead-calcium automotive battery and the low antimonial-lead battery has cut into the demand for the standard antimonial-lead battery. However, any decrease in the demand for antimony as a result of these batteries could be offset somewhat by growth in the demand for other types of batteries with high antimony content, such as batteries used in industrial traction equipment, and by increased consumption of antimony oxide as a flame retardant.

World mine production of antimony in 1978 was estimated by the United States Bureau of Mines to be 66 906 tonnes, compared with 71 395 tonnes in 1977. Lower antimony output by Bolivia and Thailand was the main cause for reduced world output.

The world's major primary antimony producers in decreasing order of output in 1978 were: Bolivia, the People's Republic of China, the Republic of South Africa and U.S.S.R. In 1978 it is estimated that these four countries accounted for about 64 per cent of the world total. Other countries with significant output were Canada, Thailand, Yugoslavia, Mexico, Turkey, Morocco and Australia. In Australia the Silver Spec mine, an antimony-gold producer, closed early in 1978.

Consolidated Murchison Limited operates the world's largest antimony mine near Gravelotte in northern Transvaal, Republic of South Africa. The company processed 563 150 tonnes of ore in 1978, compared with 671 900 tonnes in 1977. Mine output was 16 290 tonnes of antimony

Table 2. Canada, consumption and consumers' stocks of antimony[1], 1960, 1965, 1970 and 1975-78

	Consumption			On hand at end of year		
	Antimony Metal	Antimonial Lead Alloy[2]	Total	Antimony Metal	Antimonial Lead Alloy[2]	Total
		(kilograms)			(kilograms)	
1960	431 691	1 029 431	1 461 122	205 359	119 119	324 478
1965	299 206	1 258 828	1 558 034	109 241	60 771	170 012
1970	518 007	635 212	1 153 219	131 501	91 563	223 064
1975	454 164	723 155	1 177 319	116 760	170 478	287 238
1976	437 998	1 038 234	1 476 232	30 338	224 664	255 002
1977	370 867	1 204 416	1 575 283	27 932	132 262	160 194
1978	347 906	1 000 732	1 348 638	101 814	91 049	192 863

Source: Statistics Canada.
[1] Available data, as reported by consumers. [2] Antimony content of primary and secondary antimonial lead alloys.

concentrates and cobbed ore in 1978, with a grade of under 60 per cent of contained antimony, compared with 19 825 tonnes with an average grade of 57.25 per cent antimony in 1977. The concentrate contains some gold – 177 kg in 1978. Reserves are sufficient for eight years of mine operation at the current production level. Additional orebodies were constantly being searched for. Despite a lower-milling rate the unit costs increased by only 6 per cent because of improved mining and metallurgical procedures. About one third of the mine's concentrate output was converted to crude antimony oxide at the nearby plant of Antimony Products (Proprietary) Limited, in which Consolidated Murchison holds a 37.5 per cent interest. Most of the product from this plant was exported and requires further refining. Metallurgical problems occur in controlling the arsenic content in the final concentrate.

Bolivia continued to be the world's largest antimony producing country in 1978 with an estimated mine output of 12 672 tonnes. In 1978 Bolivia established a National Committee of Antimony Producers to look after interests of the private miners of antimony and to work towards the establishment of an International Antimony Council. Bolivia plans to build a lead-silver smelter near Potosi and antimony will be one of the byproducts to be produced. No concrete action has been taken on this project at year-end.

Expansion programs in Yugoslavia at the Brskovo mine in Jojkova and the Srebrencia and Trepca mines in Kosovska Mitrovica should increase the output of antimony. Also it is reported that a new lead smelter with a capacity of 163 000 tonnes is under construction in the chief lead-zinc complex at Trepca and antimony will be one of the byproducts to be produced at this plant.

ASARCO Incorporated reported that in December 1978 it began full production of antimony oxide at its new $2.2 million plant at Omaha, Nebraska. The plant capacity is 204 tonnes of antimony oxide per month. It converts antimony, which is a byproduct of lead ores, into antimony oxide.

N L Industries, Inc. sold its antimony plant at Laredo, Texas to Anzon America Limited, a new subsidiary of Lead Industries Group Ltd., a United Kingdom company. Anzon

Table 3. World mine production of Antimony, 1976-78

	1976	1977	1978[p]
		(tonnes)	
Bolivia	15 307	15 156	12 672
People's Republic of China[e]	12 000	12 000	12 000
Republic of South Africa	10 698	11 535	10 478
U.S.S.R.[e]	7 700	7 900	7 900
Canada[e,1]	2 300	3 200	3 000
Thailand	3 671	5 238	2 873
Yugoslavia	2 021	2 248	2 760
Mexico[2]	2 546	2 698	2 457
Turkey	1 784	2 438	2 440
Morocco	1 415	1 409	2 110
Australia	1 892	1 574	2 100
Italy	1 009	808	931
United States	257	553	907
Peru	603	823	895
Czechoslovakia	285	300	300
Guatemala	1 120	918	230
Other countries	2 069	2 597	2 853
Total	66 677	71 395	66 906

Source: The United States Department of the Interior, U.S. Bureau of Mines, Mineral Trade Notes, Vol. 76, No. 6, June 1979.
[1] Partly estimated on the basis of value of total production of antimonial lead. [2] Antimony content of ores for export plus antimony content of antimonial lead and other smelter products.
[p] Preliminary; [e] Estimated.

will get N L's antimony trioxide customers along with the plant. N L Industries closed the smelter in November 1977 because of the depressed state of the antimony market.

The United States was again the non-communist world's largest consumer of antimony and continued to depend on foreign suppliers, particularly Bolivia and Canada for ores and concentrates, the People's Republic of China for antimony metal and the Republic of South Africa, United Kingdom, France and the People's Republic of China for antimony oxide. The People's Republic of China was the largest overall supplier of antimony in 1978, with 2 878 tonnes, followed by the Republic of South Africa, with 2 283 tonnes. The United States total consumption of primary antimony in 1978 was 11 653 tonnes and was equivalent to over 17 per cent of the world primary production.

Table 4. Industrial consumption of primary antimony in the United States, by class of material produced, 1976-78

	1976	1977	1978p
	(tonnes, antimony content)		
Metal products			
Ammunition	57	125	122
Antimonial lead	3 503	2 663	2 086
Bearing metal and bearings	367	240	194
Cable covering	17	15	18
Castings	22	12	—
Collapsible tubes and foil	21	15	16
Sheet and pipe	67	51	31
Solder	170	200	122
Type metal	72	75	13
Other	149	94	33
Total	4 445	3 490	2 635
Nonmetal products			
Ammunition primers	12	12	7
Fireworks	11	8	3
Flameproofing chemicals and compounds	5 037	5 230	3 466
Ceramics and glass	1 143	1 403	1 324
Pigments	376	363	198
Plastics	1 158	1 364	656
Rubber products	524	429	34
Other	1 207	241	18
Total	9 468	9 050	5 706
Total reported	13 913	12 540	8 341
Grand total	13 913	12 540	11 653[1]

Sources: U.S. Bureau of Mines, Mineral Industry Surveys.
[1] Estimated 100 per cent coverage based on reports from respondents that consumed 69 per cent of the total antimony in 1977.
p Preliminary; — Nil.

In 1978 there were no sales of antimony by the United States General Services Administration (GSA) from the nation's strategic and critical stockpile. The stockpile goal as of November 30, 1978 was 18 262 tonnes. At the end of 1978 the stockpile contained a total of 36 949 tonnes, leaving a surplus of 18 687 tonnes of antimony which may not be disposed of without congressional approval. The disposal policy of the United States Administration has yet to be determined.

Uses

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

Antimony hardens and strengthens lead and inhibits chemical corrosion. The use of antimonial lead in storage batteries remains its major outlet, but due to technological developments the antimony content in batteries has been progressively reduced in recent years, from about 12 per cent to current levels that vary from 2.5 per cent to 6 per cent of the antimonial lead contained. Because of this rapid technological change in the lead-acid battery market, the use of antimony in this sector is expected to decline substantially over the next five to ten years through a replacement of antimony by calcium and other lead alloys.

Antimonial-lead alloys are also used for power transmission and communications equipment, printing metal, solder, ammunition, chemical pumps and pipes, tank linings, roofing sheets and antifriction bearings. Antimony increases hardness, minimizes shrinkage, permits sharp definition and lowers the melting point of type metal. In antifriction bearings, the antimony forms hard tin-antimony crystals that increase bearing life.

Antimony oxide (Sb_2O_3), usually produced directly from high-grade sulphide ore, is used extensively in plastics and in flameproofing compounds, the most important growth area in antimony consumption.

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

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

Outlook

Changes in the lead-acid battery technology, which led to the introduction of maintenance free batteries that use either a nonantimonial lead or low-antimony-lead alloy, has drastically reduced the demand for antimony. The declining demand for antimonial lead auto batteries may be offset somewhat by growth in demand for other types of batteries that use antimony, such as industrial type batteries used by industry. Stocks of antimonial lead in the hands of the secondary refiners could increase because the new antimonial lead battery contains about 50 per cent less antimony than the older batteries. This surplus would last at least until the new antimonial batteries enter the secondary market.

The use of antimony oxide in flame retardants could expand over the years, especially in the installation of flame-proofed materials in automobiles, which is obligatory under government regulations in the United States. Government regulations for flame-proofing in the United States also apply to a number of other applications, such as children's sleepwear, bedding products, carpet fibres and other textiles.

In the short- to medium-term the supply of antimony will be more than adequate to meet demand. Many producers lowered output in 1978 to offset an expected lower demand. The price of antimony strengthened towards the end of 1978 but no large price increase is anticipated in the near future. China is a large supplier of antimony metal and oxide to the world's market, but its unpredictability in making supplies available to the world markets could affect world prices. In the long-term, reserves should be sufficient to meet requirements.

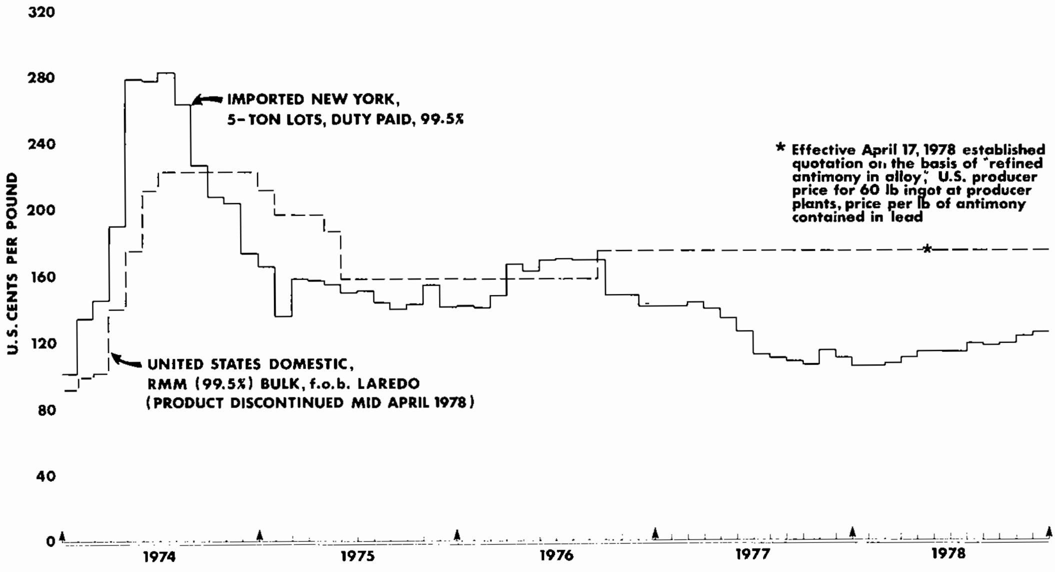
Prices

The traditional United States method of pricing antimony metal on the basis of RMM brand for 99.5 per cent antimony and the Lone Star brand antimony metal for 99.8 per cent antimony, which were produced at N L Industries, Inc.'s plant, Laredo, Texas, was discontinued in April 1978 because the plant closed in 1977 and all stockpiled metal was depleted by April. A new quotation was established effective April 17, 1978. The new price is based on the antimony contained in alloy for 60 lb ingots fob at the plants of N L Industries, Inc. and RSR Corporation, the two largest United States antimony alloy producers. The new price remained unchanged at $U.S. 1.75 per pound of antimony throughout the year, the same price as quoted for the RMM brand in the first part of the year.

The New York dealer price for foreign antimony metal increased steadily during 1978. Early in January the dealer price for 99.5 to 99.6 per cent antimony metal cif port, for 5 short-ton lots, as quoted in *Metals Week*, was $U.S. 1.05 to $U.S. 1.10 per pound of antimony. In March the price started an upward trend, closing for the year at $U.S. 1.23 to $U.S. 1.28 per pound of antimony, near the peak price for the year of $U.S. 1.28 to $U.S. 1.30 per pound obtained early in December 1978.

The European free market metal price, 99.6 per cent antimony, cif Europe, as quoted in *Metals Bulletin*, opened for the year 1978 at $U.S. 2 140 to $U.S. 2 180 per tonne of antimony. In March the antimony price began moving upwards and closed for the year 1978 at $U.S. 2 625 to $U.S. 2 700 per tonne. The peak price for antimony for the year 1978 was $U.S. 2 700 to $U.S. 2 750 per tonne and it was recorded on November 23.

ANTIMONY METAL PRICES



Source: METALS WEEK

Antimony ore prices in the United States market, as quoted in *Metals Week*, varied slightly during 1978. The price from the beginning of the year until mid-October was quoted at \$U.S. 16.20 to \$U.S. 18.20 per short ton unit (stu) for 60 per cent lump ore. In early November the quoted price was \$U.S. 19.00 to \$U.S. 19.75 per stu and it remained at this level for the balance of the year.

The price for antimony trioxide, 98 per cent metal fob Laredo, Texas remained unchanged during 1978 at \$U.S. 1.64 to \$U.S. 1.80 per pound.

Tariffs

Canada

Item No.		British Preferential	General Preferential	Most Favoured Nation	General
33000-1	Antimony, or regulus of, not ground, pulverized or otherwise manufactured	free	free	free	free
33502-1	Antimony oxides	free	free	12½%	25%

United States

TSUS No.		Non-communist countries	Communist countries except Yugoslavia
601.03	Antimony ore	free	free
632.02	Antimony metal, unwrought (duty on waste and scrap temporarily suspended)	1¢ per pound	2¢ per pound

European Economic Community (EEC)

Brussels Tariff Nomenclature No.		Autonomous	Conventional
26.01	Antimony ore	free	free
81.04	I. Antimony, unwrought; waste and scrap	8%	*
	II. Other antimony	10%	8%

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States, Annotated (1978) ITC Publication 843; Official Journal of the European Communities, 1978.
* Where no conventional duty is quoted, duty shall normally be chargeable at the rate of the autonomous duty.

Asbestos

G.O. VAGT

Shipments of asbestos in 1978 were lower than in 1977, mainly as a result of decreased construction industry activity in the industrialized countries. Major strikes by employees of three companies, in addition to closure of the Clinton Creek, Yukon Territory mine owned by Cassiar Asbestos Corporation Limited, also contributed to lower output.

The Quebec government passed, on May 25, 1978, Bill 70 to establish the Société nationale de l'amiante (SNA). This law is expected to allow SNA to purchase from General Dynamics Corporation, of St. Louis, Missouri, its 54.6 per cent holding in Asbestos Corporation Limited, the second-largest asbestos producer in Canada.

Canadian production (shipments)

Canadian production of asbestos fibre in 1978 was 1 380 000 tonnes valued at $601 631 000, compared with 1 517 360 tonnes valued at $563 532 418 in 1977. Approximately 88 per cent of total production is from Quebec, 5 per cent each from British Columbia and Yukon Territory and 2 per cent from Newfoundland.

Since 1977, total production data has included the approximate quantities of fibre contained in shipments of concentrate from Ungava to West Germany, not included are relatively small quantities of serpentine filler produced by Hedman Mines Limited, Timmins, Ontario.

Canada exports approximately 95 per cent of its total production of asbestos fibre to more than 80 countries. Exports totalled 1 397 939 tonnes* in 1978 with approximately 75 per cent of the total distributed among the following nine countries: United States, 38.6 per cent; West Germany, 10.8; Japan, 8.4; the United Kingdom, 6.3; Mexico, 3.1; France, 2.7; Brazil, 2.2; Spain, 1.8 and Belgium-Luxembourg 1.6 per cent. In 1977, Canadian exports provided the noted approximate percentage of total asbestos imports into: United States, 94 per cent; European Economic Community, 63; Japan, 40; Eastern Europe, 6 and others, 42 per cent.

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Strikes resulted in a three-month work stoppage at Advocate Mines Limited, a four-month stoppage at Carey-Canada Mines Ltd. and a four-month stoppage that continued into mid-January 1979 at Cassiar Asbestos Corporation Limited.

Bill 70, introduced last year to create the Quebec provincial corporation, Société national de l'aminate (SNA), was assented to in May, allowing SNA to officially become an active enterprise responsible for management of Asbestos Corporation Limited (ACL) following expected acquisition of control from General Dynamics Corporation. Bill 121, to enable the Quebec government to expropriate some of the assets of ACL, was tabled in the Quebec National Assembly on December 15, 1978. The bill was introduced following an announcement by the finance minister that attempts to negotiate the purchase of the 54.6 per cent of ACL held by General Dynamics Corporation were at an impasse. Representatives for the Quebec government arrived at an evaluation of approximately $42 a share for ACL, whereas consultants for General Dynamics arrived at a figure of about $100 a share. The bill provides for an arbitration committee if a sale price cannot be agreed upon within two months of a notice of expropriation. Rights to appeal an arbitral decision in the regular courts will be available to both parties. As defined by Quebec, the indemnity to be paid to ACL would be calculated on the basis of "fair market value" of the assets at the time of expropriation and established in relation to the company's continued operation.

Developments at the asbestos producing mines in Canada are highlighted in the accompanying table. Johns-Manville Canada Inc., continued its $77 million, five-year investment program designed to ensure optimum annual production of over 600 000 tonnes of fibre per year over the next 25 years.

Asbestos Corporation Limited invested approximately $21 million for capital expenditures and mine development. Of this amount, $5 million was attributed to the underground development program at the Asbestos Hill mine in Ungava. Approximately $29 million has been spent or committed during the past three years to improve environmental conditions at the mine.

Table 1. Canada, asbestos production and trade, 1977 and 1978

	1977		1978p	
	(tonnes)	($)	(tonnes)	($)
Production (shipments)				
By type				
Crude, groups 1, 2 and other milled	1	2 659	. .	. .
Group 3, spinning	26 853	30 822 916	. .	. .
Group 4, shingle	523 819	316 918 002	. .	. .
Group 5, paper	211 514	87 676 979	. .	. .
Group 6, stucco	234 867	60 934 642	. .	. .
Group 7, refuse	520 304	67 177 094	. .	. .
Group 8, sand	2	126	. .	. .
Total	1 517 360	563 532 418	1 380 000	601 631 000[1]
By province				
Quebec	1 253 353	416 129 432	1 216 000	509 431 000
British Columbia	97 033	69 729 205	73 000	47 257 000
Yukon	95 590	47 493 872	64 000	32 404 000
Newfoundland	64 759	29 449 609	27 000	12 539 000
Ontario	6 625	730 300	—	—
Total	1 517 360	563 532 418	1 380 000	601 631 000
Exports				
Crude				
United States	1	3 000	1	2 000
Total	1	3 000	1	2 000
Milled fibre (groups 3, 4 and 5)				
United States	123 342	74 257 000	126 354	83 819 000
West Germany	90 625	54 562 000	123 318	62 126 000
United Kingdom	40 917	26 527 000	39 494	27 828 000
Mexico	24 490	14 795 000	35 463	23 886 000
France	23 310	13 783 000	26 498	17 513 000
Japan	35 326	18 012 000	32 974	17 429 000
India	16 182	9 907 000	21 556	13 950 000
Spain	35 292	21 642 000	18 525	12 229 000
Brazil	14 559	8 742 000	17 570	10 856 000
Belgium-Luxembourg	14 241	8 610 000	13 983	9 859 000
Italy	23 252	14 721 000	13 518	9 715 000
Malaysia	11 330	6 148 000	14 403	8 626 000
Other countries	252 807	148 669 000	205 893	132 684 000
Total	705 673	420 375 000	689 549	430 520 000
Shorts (groups 6, 7, 8 and 9)				
United States	389 630	64 909 000	413 137	71 604 000
Japan	87 894	20 405 000	84 445	20 185 000
United Kingdom	43 441	7 486 000	48 344	8 944 000
West Germany	33 852	6 733 000	27 084	5 323 000
Netherlands	27 451	4 389 000	23 705	4 247 000
Brazil	8 941	1 353 000	12 886	2 528 000
Belgium-Luxembourg	8 858	1 994 000	9 168	2 456 000
Mexico	5 079	1 176 000	8 386	2 209 000
France	15 458	2 493 000	12 003	2 175 000
Venezuela	4 321	839 000	5 791	1 612 000
Thailand	7 677	2 119 000	5 431	1 593 000
Spain	6 459	1 589 000	6 162	1 583 000
Taiwan	2 613	754 000	4 583	1 426 000
South Korea	9 649	2 716 000	3 965	1 163 000

Table 1. (cont'd)

	1977		1978ᵖ	
	(tonnes)	($)	(tonnes)	($)
Shorts (cont'd)				
Argentina	6 815	1 270 000	4 274	987 000
Other countries	51 432	12 690 000	39 025	9 737 000
Total	709 570	132 915 000	708 389	137 772 000
Grand total crude, milled fibres and shorts	1 415 244	553 293 000	1 397 939	568 294 000
Manufactured products				
Asbestos cloth, dryer felts, sheets				
United States		1 085 000		3 195 000
United Kingdom		88 000		215 000
South Africa		—		99 000
Finland		—		77 000
Thailand		32 000		46 000
Australia		2 000		35 000
Other countries		35 000		159 000
Total		1 242 000		3 826 000
Brake linings and clutch facings				
United States		2 811 000		2 992 000
Australia		124 000		124 000
Hong Kong		44 000		93 000
Ecuador		146 000		90 000
France		50 000		80 000
Guatemala		21 000		46 000
Netherlands		7 000		11 000
Uruguay		16 000		10 000
Taiwan		—		10 000
Other countries		118 000		35 000
Total		3 337 000		3 491 000
Asbestos and asbestos cement building materials				
United States		12 049 000		12 189 000
Mexico		1 000		949 000
Australia		138 000		203 000
Singapore		342 000		179 000
Netherlands		606 000		171 000
United Kingdom		748 000		107 000
Belgium-Luxembourg		—		95 000
Ivory Coast		—		50 000
Thailand		58 000		25 000
Other countries		1 068 000		182 000
Total		15 010 000		14 150 000
Asbestos basic products, nes				
United States		5 505 000		5 123 000
Switzerland		117 000		85 000
U.S.S.R.		—		80 000
France		6 000		22 000
Netherlands Antilles		28 000		9 000

Table 1. (cont'd)

	1977		1978ᵖ	
	(tonnes)	($)	(tonnes)	($)
Asbestos basic products (cont'd)				
Other countries		56 000		32 000
Total		5 712 000		5 351 000
Total exports, Asbestos manufactured		25 301 000		26 818 000
Imports				
Asbestos, unmanufactured	4 112	2 035 000	756	556 000
Asbestos, manufactured				
Cloth, dryer felts, sheets, woven or felted		3 949 000		4 504 000
Packing		2 087 000		2 258 000
Brake linings		4 612 000		6 758 000
Clutch facings		1 305 000		1 258 000
Asbestos-cement shingles and siding		88 000		78 000
Asbestos-cement board and sheets		525 000		567 000
Asbestos building materials, nes		5 933 000		6 770 000
Asbestos basic products, nes		3 790 000		4 317 000
Total Asbestos, manufactured		22 289 000		26 510 000
Total Asbestos, unmanufactured and manufactured		24 324 000		27 066 000

Source: Statistics Canada.
[1] Value of containers not included.
ᵖ Preliminary; — Nil; nes Not elsewhere specified; . . Not available.

Bell Asbestos Mines, Ltd., continued its large expansion and improvement program to increase underground automation and to increase levels of production.

At Carey-Canadian Mines Ltd. and at Advocate Mines Limited, major emphasis continued to be placed on modernization and environmental control programs.

Cassiar Asbestos Corporation Limited ceased its Clinton Creek, Yukon Territory mining operation as planned because ore reserves are essentially depleted. The mine officially started production in 1968 and produced 937 756 tonnes of fibre, valued at $295 million. The closure of the mine also resulted in the shutdown of Cassiar's Transport Division based in Whitehorse, Yukon Territory. All of the company's shipments enroute to Vancouver from the Cassiar, British Columbia mine started to pass through the port of Stewart, British Columbia instead of Whitehorse and Fort Nelson.

Prospective producers

Brinco Limited continued discussions with prospective partners that could lead to the development of the "A" asbestos deposit of Abitibi Asbestos Mining Company Limited. This property is located 84 kilometres (km) north of Amos, Quebec. Capital costs to bring the project into production are now estimated to be over $400 million, based on an annual output of approximately 200 000 tonnes of fibre. Ore reserves in the "A" deposit are estimated at 100 million tonnes averaging 3.5 per cent asbestos fibre.

Rio Algom Limited held in abeyance further development of the Roberge Lake Project. This property, owned by McAdam Mining Corporation Limited, is situated approximately 32 km east of Chibougamau, Quebec.

Cassiar continued the evaluation of its Kutcho Creek property near Dease Lake in northern British Columbia.

World production, and developments in major markets

Total world production of asbestos in 1978 was an estimated 4.8 million tonnes, based on the inclusion of Russian grades approximately equivalent to Canadian grades. Chrysotile accounted for about 90 per cent of world production with the remaining production consisting of about 6 per cent crocidolite (blue asbestos) and 3 per cent amosite. Less than 1 per cent of other types of asbestos, including tremolite and anthophyllite, was produced, mainly in the United States.

The accompanying diagrams show a breakdown of 1977 world asbestos production and consumption by country. Discrepancies occur in the data available from the U.S.S.R. and also in the interpretation of these data, resulting in problems of statistical correlation. Most of the annual output from the U.S.S.R. is consumed domestically, although about 600 000 tonnes are exported, mainly to

Table 2. Canadian asbestos producers and prospective producers, 1978.

	Mine Location	Mill Capacity (tonnes) ore/day	Mill Capacity (tonnes) fibre/year	Remarks
Producers				
Advocate Mines Limited	Baie Verte, Nfld.	6 800	80 000	Open pit. Produces groups 4 and 6.
Carey-Canadian Mines Ltd.	East Broughton, Que.	5 000	210 000	Open pit. Mainly produces groups 6 and 7.
Asbestos Corporation Limited				World's major independent asbestos producer.
Asbestos Hill mine	Putuniq, Que.	5 400	90 000	Annual rated capacity 272 000 tonnes concentrate. Final processing of fibre in West Germany.
British Canadian mine	Black Lake, Que.	11 200		Open pit, two milling plants.
King-Beaver mine	Thetford Mines, Que.		210 000	Underground and open pit.
Mormandie mine	Black Lake, Que.	6 800		Reserves exhausted. Mill processes K-B open-pit ore.
Bell Asbestos Mines, Ltd.	Thetford Mines, Que.	2 700	55 000	Underground.
Lake Asbestos of Quebec, Ltd.	Black Lake, Que.	8 200	235 000	Open pit.
National Mines Division	Thetford Mines, Que.	3 200		Open pit.
Johns-Manville Canada Inc.				
Jeffery mine	Asbestos, Que.	30 000	645 000	Open pit (western world's largest known asbestos deposit)
United Asbestos Inc.	Matachewan, Ont.	3 600	100 000	Inactive.
Cassiar Asbestos Corporation Limited				
Cassiar mine	Cassiar, B.C.	3 000	100 000+	Open pit.
Clinton mine	Clinton Creek, Yukon	3 600	100 000+	Open pit. Closed in August after depletion of reserves.
Prospective Producers				
Abitibi Asbestos Mining Company Limited	Amos, Que.	11 800		Feasibility study underway.
McAdam Mining Corporation Limited	Chibougamau, Que.	4 500		Feasibility study underway.
Cassiar Asbestos Corporation Ltd.	Dease Lake, B.C.			Possible future development.

Sources: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa; Quebec Asbestos Mining Association, Quebec.

eastern European countries, Japan, France, West Germany and India.

Asbestos reserves in the U.S.S.R. are known to be very large and are probably greater than those in Canada. The three major producing areas in the U.S.S.R. are: the Bazhenovo deposits of the Uralasbest Combine in the Central Urals, near Sverdlovsk, where there is capacity of about 1.7 million tonnes per year of fibre; the Kustanay Combine in the Dzhetygara district of Northwest Kazakhstan, along the eastern flanks of the southern Urals, where there is capacity of about 600 000 tonnes per year; and Aktovrak, Tuva district to the west of Lake Baikal, with a reported capacity of 200 000 tonnes per year. Progress continues at the new Kiembay deposit in the southern Urals where several Council for Mutual Economic Assistance (COMECON) countries are assisting in the completion of the project designed to produce 550 000 tonnes per year of asbestos. The COMECON countries are expected to receive most of the output from this new project.

The Republic of South Africa has the only commercial deposit of amosite in the world and is also a major producer of crocidolite and chrysotile. Approximately 30 per cent of this country's total asbestos production of about 360 000 tonnes is chrysotile. Cutbacks in production of amosite and crocidolite were implemented at year-end as a result of depressed world demand.

Official figures for asbestos output have not been available from Rhodesia since the country's Unilateral Declaration of Independence in November, 1965 and subsequent imposition of United Nations trade sanctions. Rhodesia was the third-largest producer of asbestos in the western world, after Canada and Republic of South Africa, and the country undoubtedly remains a world-ranking producer with an estimated output of 200 000 tonnes per year.

Most United States production of approximately 100 000 tonnes per year is from California and Vermont. Significant changes in levels of production are not expected. The United States produces approximately 17 per cent of its asbestos needs and imports 83 per cent, 95 per cent of which is chrysotile from Canada.

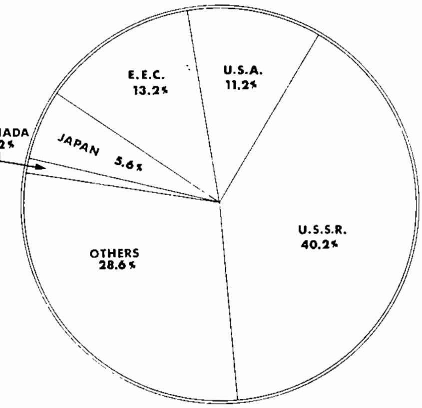
Woodsreef Mines Limited, N.S.W., Australia, remained active and is expected to receive government assistance in its attempt to attain its production goal of 100 000 tonnes of fibre per year.

In Greece, construction started on a new 100 000-tonne-per-year mill financed by the Hellenic Industrial Development Bank. The plant is scheduled to begin operations in mid-1980. The expected life of the mine is 20 years, based on presently defined reserves. About 75 per cent of the production is expected to be for export markets.

Johns-Manville Corporation, with the Gulf International Corporation group of Kuwait and the Sudanese government, continued their evaluation of asbestos deposits in the Sudan. A feasibility study will evaluate the possibility of constructing a plant to produce 100 000 tonnes of fibre per year.

Asbestos output in Brazil is expected to be 125 000 tonnes per year in 1980. Other asbestos projects in various stages of development are underway in Brazil, Mexico, Bolivia, Colombia, New Zealand and Yugoslavia.

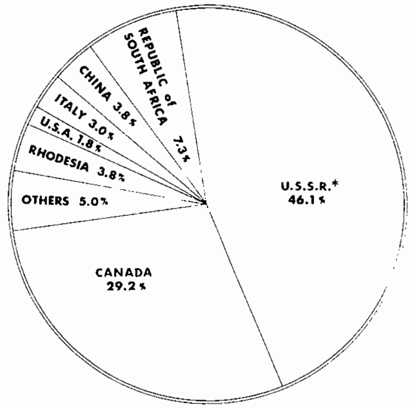
ASBESTOS APPARENT WORLD CONSUMPTION 1977



APPARENT CONSUMPTION 5,470,417 m.t.

Source: EMR estimates from numerous sources.

ASBESTOS WORLD PRODUCTION 1977



PRODUCTION 5,202,286 m.t.

Source: EMR estimates from numerous sources.
*Approximately equivalent to Canadian grades.

Fibre groups, uses and technology

The major standard used to evaluate the quality of asbestos is that developed by the industry in Quebec, whereby asbestos is classified and priced by groups according to fiber length. The longest fibre corresponds to group No. 1, the shortest to group No. 9. Because there are more than 3 000 uses for asbestos, it is more appropriate to classify the groups in categories and describe the major purposes the fibres serve than to list the products in which they are used.

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

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

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

In the United States, by far Canada's major market, about 62 per cent of asbestos is used in the construction industry in the form of roofing and flooring products and asbestos-cement pipes and sheets. A breakdown of the total apparent consumption of asbestos in the United States is as follows: asbestos-cement pipe, 24 per cent; flooring products, 23; friction products, 14; roofing products, 9; asbestos-cement sheet, 6; coatings and compounds, 5; paper, 4; packing and gaskets, 4; insulation 3; textiles and plastics, 1 per cent each; and others, 6 per cent.

Asbestos, as related to health hazards, remained a very high profile issue in the United States. The Department of Health, Education and Welfare's public awareness program on asbestos exposure consisted of radio and television spot announcements "aired" throughout the country. Publications were widely distributed with a primary aim to contact all persons who may suspect disease symptoms resulting from exposure to asbestos dust, particularly in shipyards during the Second World War.

The Consumer Product Safety Commission in the U.S. is currently reviewing studies that may lead to additional recommendations limiting the use of asbestos-based products. Thus far, bans have been effective for only a minor percentage of the total asbestos fibre market.

At a recent meeting on environmental health hazards sponosred by the New York Academy of Sciences it was stated by Dr. I. Selikoff that: "There is no evidence that the general public in U.S. cities is exposed to health risks from asbestos." Dr. Selikoff was one of the first to find a link between asbestos and lung cancer and is a scientist at the Mount Sinai School of Medicine.

Law suits against American, British and Canadian producers of asbestos and asbestos-based products continue to be filed in the United States.

In Canada, federal emission regulations, pursuant to the Clean Air Act and as recommended by the Department of Fisheries and the Environment, became effective December 31, 1978. These regulations require that the concentration of asbestos fibres contained in emissions to the ambient air at a mine or mill, from crushing, drying or milling operations, or from dry rock storage, shall not exceed two asbestos fibres per cubic centimetre (cm^3). Quebec in-plant environmental regulations are presently five fibres per cm^3 (January 1979) and are expected to be lowered to two fibres per cm^3 by January 1, 1981.

An independent study commissioned by The Quebec Asbestos Mining Association to evaluate the feasibility of manufacturing more asbestos products in Quebec concluded that there may be an opportunity to manufacture finished asbestos-cement sheet, flooring felt and molded friction materials. Investment of approximately $60 million would be necessary and 400 new jobs could be created. If the projects materialized, estimated asbestos fibre consumption would increase about 40 000 tonnes, or from the present 3 per cent of Quebec's total asbestos output to more than 7 per cent of output.

Table 3. Canada, asbestos production and exports, 1960, 1965, 1970 and 1975-78

	Crude	Milled	Shorts	Total
		(tonnes)		
Production[1]				
1960	299	438 336	576 011	1 014 646
1965	148	598 377	660 840	1 259 365
1970	6 579	668 629	832 210	1 507 418
1975	5	480 579	575 083	1 055 667
1976	27	681 003	855 061	1 536 091
1977	1	762 186	755 173	1 517 360
1978[p]	. .	. .	. .	1 380 000
Exports				
1960	219	415 539	553 563	969 321
1965	112	572 231	624 600	1 196 943
1970	91	747 814	669 509	1 417 414
1975	183	570 418[r]	514 997[r]	1 085 598[r]
1976	83	721 423[r]	776 471[r]	1 497 977[r]
1977	1	705 673	709 570	1 415 244
1978[p]	1	689 549	708 389	1 397 939

Source: Statistics Canada.
[1] Producers' shipments.
[p] Preliminary; . . Not available; [r] revised.

The Montreal Institute of Occupational and Environmental Health, founded in 1966, placed increased emphasis on methods to measure airborne asbestos fibre and reduce concentrations. The Institute's objective since inception has been the elimination of asbestos-related health hazards. Other research goals by industry and government, in addition to those relating to health, product safety and epidemiology, will continue to be oriented toward technological innovations and the development of new asbestos-based products that could lead to greater utilization of fibre. The asbestos research program established at the University of Sherbrooke in 1977 has mainly been oriented toward the development of new asbestos-based products and utilization of asbestos tailings. Asbestos research programs at Sherbrooke are coordinated with those at the Quebec Industrial Research Centre.

A mining and milling industry-goverment delegation visited the Uralasbest and Kustanay industrial complexes in the central and southern Urals of Russia in 1978. Plans for greater output are well advanced. Potential new ore reserves, particularly in eastern Siberia, appeared to be substantial and planning authorities stated that more emphasis is being placed on the use of asbestos-cement construction materials.

Outlook

Stronger demand for all grades of asbestos fibre is expected to continue into 1979, following a trend that started in late 1978.

Western world growth in asbestos demand is estimated to be in the range of 1.5 to 2 per cent during the next several years. Slow growth, or lack of growth in some industrialized countries, is expected to be offset by increased demand for asbestos from developing countries. Asbestos is expected to remain very cost competitive with its substitutes.

In Canada and elsewhere, mining companies and asbestos-based product manufacturers have greatly improved environmental conditions and most are expected to meet presently defined regulations as these become effective. Studies have indicated that employees who smoked and who were exposed to relatively high concentrations of asbestos over a long period of time suffered a much higher incidence of disease than others. These and other reasonably conclusive findings have led industry to initiate employee information programs and to define clearly certain work rules that must be followed. The rate of growth of the Canadian asbestos mining industry will be influenced by the environmental control and product-use regulations finally adopted in the United States and the European Economic Community because approximately 60 per cent of Canadian asbestos exports are destined for these markets. Environmental-health studies are ongoing in the industrialized countries and, based on present information, regulatory bodies assume that the public and the workplace can be satisfactorily protected from the risks associated with asbestos exposure through appropriate regulations and their enforcement.

If glass fibres can become cost competitive these could replace, or partially replace, asbestos in some asbestos-cement products. No satisfactory cost-competitive substitutes are available for asbestos in many applications, particulary for friction materials.

Quebec producers raised prices an average of 5.6 per cent in 1978. As of January 1, 1979, the Quebec asbestos price range was increased an average of 7.1 per cent. Cassiar Asbestos Corporation Limited increased fibre prices approximately 4 per cent in 1978 and about 6.5 per cent in January 1979.

Canadian asbestos prices quoted in "Asbestos"[1]

	Jan. 1, 1979
	($ per short ton)
Quebec, fob mines	
Crude No. 2	2 295
Group	
No. 3 (spinning fibre)	1 032 - 1 606
No. 4 (asbestos-cement fibre)	687 - 1 011
No. 5 (paper fibre)	388 - 537
No. 6 (waste, stucco, plaster)	330 - 332
No. 7 (refuse, shorts)	113 - 218
Cassiar, fob North Vancouver, B.C.	
Canadian group	
No. 3 (nonferrous spinning fibre)	
AAA grade	2 000
AA grade	1 600
A grade	1 050
AC grade	960
No. 4 AK grade (single fibre asbestos-cement)	850
No. 4 AS grade	740
No. 4 CT grade	680
No. 5 AX grade	670
No. 5 CY grade	470
No. 5 AY grade	470

[1]*Asbestos* is published monthly by Stover Publishing Company.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		%	%	%	%
31210-1	Asbestos, crude	free	free	25	free
31215-1	Asbestos, yarns, wholly or in part asbestos, for use in manufacture of clutch facings and brake linings	7.5	7.5	25	5
31225-1	Asbestos felt, rubber impregnated for use in manufacturing floor coverings	free	free	25	free
31200-1	Asbestos, in any form other than crude, and all manufactures thereof, nop	15	22.5	25	8

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		%	%	%	%
31205-1	Asbestos in any form other than crude, and all manufactures thereof, when made from crude asbestos of British Commonwealth origin, nop	free	12.5	25	free
31220-1	Asbestos woven fabric, wholly or in part asbestos for use in manufacture of clutch facings and brake linings	12.5	12.5	30	8

United States

Item No.		
518.11	Asbestos, not manufactured, crude, fibres, stucco, sand and refuse containing not more than 15 per cent by weight of foreign matter	free
		(% ad valorem)
518.21	Asbestos, yarn, slivers, rovings, wick, rope, cord, cloth, tape and tubing	4
518.51	Asbestos articles not specifically provided for	4.5
	Articles in part asbestos and hydraulic cement	(¢ per lb.)
518.41	Pipes and tubes and fittings thereof	0.15
518.44	Other	0.1

Sources: Custom Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa; Tariff Schedule of the United States, Annotated (1978), USITC Publication 843.
nop Not otherwise provided for.

Barite and Celestite

G.O. VAGT

Production of barite in 1978 was 105 741 tonnes * valued at \$1.85 million. This decreased level of production from 116 950 tonnes in 1977 resulted from closure of the Walton, Nova Scotia mine. Imports of barium carbonate, one of the most important barium chemicals derived from barite, amounted to 2 448 tonnes valued at \$791 000 in 1978.

Barite ($BaSO_4$) is a valuable industrial mineral because of its high specific gravity (4.5), low abrasiveness, chemical stability and lack of magnetic and toxic effects. Its dominant use is as a weighting agent in oil and gas well-drilling muds required to counteract high pressures confined by the substrata.

Barite is found in many countries of the world and is the raw material from which nearly all other barium compounds are derived. Witherite ($BaCO_3$) was formerly of importance but it was found in relatively large quantities only in the north of England. The United States, the principal producer of barite, with about 28 per cent of the total production, is followed by India and Ireland, both with about 6 per cent of the total, and by Mexico and Peru, both with about 5 per cent, according to United States Bureau of Mines. Canada is eleventh in world production and exports approximately 40 per cent of its output, mainly as crude barite, to grinding plants in the United States.

Production and occurrences in Canada

Barite is found in a variety of geological environments: as the principal mineral in veins along with fluorite, calcite and quartz; as a gangue mineral in some lead-zinc-silver deposits; and as irregular replacement deposits in sedimentary rocks. Pure barite is white and is most common in veins; impure barite may be near-white, grey, brown or light red. Barite was produced from operations in Nova Scotia, Ontario and British Columbia in 1978.

The Walton, Nova Scotia mine, operated by Dresser Minerals Division of Dresser Industries, Inc., ceased production from its underground mining operations as well as from stockpiles. Mining problems have persisted since 1970, when flooding first occurred, and became insurmountable as a result of severe flooding in 1978. The mine produced more than 4 million tonnes of barite since start-up in 1941.

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

Extender Minerals of Canada Limited operates a mine near Matachewan, Ontario. Barite is mined from a vein deposit by open-pit methods, with all beneficiation being done on the site.

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

Considerable efforts have been directed toward the feasibility of recovering barite from the tailings at Buchans. Production plans may be realized in the future as oil and gas exploration increase along the east coast of North America. The Lake Ainslie deposit on Cape Breton Island contains about 4.5 million tonnes of ore, grading 33 per cent barite and 17 per cent fluorspar. International Mogul Mines Ltd., carried out limited metallurgical tests on the deposit during 1978.

Uses, consumption and trade

The dominant use for barite is as a weighting agent in oil and gas well-drilling muds to control their density. Principal specifications are usually a minimum specific gravity of 4.20, a particle size of at least 95 per cent minus 325 mesh and a maximum water-soluble solids content of 250 ppm.

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, barite production, trade and consumption, 1977 and 1978

	1977		1978^p	
	(tonnes)	($)	(tonnes)	($)
Production (mine shipments)	116 950	2 836 241	105 741	1 850 000
Imports				
United States	5 979	747 000	15 635	2 093 000
Total	5 979	747 000	15 635	2 093 000
Exports				
United States	65 509	1 345 000	43 082	1 188 000
Venezuela	3 912	80 000	13 701	303 000
Total	69 421	1 425 000	56 783	1 491 000

	1976	1977
Consumption[1]		
Well drilling	54 767^e	48 758^e
Paints and varnish	2 140	2 474
Glass and glass products[2]	169	156
Rubber goods	86	810
Other[3]	904	1 310
Total	58 066	53 508

Sources: Statistics Canada; Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Available data reported by consumers with estimates by Mineral Policy Sector. [2] Includes glass fibre and glass wool. [3] Other includes bearings and brake linings, ceramics, chemicals and plastics.
^p Preliminary; ^e Estimated.

In 1977, consumption of barite in Canada was an estimated 53 508 tonnes, with over 90 per cent of this utilized in the oil well-drilling industry.

Barite is used in paint as a special filler or "extender pigment". This is a vital constituent that provides bulk, improves consistency of texture, surface characteristics and application properties, and controls prime pigment settling and the viscosity of paints. Specifications for barite used in the paint industry call for 95 per cent $BaSO_4$, a particle size of at least minus 200 mesh and a high degree of whiteness or light reflectance. Final "wet milled" and "floated" products result in smooth micro-crystalline surfaces that prevent agglomeration, thus allowing easy dispersal in water as well as in oil-soluble binders. When barite is used in highly pigmented distemper or latex paints, a degree of light scattering is attributed to the barite, therefore allowing it to function as a pigment.

The glass industry uses barite to increase the workability of glass, to act as a flux, assist decolouration and to increase the brilliance or lustre of the product. Specifications call for a minimum of 98 per cent $BaSO_4$, not more than 0.15 per cent ferric oxide (Fe_2O_3) and a particle size range of 40 to 140 mesh.

The specifications vary for natural barite used as a filler in rubber goods, but the main factors are whiteness and particle size range.

The balance of Canada's barite is used in the manufacture of ceramic products, chemicals, plastics and brake linings. Barite may become an important ingredient in heavy concrete used as a radiation shield.

There is no barium chemicals industry in Canada. Some important chemicals obtained from barium include barium nitrate, acetate, oxide, hydroxide and stearate, all derived from barium carbonate. Two other important compounds are chemical or precipitated barium sulphate, referred to in the trade as blanc fixe, and lithopone, a chemically precipitated mixture of 70 per cent barium sulphate and 30 per cent zinc sulphide. Lithopone, a white pigment, is still in demand for certain purposes such as undercoatings, filling pastes, emulsion paints and wallpaper coatings. Lithopone, however, has largely been replaced by titanium dioxide pigments in most uses.

Specifications of barite for the barium chemicals industry call for 95 per cent $BaSO_4$ and not more than 2 per cent Fe_2O_3.

World review

World production of barite in 1978 was an estimated 6.1 million tonnes, according to the United States Bureau of Mines. An estimated 75 per cent of this quantity was consumed in oil well-drilling operations and most barite was supplied by oil-field service companies closely interrelated with the drilling companies. Most of these companies are controlled or associated with one of the following major United States organizations: Baroid Division of NL Industries, Inc.; Dresser Industries Inc.; Milchem Inc.; and IMCO Services, a division of Halliburton Company. World demand is most economically served by production from many countries and the viability of any deposit is mainly influenced by transportation costs to markets.

The United States is by far the world's largest producer of barite and production reached an all-time high in 1978. Mines produced an estimated 1.7 million tonnes, derived mostly from Nevada, Arkansas and Missouri. Annual imports of barite to the United States during 1977 and 1978 were 870 000 and 1 million tonnes, respectively. Following the United States, which accounted for 27.9 per cent of the total world production, were India, 5.9 per cent; Ireland, 5.7; Peru, 5.2; Mexico, 5.2; West Germany, 4.1; France, 3.0; Italy, 2.6; Morocco, 2.6; Yugoslavia, 1.1; Canada, 0.7; Greece, 0.7; other non-communist countries, 21.4; and communist countries, except Yugoslavia, 13.9 per cent, according to the United States Bureau of Mines.

The United States, the principal consumer of barite, used an estimated 2.5 million tonnes in 1978. Imports into the United States for the years 1974 to 1977, inclusive, came from: Peru, 30 per cent; Ireland, 21; Mexico, 13 and others, 36 per cent. Of the total 1977 consumption of barite in the United States, approximately 90 per cent was used in the oil and gas well-drilling industry.

Table 2. Canada, barite production, trade and consumption, 1960, 1965, 1970 and 1975-78

	Production[1]	Imports	Exports	Consumption[2]
	(tonnes)			
1960	142 560	1 833	122 445	21 948[r]
1965	184 181	3 344	167 858	19 667[r]
1970	133 584	6 827	90 305	50 106[r]
1975	81 356	4 479	45 606	40 229
1976	100 266	18 097	60 297	58 066
1977	116 950	5 979	69 421	53 508
1978[p]	105 741	15 635	56 783	64 593

Sources: Statistics Canada; Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Mine shipments. [2] Apparent consumption.
[p] Preliminary; [r] Revised.

Table 3. World mine production of barite, 1976-78 and reserves, 1978

	Mine Production			Reserves
	1976	1977	1978[e]	1978
	(000 tonnes)			
United States	1 120	1 355	1 542	23 000
Ireland	323	299	318	3 000
Peru	331	281	290	4 000
Mexico	270	280	290	4 000
West Germany	262	290	227	2 000
Italy	179	136	145	2 000
France	150	150	163	2 000
Morocco	137	140	145	2 000
Canada	100	117	106	3 000
Greece	44	39	36	2 000
Yugoslavia	56	59	64	2 000
Other non-communist countries	1 140	1 433	1 507	28 000
Communist countries[e] (except Yugoslavia)	1 025	766	771	16 000
World totals	5 137	5 354	5 604	93 000

Sources: United States Bureau of Mines, Mineral Commodity Summaries, January, 1978; United States Bureau of Mines, Mineral Trade Notes, July 1978; Statistics Canada.
[e] Estimated.

Strontium compounds

421.70	Carbonate, not precipitated, including strontianite	free
421.72	Carbonate, precipitated	6
421.74	Nitrate	6
421.76	Oxide	6
421.82	Sulfate, mineral (celestite)	free
421.84	Sulfate, other	5
421.86	Other	5

Sources: Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978), USITC Publication 843.
[1] Duty on waste and scrap suspended to June 30, 1981.

Bentonite

G.O. VAGT

Known Canadian bentonite occurrences are confined to Cretaceous and Tertiary rocks at many localities in Manitoba, Saskatchewan, Alberta and British Columbia. Although clay beds occur in rocks older than Cretaceous, none of these in Canada have been identified as bentonite.

Bentonite is a clay composed mainly of the mineral montmorillonite, a member of the smectite group of clay minerals. The term "smectite", as a group name, replaces confusing terminology that includes "montmorillonite" as both mineral species and group names. Montmorillonite is a hydrated aluminum silicate with weakly-attached cations of sodium and calcium which impart different properties to bentonite, depending on amounts and proportions present. One method of classifying bentonite is based on its swelling capacity when wet. With sodium as the dominant or abundant exchangeable ion, swelling from 15 to 20 times the original dry volume will occur, and when added to water, gel-like masses result. Sodium bentonite also possesses a high drybonding strength, especially at high temperatures, a feature important in the manufacture of some ceramic products.

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

Another clay, "fuller's earth", also contains mainly smectite-group clay minerals and is very similar to nonswelling bentonite. These clays have natural bleaching and absorbent properties and were originally used by fullers to remove dirt and oil from wool. The terminology is confusing, and bentonite and fuller's earth may or may not be separated in world trade and production figures.

Bentonites may originate from smectitic clays formed from volcanic ash, tuff or glass, other igneous rocks, or from rocks of sedimentary or uncertain origin. The deposits occur in relatively flat-lying beds of various chemical compositions and impurities; the latter consisting of quartz, chlorite, biotite, feldspar, pyroxenes, zircon and various other minerals. Natural clay may be creamy white, grey, blue, green or brown; and, in places, beds of a distinctly different colour are adjacent. Fresh, moist surfaces are waxy in appearance; on drying, the colour lightens and the clay has a distinctive cracked or crumbly texture.

Production in Canada

Three companies presently mine and process bentonite in Canada. Statistics on total production and exports are not available for publication.

In Saskatchewan, Avonlea Mineral Industries Ltd., inaugurated a $1.4 million bentonite processing plant in Wilcox, Saskatchewan, approximately 30 kilometres (km) south of Regina. Raw material is transported a distance of approximately 20 km to the 50 000-tonne*-a-year plant. Major uses of the final product are for iron ore pelletizing, oilwell-drilling mud, binder in foundry moulds and for reservoir sealing.

In Alberta, Dresser Minerals Division of Dresser Industries, Inc., recovers swelling bentonite from the Edmonton Formation of Upper Cretaceous age. The deposits are in the Battle River Valley, 14 km south of Rosalind, the site of the company's processing plant. The bentonite is mined selectively from relatively shallow paddocks or pits in the dry summer months. Some natural drying may be done by spreading and harrowing the material before trucking it to the plant for drying, pulverizing and bagging. Bentonite of intermediate swelling quality from Alberta may be used as a foundry clay, as a sealer for farm reservoirs, as feed pelletizing material, as a drilling-mud additive, as an additive to water for fire fighting and as a soil stabilizer.

Pembina Mountain Clays Ltd. mines nonswelling bentonite from the Upper Cretaceous Vermilion River Formation, 30 km northwest of Morden, Manitoba, which is 130 km southwest of Winnipeg. Some bentonite is dried and pulverized in a plant at Morden, but the bulk of production is railed from Morden to the company's

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

activation plant at Winnipeg, where it is leached, washed, filtered, dried, pulverized and bagged. The main use is for decolouring and purifying mineral and vegetable oils, animal fats and tallows. Highly sorptive properties also make this bentonite suitable for pet litter and floor sweeping compounds.

Uses, consumption and trade

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

Select swelling bentonite has found widespread and rapidly growing use as a binder in the pelletizing of iron ore concentrates.

Over 75 per cent of the reported total consumption of bentonite in 1977 was used for this purpose, according to Statistics Canada. About 8 kilograms (kg) of bentonite are used in every tonne of concentrate to provide pellets with sufficient "green" strength to withstand handling during the drying and firing stages. The amount of bentonite required varies with the mineralogy and particle size of the concentrate. The large volume requirements of individual pelletizing plants has tended to result in more emphasis on low cost and availability rather than on higher cost material with stringent specifications.

Special muds used in oil- and gas-well drilling contain about 10 per cent swelling bentonite, which is used principally to prevent the loss of drilling fluid into permeable zones by forming a mud cake on the wall of the drill hole. Of equal importance, swelling bentonite acts as a suspension agent to carry drill cuttings in water-based muds to the surface. Synthetic bentonite (sodium-exchanged calcium bentonites) may also be used in special muds, depending upon the cost and availability of natural swelling bentonites.

Swelling bentonite, often blended with nonswelling bentonite, serves as a binder in moulding sands used by iron and steel foundries.

Swelling bentonite is also used as a binder in livestock feeds. Small quantities are used as a plasticizer in abrasive and ceramic mixes and as a filler in paints, paper, rubber, pesticides, cosmetics, medicinal products and cleaning and polishing compounds. Engineering applications are: in grout for sealing subsurface water-bearing zones, dams and reservoirs; as additives to cements, mortars and concretes to suppress bleeding of the mixing water; as a compacting

Table 1. Canada, bentonite imports and consumption, 1977 and 1978

	1977		1978[p]	
	(tonnes)	($)	(tonnes)	($)
Imports				
Bentonite				
United States	325 543	7 226 000	218 275	6 256 000
Greece	33 181	659 000	77 438	1 555 000
Total	358 724	7 885 000	295 713	7 811 000
Activated clays and earths				
United States	8 607	3 025 000	12 208	3 747 000
France	363	481 000	1 038	844 000
West Germany	58	26 000	66	51 000
Greece	111 081	2 179 000	—	—
Other countries	24	39 000	7	1 000
Total	120 133	5 750 000	13 319	4 643 000
Fuller's earth				
United States	2 356	122 000	226	14 000
Consumption[1] (available data)	1975	1976	1977[p]	
Pelletizing iron ore	202 401	241 604	256 066	
Foundries	59 439	61 209[e]	55 575[e]	
Well drilling	18 967	22 820	22 832	
Fertilizer stock and poultry feed	1 387	1 389	1 579	
Paint and varnish	290	183	166	
Chemicals	36	65	180	
Other products[2]	1 749	1 612	1 419	
Total	284 269	328 882	337 817	

Source: Statistics Canada.
[1]Does not include activated clays and earths or fuller's earth. Breakdown by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa. [2]Refractory brick and mixes, rubber products, paper and paper products, ceramic products and other miscellaneous minor uses.
[p] Preliminary; — Nil; [e] Estimated.

agent for gravels and soils; and as a ground-stabilizing medium for excavations when used in a bentonite-water suspension. Bentonite slurry is also used effectively in fighting forest fires.

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

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

Consumption of bentonite in Canada has increased substantially in the last decade, largely because of increased consumption as a binder in iron ore concentrate pelletizing, as more of these plants have been constructed. Consumption of bentonite in the oil and gas industry is subject to considerable fluctuation that is not necessarily directly related to the footage drilled. Factors such as age and degree of compaction of the rock formations encountered as well as the severity of subsurface geopressures and temperatures, which vary from region to region, are also important determinants. Quantities of activated clays and fuller's earth are imported mainly from the United States and Greece. Some activated bentonite from Manitoba is exported to the United States.

Bentonite production in the United States is mainly from extensive deposits in Wyoming, where the name was derived from the Cretaceous Fort Benton Formation. These Cretaceous deposits are the world's most outstanding swelling bentonite occurrences and the specifications and standards for bentonite used in industry are based on these high-quality clays. Although there are numerous occurrences of bentonite in many countries, it is mined in only a few. In recent years, Wyoming producers have lost some markets for bentonite used in iron ore pelletizing in eastern Canada to Greek bentonite producers. The cost spread between rail and ocean transportation is the principal reason for this change. Canada is the main importer from the United States, which also ships some bentonite to Australia and western Europe. Expansion to existing plants and construction of new plants are under way in several states.

Nonswelling bentonite, fuller's earth and bleaching clays are produced in numerous states, the major ones being Florida, Georgia, Mississippi and Texas.

Outlook

Transportation costs to distant pelletizing plants add considerably to the cost of natural swelling Wyoming bentonite, which for many years was specified as the bonding agent for thermally processed iron ore pellets. For this reason, attention will increasingly be directed toward finding nearer sources of natural bentonite or toward the use of soda-activated bentonites.

It is expected that bentonite consumption in Canada will continue to hold its own, relative to substitute binders. Although increasing emphasis is being placed on direct reduction (DR) processing of iron ore the tonnage processed by DR methods will remain a small proportion of the total for many years. Countering expansions to Canadian iron ore pelletizing plant capacity in recent years, some small iron ore producers are expected to cease operations before 1980. This will contribute to a slower net growth in industry output. In the oil well drilling industry there is a trend toward the use of low-solids mud systems, utilizing organic polymers. Also, in land-based regions where high-temperature drilling is carried out there is an increasing use of oil-based muds.

Table 2. Canada, bentonite imports[1] and consumption[2], 1960, 1965, 1970 and 1975-78

	Imports		Consumption
	(tonnes)	($)	(tonnes)
1960	. .	1 590 441	61 903[r]
1965	174 334	2 310 566	157 539[r]
1970	351 066	5 590 000	285 671[r]
1975	287 886	9 388 000	286 109[r]
1976	367 162	10 244 000	335 553
1977	481 213	13 757 000	344 124
1978[p]	309 258	12 468 000	. .

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

Prices

United States bentonite prices according to "Chemical Marketing Reporter", December 29, 1978

	($)
Bentonite, domestic, 200 mesh, bags, carlots, fob mines Western, per short ton	2800 – 30.00
Bentonite, imported Italian, white, high-gel, bags, 5-ton lots, ex-warehouse per lb.	No Prices [1]

[1]In *Chemical Marketing Reporter*, November 28, 1977 a price of $.1688 per lb. was quoted.

Tariffs

Canada

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

United States

Item No.		(¢ per long ton)
521.61	Bentonite	40
521.51	Fuller's earth, not beneficiated	25
521.54	Fuller's earth, wholly or partly beneficiated	50
		(¢ per lb)
521.87	Clays, artifically activated with acid or other material	0.05 +6% ad valorem

Sources: Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1978), USITC Publication 843.

Beryllium

D. PEARSON

Beryllium is a light metal rarely seen in the pure form. It has a density between that of aluminum and magnesium and a tensile strength considerably higher than either one of those metals. In the pure state, the metal is brittle and without special treatment cannot be rolled in either the cold or hot condition. Beryllium is used as a metal, an alloy and as the oxide. Most of the consumption of beryllium is in the form of alloys and oxide.

Occurrences and recovery

Canada. Throughout Canada, beryllium-containing deposits have been reported in 75 locations and nearly all are related to granitic intrusions. However, no commercial exploitation occurs at present. Attempts have been made to recover beryllium either as a byproduct or as a primary product at various locations in Canada but none were economically viable on a continuing basis.

World. There are two main sources of beryllium – beryl and bertrandite. The latter is the major source of beryllium in the United States. Beryl is normally found in the form of crystals in pegmatite dykes. The dykes rarely contain sufficient beryl to make an economic extraction possible except where deposits are mined for gems and the nongem beryl is a byproduct, as in Brazil. In some cases, metals such as molybdenum and lithium are the primary product and associated beryl is the byproduct. The accompanying table lists the chief sources of beryl as reported by the United States Bureau of Mines. In the United States, Brush Wellman Inc. and Kawecki Berylco Industries, Inc. are the two major processors of beryllium raw materials and the only producers of beryllium metal. Brush Wellman Inc. mines bertrandite and processes it at a plant at Delta, Utah. That company also processes beryl ore for Kawecki Berylco Industries on a toll basis.

Several processes have been developed for treating beryllium ore. The two major ones, the fluoride process and the sulphate process, are currently used in the United States to obtain a beryllium oxide concentrate. In the fluoride process, to obtain metallic beryllium, the oxide concentrate is dissolved in an aqueous solution of acid ammonium fluoride. The resulting ammonium-beryllium fluoride is heated to expel the ammonia and the resulting residue of beryllium fluoride is reduced by magnesium in a graphite-lined furnace. Beryllium separates and floats on a molten slag, permitting separation.

Beryllium, when cast, tends to develop coarse crystals, causing brittleness and low tensile strength. To overcome this problem, powder metallurgy is usually employed to fabricate the metal. Clean vacuum-cast ingots are machined and the resulting chips are ground to a powder in an inert atmosphere. The powder is compacted into a dense fine-grained structure by hot-pressing under vacuum. The compacted ingots can then be extruded, drawn, or rolled to shape.

Production

Annual world mine production of beryl in 1978, according to the United States Bureau of Mines, was 2 308 tonnes*. Production has been steadily decreasing over the past seven years. World production of beryllium metal has also fallen. It is estimated that 89 tonnes were produced in 1978 compared with 97 tonnes in 1977 (see Table 1). United States production is not included in the table because there are only two producers. Canada's imports of beryllium metal and beryllium alloys for 1976 to 1978 are shown in Table 3. Statistical data on world and Canadian consumption of beryllium are not available; however, from the import figures it can be inferred that Canadian consumption decreased between 1977 and 1978.

Uses

Beryllium has three main uses. As the oxide, it is a unique ceramic material that conducts heat well but does not conduct electricity and therefore is ideal as a heat sink and for electrical resistors in small electronic devices. Beryllium and its oxide are useful in making certain inorganic and organic chemicals. Beryllium metal finds considerable use in alloying, particularly with copper, which accounts for more than half of the beryllium used. Parts made of beryllium-copper alloy have a long service life and seldom require replacement. Beryllium both hardens and strengthens the copper. The alloys have excellent electrical and thermal conductivity. Typical applications are for

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

springs, contacts for switchgear relays, bellows and bushings. The alloy is excellent as a mould material for casting plastic articles because better surface reproduction is obtained and the moulds last considerably longer than moulds made of other metal alloys. It is corrosion resistant and this property makes it ideal for use in underwater housings. Beryllium-copper alloy is nonsparking so that it is useful for making tools for use in potentially explosive environments.

An alloy of nickel containing approximately 2 per cent beryllium plus a fraction of titanium has high strength and is corrosion resistant. It is used for electrical connectors where high temperature limits the use of beryllium-copper alloys.

In aluminum-magnesium alloys, small amounts of beryllium are used to prevent magnesium losses during preparation of the alloys.

In the nuclear industry, beryllium metal is used as a fuel container and as a neutron moderator and reflector. However, because the metal becomes brittle when exposed to radiation for some time, its use is limited to those areas that are not stressed or subject to shock.

Beryl is an important source of gem stones. When pure, the mineral is colourless but impurities impart a variety of colours to produce gems such as the green-coloured emerald and the sea blue variety called aquamarine. Most of the world's emeralds come from Colombia, Brazil and Russia.

Table 1. World mine production of beryllium, 1976-78

	1976	1977	1978[e]
	(tonnes)		
Central economy countries	65	68	68
Brazil	29	17	13
Argentina	8	3	3
Southern Rhodesia	3	3	2
Uganda	2	2	1
Other market economy countries	3	4	2
World total[1]	110	97	89

Source: U.S. Bureau of Mines, Mineral Commodity Summaries, 1979.
[1] United States production figures are withheld to avoid disclosing confidential data, and therefore are not included in world totals.
[e] Estimated.

Table 2. Estimated world production of beryl, 1974-78

	1974	1975	1976	1977	1978
			(tonnes)		
U.S.S.R.	1 542	1 597	1 651	1 696	1 750
Brazil	907	699	454	426	400
Argentina	113	275	112	100	75
Southern Rhodesia	64	64	64	64	40
Rwanda	59	18	64	54	28
Uganda	54	54	54	45	..
Madagascar	13	15	17	14	11
Mozambique	8	8	9	9	..
Other countries	387	255	2	1	4
World total[1]	3 147	2 985	2 427	2 409	2 308

Source: U.S. Bureau of Mines.
[1] United States production figures are withheld to avoid disclosing confidential data and therefore are not included in world totals.
. . Not available.

Table 3. Canada, beryllium imports, 1976-78

	1976		1977		1978	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Beryllium metal	3.9	58 000	6.3	72 000	1.7	172 000
Beryllium alloys	12.5	161 000	17.3	185 000	16.4	230 000

Source: Statistics Canada.

Specifications and prices

The prices of beryl ore and of some beryllium products, as quoted in *Metals Week*, are listed below in United States funds. Beryllium-copper alloy prices varied during the year depending upon the price of both beryllium and copper.

	Price Range 1978
	($U.S.)
Beryl ore, per tonne	44.09-55.12
U.S. beryllium-copper alloy, Number 25, 2% Be content, available in strip, rod, bar and wire, per kilogram	9.57-10.52
U.S. beryllium-copper casting alloy, Number 20C, 2-2¼% Be, 5-pound ingots, per kilogram	6.22-6.88
U.S. beryllium-copper master alloy, 4% Be, 5-pound ingots, per kilogram	136.69-147.71
Beryllium rod, 5-inch diameter, delivered price, per kilogram	340.70-340.83

Outlook

Although the market for beryllium alloys was weak at the beginning of 1978, it improved during the year. This buoyancy is expected to continue throughout 1979. The demand for electronic components, using the oxide substrate, should continue to increase. Little change in the demand for beryllium metal is expected.

Tariffs

Canada

Item Number		British Preferential	Most Favoured Nation	General	General Preferential
34907-1	Beryllium-copper alloys	5%	5%	25%	3%
35101-1	Beryllium metal	free	5%	25%	free

United States

Item Number		Free World	Statutory[1]
601.09	Beryllium ore	free	free
612.20	Beryllium-copper master alloy	0.6¢ per pound plus 10%	3¢ per pound plus 25%
628.05	Unwrought beryllium, waste or scrap	8.5%[2]	25%[2]
628.10	Beryllium, wrought	9%	45%
417.90	Beryllium oxide or carbonate	5%	25%
417.92	Other beryllium compounds	5%	25%

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978), USITC Publication 843.
[1] Statutory rates apply to central economy countries except Yugoslavia, Romania and Hungary. [2] Duty on waste and scrap is suspended until June 30, 1979.

Bismuth

J.J. HOGAN

Bismuth is obtained in Canada from the processing of certain lead-zinc, lead-zinc-copper and copper ores. The more important sources are the lead-zinc-copper ores mined in New Brunswick and the lead-zinc ores mined in southeastern British Columbia. Smaller amounts have been recovered in the past from ores mined in Ontario and Quebec.

Bismuth production in Canada in 1978, based on bismuth recovered from domestic ores and concentrates plus the recoverable bismuth content of bullion and concentrates exported, was 158 000 kilograms (kg) valued at $1 341 000, compared with 164 685 kg in 1977 valued at $2 246 754. Bismuth output declined by only 4 per cent, but the value of production declined by 40 per cent because of a sharp decline in the price of the metal. Inventory of metallic bismuth held by Canadian consumers as of December 31, 1978 totalled 3 663 kg, compared with the 3 877 kg in stock as of December 31, 1977.

In 1978 world mine production of bismuth, as estimated by the United States Bureau of Mines, excluding United States production, was 4.22 million kg, compared with 4.51 million kg in 1977. Australia and Mexico were the two leading producers, followed by Japan, Peru and Bolivia. These five countries accounted for over 81 per cent of the world's total 1978 output. The United States, which is a substantial producer from its own and imported ores, does not publish production statistics because one company, ASARCO Incorporated, accounts for almost all of the country's primary refined metal output.

Domestic sources

The Smelting Division of Brunswick Mining and Smelting Corporation Limited produces bismuth metal and alloys at its plant at Belledune, about 40 kilometres (km) northwest of Bathurst, New Brunswick. Bismuth production was contained in a bismuth-lead product containing 108 862 kg of bismuth, compared with 178 000 kg of bismuth contained in similar alloys produced in 1977. The Kroll-Betterton process is used to treat the desilverized lead bullion and produce a bismuth-lead-calcium-magnesium dross. The dross is then refined pyrometallurgically with chlorine to produce bismuth metal or alloy.

The other primary bismuth metal producer is Cominco Ltd. at its lead-zinc plant in Trail, British Columbia. Cominco derives most of its Canadian output from lead concentrates produced at its Sullivan lead-zinc mine at Kimberley. Other sources include lead concentrates from other company mines and from domestic and foreign custom shippers. Lead bullion produced from the smelting of these concentrates contains about 0.05 per cent bismuth. Bismuth is recovered as 99.99 + per cent metal from the treatment of residues resulting from the electrolytic refining of lead bullion. Production in 1978 totalled 77 184 kg, compared with 77 444 kg in 1977. (A substantial part of this production is derived from imported materials.) Bismuth for use in research and in the electronics industry is further processed at Cominco's near-by high-purity plant to give it a purity of up to 99.9999 per cent.

Late in 1977 Brunswick Tin Mines Limited entered into an agreement with Billiton Exploration Canada Limited, a subsidiary of Billiton International Metals, that permits Billiton to carry out a feasibility study on Brunswick Tin's property located about 64 km north of St. Andrews in Charlotte County, New Brunswick. There are a number of zones on the property but reportedly the zone under investigation contains an estimated 6.4 million tonnes* averaging 0.39 per cent tungsten oxide, 0.22 per cent molybdenum and 0.11 per cent bismuth. A bulk sample of about 9 000 tonnes was shipped to the Sullico Resources Ltd. concentrator for test runs. If the results of the feasibility study are positive a joint-venture will be formed to operate the mine.

Some bismuth occurs in the silver-copper ore being mined by Terra Mining and Exploration Limited, near Port Radium on the east shore of Great Bear Lake, Northwest Territories.

World developments

To 1978 the bismuth market continued the poor performance it had experienced in the past few years. Stocks are more than adequate to meet demand. Bismuth demand and

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, bismuth production and consumption, 1977 and 1978

	1977		1978p	
	(kilograms)	($)	(kilograms)	($)
Production, all forms[1]				
New Brunswick	146 145	2 059 142	136 000	1 156 000
British Columbia	18 540	187 612	22 000	185 000
Total	164 685	2 246 754	158 000	1 341 000

	1976	1977
	(kilograms)	(kilograms)
Consumption, refined metal (available data)		
Fusible alloys	3 543	2 299
Other uses	17 562	22 716
Total	21 105	25 015

Source: Statistics Canada.
[1] Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported.
[p] Preliminary.

price have been in a decline partly because of a significant drop in consumption by the pharmaceutical industry in France, which was a major consumer of bismuth for pharmaceutical products. Further to the strict regulations applied by France since 1975 to the sale of bismuth salts, the government announced in July 1978, a total suspension of over-the-counter sales of bismuth salts for a period of one year beginning on September 15, 1978. Bismuth salt preparations during this period can only be obtained through a doctor's prescription.

In the United States consumption of bismuth in 1978 was 1 139 387 kg up 5.5 per cent from the 1 079 402 kg consumed in 1977. The pharmaceutical industry was the largest consumer of bismuth, accounting for 521 496 kg in 1978, about 45.8 per cent of the total. Consumption in this field declined by 9.8 per cent over the previous year. Fusible alloys consumption was 379 219 kg, an increase of over 36 per cent, with the other major consumer, metallurgical additives, accounting for 220 125 kg. No sales of bismuth were made from the nation's strategic and critical materials stockpile in 1978. The goal established by the U.S. Federal Preparedness Agency for bismuth is 349 720 kg. At the end of 1977 the stockpile contained 943 920 kg, leaving a surplus of 594 200 kg. It cannot be disposed of without congressional approval. The disposal policy is under discussion by the U.S. Congress.

Australia is one of the world's major producers of bismuth. Peko-Wallsend Ltd., the major producer of bismuth in Australia, operated the Warrego gold mine which is high in bismuth and which is located in the Tennant Creek area, Northern Territory. Development work continued at the nearby Gecko mine and the discovery of a further ore zone has increased reserves by about 4 million tonnes grading 3.4 per cent copper. Deeper development was carried out on the Warrego property. The company's copper smelter and bismuth plant at Tennant Creek remained closed but it could resume operations in 1979. This would add to Australia's bismuth output.

A new plant to remove bismuth from lead is to be built at Fort Pirie, South Australia by The Broken Hill Associated Smelters Pty. Ltd. at a cost of $5.5 million (Australian). The bismuth content of the lead-zinc ores of The Consolidated Zinc Corp. Ltd. and The Zinc Corporation Ltd. at Broken Hill, New South Wales, treated at the Port Pirie smelter, has recently been rising.

Bolivia is one of the few countries where the bismuth content of some ores is high enough for them to be mined primarily to obtain bismuth. Bolivia is therefore in a position to adjust its output to meet market demand. Most of Bolivia's output is produced by four main mines in the Quechisla group of mines, which are operated by the state-owned Corporation Minera de Bolivia (COMIBOL). These mines are located in southern Bolivia. COMIBOL operates the country's sole bismuth smelter at Telamaya about 100 km north of Quechisla. The smelter can handle 4 800 tonnes of concentrate per year equivalent to about 800 tonnes of bismuth per year, which is greater than Bolivia's present output. COMIBOL also operates the country's sole bismuth metal refinery at Quechisla with an annual capacity of 650 tonnes of 99.99 per cent bismuth. Bolivia also exports some bismuth contained in ores and concentrates. In view of the poor market conditions for bismuth, Bolivia announced early in February 1978 that it would make a significant reduction in its bismuth output. Bismuth production in 1978 was estimated at 482 226 kg compared with 679 579 kg in 1977, a decline of 29 per cent.

Peru continued to be one of the world's major producers of bismuth. Refined bismuth metal was produced as a byproduct of lead at the La Oroya smelting and refining

Table 2. Canada, bismuth production and consumption, 1965, 1970 and 1975-78

	Production all forms[1]	Consumption[2]
	(kilograms)	
1965	194 482	21 899
1970	267 774	11 135
1975	156 605	29 267
1976	129 578	21 105
1977	164 685	25 015
1978^p	158 000	..

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

complex of Empresa Minera del Peru (Centromin).

In March 1978, members of the Bismuth Institute held a closed meeting in Lima, Peru. The Institute was incorporated in 1973 and the six sponsoring members* are the world's major producers. The principal objectives of the Institute are an increased use of bismuth in its current applications and the development of new uses for the metal, its alloys and compounds. Statistics are kept on consumption and production of bismuth. The Institute's headquarters are in La Paz, Bolivia, but it maintains an information centre in Brussels, Belgium.

*Cerro de Pasco Corporation, Peru; Corporacion Minera de Bolivia (COMIBOL); Mining & Chemical Products Limited, United Kingdom; Salsigne S.A., France; Sidech S.A., Belgium; and Peko-Wallsend Ltd., Australia, Industrial Minera Mexico S.A. later became a member of the Institute.

Uses

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

Another important outlet for the metal is fusible or low-melting point alloys for fire-protection devices, electrical fuses, fusible plugs and solders. Many of these alloys contain 50 per cent or more bismuth, with the chief additive metals being cadmium, lead and tin. In safety applications, the dependability of the melting temperatures of the various bismuth alloy compositions is of utmost importance. Pure bismuth metal expands 3.3 per cent on changing from a

Table 3. World mine production of bismuth, 1976-78

	1976	1977	1978^p
		(kilograms)	
Australia	748 606	912 000	1 000 000^e
Mexico[2]	557 000	729 000	730 000^e
Japan	681 501	697 719	623 841
Peru	521 279	585 467	590 000^e
Bolivia	611 697[1]	679 579	482 226
People's Republic of China	250 000^e	250 000^e	250 000^e
Canada	129 578	164 685	158 000
Republic of Korea	174 000	134 000	140 000^e
Romania	80 000^e	80 000^e	80 000^e
U.S.S.R.	60 000^e	65 000^e	70 000^e
France	63 000	52 000	60 000^e
Yugoslavia	78 138	74 236	12 500
Other countries	29 900	28 300	26 200
Total[3]	3 984 699	4 451 986	4 222 767

Source: United States Department of the Interior, Mineral Trade Notes, Vol. 76, No. 3, March 1979.
[1] Production by Corporacion Minera de Bolivia (COMIBOL) plus exports by medium and small mines. [2] Bismuth content of refined metal, bullion and alloys produced indigenously, plus recoverable bismuth content of ores and concentrates exported for processing. [3] Total for listed figures only; it excludes United States production, which is not available for publication, as well as that of some smaller producing countries.
^{p} Preliminary; ^{e} Estimated.

molten to a solid state. Nonshrinking, low-melting point bismuth alloys are used in the holding of jet engine airfoil blades during the machining of the root sections. Bismuth-tin alloys are sprayed on patterns to make moulds in the plastic industry.

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

Bismuth is used in catalysts in the production of acrylonitrile for acrylic fibres and plastics. This use suffered some decline in the 1960s but technological improvements in the process have led to increased demand in the 1970s. The rubber industry also uses a bismuth compound to accelerate the vulcanization process.

Outlook

The reduction in the use of bismuth in pharmaceuticals has been largely responsible for the recent depressed situation in the world's bismuth market and no significant improvement is expected in the short- to medium-term. In 1978 the bismuth price declined steadily but firmed in the early part of 1979. No sharp price increase is expected. Research is being done to develop new uses for the metal but at present there are no new uses for bismuth on the horizon. In the short term any increased consumption of bismuth will depend on expansion in its present applications, especially in the metallurgical and alloy industry. The United States Bureau of Mines has forecast that demand for bismuth in the United States should increase at an annual rate of about 2 per cent to 1985.

To partly offset the oversupply situation, Bolivia, the only major producer which mines bismuth ores primarily for their bismuth content, significantly cut back on its annual rate of output in the early part of 1978. Bismuth in the other countries is mainly a byproduct of the lead and copper industries and bismuth output is a function of the demand for these metals. There are a few new base metal developments, either underway or planned in different parts of the world, in which bismuth is a byproduct and recovery of this metal could add to world supply. Adequate bismuth supply exists for the short- to medium-term and no problems are envisaged in the long term. The occurrence of substantial quantities of bismuth has been indicated in mineralized zones in a number of countries.

Table 4. United States consumption of bismuth by principal uses, 1977 and 1978

	1977	1978[p1]
	(kilograms, bismuth content)	
Pharmaceuticals[2]	578 108	526 801
Fusible alloys	277 244	384 972
Metallurgical additives	209 366	213 829
Other alloys	8 444	9 859
Experimental uses	273	—
Other uses	5 949	5 443[e]
Total	1 079 384	1 140 904

Source: United States Department of the Interior, Bureau of Mines, Mineral Industry Surveys, "Bismuth in the Fourth Quarter of 1978".
[1] Estimated 100 per cent coverage based on reports from respondents that consumed 87 per cent of the total bismuth metal in 1977. [2] Includes industrial and laboratory chemicals.
[p] Preliminary; — Nil; [e] Estimated.

Prices

The Canadian price for bismuth metal 99.994 per cent pure in 1978, as quoted by Cominco Ltd., was $4.50 per pound for the period January to March; $4.00 per pound for April; $3.50 per pound for the period May to November and $2.75 per pound for December. The average bismuth price for 1978 was $3.73 per pound.

The United States domestic bismuth producer price for 99.99 per cent pure as quoted in *Metals Week* was $4.50 per pound for the period January to February. In March the price dropped to $3.50 per pound. In July the bismuth price dropped fifty cents to $3.00 per pound followed by a further fifty cent decline in November to $2.50 per pound. The average producer price for bismuth in 1978 was $3.38 per pound.

The dealer price for bismuth on the New York Market opened the year at $U.S.2.70 to $U.S.2.80 per pound and declined steadily to close at the low for the year of $U.S.1.74 to $U.S.1.84 per pound.

Tariffs

Canada

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

United States

		Non-communist Countries
601.66	Bismuth ores and concentrates	free
632.10	Bismuth metal, unwrought; waste and scrap	free
632.64	Alloys of bismuth, containing by weight not less than 30% lead	free
632.66	Other alloys of bismuth	9% Ad valorem
633.00	Bismuth metal, wrought	9% Ad valorem

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the Unites States Annotated (1978) ITC Publication 843.

Cadmium

D.H. BROWN

Although cadmium is a relatively rare element in the earth's crust, it occurs most commonly as the sulphide, greenockite (CdS) which is found associated with zinc sulphide ores, particularly sphalerite [(Zn, Fe)S]. The presence of cadmium during sphalerite development results in the formation of greenockite crystals on the surface and between the sphalerite crystals. To a very small degree cadmium also displaces zinc within the sphalerite crystal structure. The intimate association of cadmium with zinc minerals continues even during separation of multimineral ores into concentrates, such that small amounts of zinc reporting to lead and copper concentrates will be accompanied by a proportionate amount of cadmium. There are no known commercial orebodies of cadmium. Accordingly, reserves at any time are a function of zinc reserves and specifically the cadmium content of those reserves. Cadmium recoveries are generally estimated to be 70 to 90 per cent from ore to concentrate and 45 to 80 per cent from concentrate to metal, or 31.5 to 72 per cent overall.

Cadmium metal is recovered as a byproduct of zinc smelting and refining. Since secondary sources are considered negligible in terms of total supply, cadmium production is strictly a function of zinc metal production, which bears little or no relationship to the demand for cadmium. Because cadmium production represents only 2 to 3 per cent of zinc plant revenues, its supply is virtually inelastic to price fluctuations.

Cadmium is initially separated in fumes collected during the roasting of zinc-bearing ores and concentrates, and in precipitates obtained during the purification of the zinc sulphate solution that results from sulphuric acid leaching of calcine, which is the product of roasting. In Canadian zinc refineries, cadmium metal is recovered either by the electrolytic process whereby the cadmium-bearing precipitate is redissolved in sulphuric acid and plated out in electrolytic cells, or by a purification process in which cadmium-bearing precipitates are releached in sulphuric acid, then filtrated and purified. The purified solution is then cemented with zinc dust to produce cadmium sponge which, in turn, is filtered, briquetted, melted and cast.

At primary zinc distillation plants cadmium is reduced and vaporized with zinc in a retort or furnace. The vapour is condensed and cadmium (BP*776°C) is separated from zinc (BP 905°C) by fractional distillation.

In Canada, metal production declined to 1 270 tonnes** in 1978 from 1 375 tonnes in 1977, however shipments increased sharply from the prior year. Producers domestic shipments increased to 151 tonnes in 1978 from 90 tonnes in 1977 and exports increased to 1 259 tonnes in 1978 from 870 tonnes in 1977. The United States and the United Kingdom continued to be Canada's major export markets, accounting for 88 per cent of total exports, with the balance being shipped to the Netherlands, Belgium and Hong Kong.

The General Services Administration in the United States did not buy or sell any cadmium for the strategic stockpile in 1978 and the stockpile goal of 11 204 tonnes remained in a deficit position of 8 333 tonnes throughout the year.

Production of cadmium in the western world, as reported by the World Bureau of Metal Statistics, is estimated to have declined to 12 815 tonnes in 1978 compared with 14 185 tonnes in 1977.

Canadian production

Canadian cadmium production in 1978, as reported by Statistics Canada, was 965 tonnes compared with 1 185 tonnes in 1977. These figures represent the metallic cadmium recovered at domestic zinc refineries from Canadian ores, plus the recoverable content of ores and concentrates exported. The Canadian mines, listed in the accompanying table, produced approximately 3 441 tonnes of cadmium in zinc concentrates in 1978, compared with 3 809 tonnes in 1977. The difference between data reported by Statistics Canada and that shown stems from the fact that many mining companies are not paid for their cadmium in zinc concentrate and thus they did not report its content in their shipments of concentrate. For the same reason, most mines do not assay for cadmium on a regular basis, and

*Boiling point.

**The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canadian primary cadmium statistics, 1976-78

	1976	1977	1978[p]
		(tonnes)	
Mine production[1]	3 391	3 809	3 441
Metal production	1 342	1 375	1 270
Metal capacity	1 705	1 705	1 705
Metal shipments:			
Domestic	123	90	151
Exports	1 556	870	1 259

Sources: Statistics Canada; Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1]Cadmium content of zinc concentrate production as shown in Table 4.
[p]Preliminary.

accordingly many of the entries listed in the table are estimated composite assays of annual production.

Metallic cadmium is recovered as a byproduct at the electrolytic zinc plants of Cominco Ltd. at Trail, British Columbia; Hudson Bay Mining and Smelting Co., Limited at Flin Flon, Manitoba; Canadian Electrolytic Zinc Limited at Valleyfield, Quebec; and Texasgulf Canada Ltd. near Timmins, Ontario. Cadmium metal production by these companies in 1978 declined to 1 270 tonnes, equivalent to 2.56 kilograms (kg) cadmium per tonne of zinc metal produced, compared with 1 375 tonnes in 1977 equivalent to 2.78 kg cadmium per tonne of zinc metal produced.

Canadian consumption

A survey of cadmium consumers in Canada, conducted by Statistics Canada (Table 3), indicates that cadmium usage declined in 1977 from 1976. Total end-usage accounted for by this survey amounted to 50.4 tonnes in 1977 compared with 53.8 tonnes in 1976. Unfortunately, the tonnage represented in this survey is not reconcilable with domestic shipments of metal by producers, which amounted to 89.6 tonnes in 1977 and 123.4 tonnes in 1976. Accordingly, the survey cannot be considered to be a reliable estimate of total consumption in Canada.

Uses

Cadmium is a soft, ductile, silver-white electropositive metal with a valence of two. It is used mainly for electroplating iron and steel products to protect them against oxidation. A cadmium coating, like a zinc coating, protects metals that are lower in the electromotive series by physical enclosure and by sacrificial corrosion. Cadmium is usually preferred to zinc as a coating because it is more ductile, is slightly more resistant to common atmospheric corrosion, can be applied more uniformly in recesses of intricately shaped parts and can be electrodeposited with less electric current per unit of area covered. It is also preferred for its more aesthetic appearance. However, because cadmium is more costly and much less plentiful than zinc, it is not as widely used. Improvements in zinc electroplating techniques in recent years have tended to reduce the consumption of cadmium in plating but it still remains the largest use for cadmium. Cadmium-plated parts are used in automobiles, household appliances, aircraft, radios, television sets and electrical equipment.

The second-largest use according to the Statistics Canada survey is in the manufacture of pigments and chemicals. Cadmium sulphides give yellow-to-orange colours and cadmium sulphoselenides give pink-to-red and maroon. Cadmium stearates act as stabilizers in the production of polyvinyl chloride plastics, and cadmium phosphors are used for tubes in both black-and-white and colour television sets. Unique photochemical properties have also created uses for cadmium in such areas as smoke alarm systems and solar energy cells.

Table 2. Canada, cadmium metal capacity, 1978

Company and Location	Annual Capacity
	(tonnes)
Canadian Electrolytic Zinc Limited, Valleyfield, Quebec	544
Cominco Ltd., Trail, British Columbia	544
Hudson Bay Mining and Smelting Co. Ltd., Flin Flon, Manitoba	163
Texasgulf Canada Ltd., Timmins, Ontario	454
Total Canada	1 705

Source: Operators List No. 3, *Metallurgical Works in Canada, Nonferrous and Precious Metals*, January 1977, Department of Energy, Mines and Resources, Ottawa.

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

Prices

Typically, zinc plants pay for 60 per cent of the cadmium in zinc concentrates above a base level of 0.2 per cent cadmium, equivalent to 2 kg of cadmium per tonne of zinc concentrate. Depending upon market conditions for cadmium and zinc concentrate, these payment terms can range from zero to 70 per cent of the full cadmium content.

Table 3. Canada, cadmium production, exports and consumption, 1977 and 1978

	1977		1978^{p}	
	(kilograms)	($)	(kilograms)	($)
Production				
All forms[1]				
Ontario	603 044	4 187 878	453 000	2 788 000
British Columbia	320 713	2 227 214	296 000	1 825 000
Quebec	121 859	846 257	166 000	1 020 000
Manitoba	50 702	352 101	34 000	212 000
Saskatchewan	10 404	72 252	13 000	77 000
Newfoundland	75 557	524 708	3 000	18 000
Yukon	1 670	11 595	—	—
New Brunswick	1 111	7 717	—	—
Northwest Territories	386	2 677	—	—
Total	1 185 446	8 232 399	965 000	5 940 000
Refined[2]	1 374 675		1 270 341	
Exports				
Cadmium metal				
United States	408 226	2 558 000	724 072	3 954 000
United Kingdom	404 129	2 392 000	378 509	1 916 000
Netherlands	47 326	258 000	125 638	651 000
Belgium-Luxembourg	10 002	61 000	10 002	55 000
Hong Kong	—	—	20 725	12 000
Other countries	—	—	337	4 000
Total	869 683	5 269 000	1 259 283	6 592 000

	1976	1977
	(kilograms)	
Consumption		
Cadmium metal[3]		
Plating	26 142	24 003
Solders	3 398	3 394
Other uses[4]	24 275	22 972
Total	53 815	50 369

Source: Statistics Canada.
[1]Production of refined cadmium from domestic ores, plus recoverable cadmium content of ores and concentrates exported. [2]Refined metal from all sources and cadmium sponge. [3]Available data reported by consumers. [4]Mainly chemicals, pigments and alloys other than solder.
^{p}Preliminary; — Nil.

Primary cadmium metal producers, including Canadian producers, normally sell metal at individual prices established by each firm. Almost all Canadian metal production is exported to the United States and the European Economic Community (EEC). North American prices, which are quoted on a delivered basis, are best represented by the "U.S. Producer" quotations published by *Metals Week* in New York. In Canada, the *Northern Miner* publishes the Cominco Ltd. month-end sales price for cadmium.

In the United States, domestic producers are the price leaders and Canadian producer price policy appears to adopt the U.S. basis. In the EEC, the "European sticks, free market price" quoted by the *Metal Bulletin* fob warehouse is the basis for most metal sales. All prices mentioned above represent cadmium metal having a minimum purity of 99.95 per cent, and are set out in the accompanying table which lists the monthly average during 1978, except for the "N.Y Dealer" quotations which are the range of weekly averages during the month and the *Northern Miner* "Cominco" quotation which is a month-end price.

Table 4. Principal cadmium producing mines in Canada, 1978 and (1977)

Company	Daily Mill Capacity	Grade of Zinc Concentrates: Cadmium	Zinc	Lead	Copper	Silver	Zinc Concentrate Produced	Cadmium Content
	(tonnes ore)	%	%	%	%	(grams/tonne)	(tonnes)	(kilograms)
Newfoundland								
ASARCO Incorporated, Buchans	1 100	0.22	56.23	3.33	0.65	141.6	27 663	60 858.6
	(1 150)	(0.22)	(55.81)	(3.11)	(0.61)	(139.9)	(26 232)	(57 710.4)
Newfoundland Zinc Mines Limited, Daniel's Harbour	1 500	0.351	62.3	—	—	—	74 395	261 126.5
	(1 350)	(0.376)	(62.6)	(. .)	(. .)	(. .)	(71 292)	(268 057.9)
New Brunswick								
Brunswick Mining and Smelting Corporation Limited, Bathurst	9 050	0.09	53.37	2.03	0.20	81.4	410 361	369 324.9
	(8 950)	(0.09)	(51.91)	(2.08)	(0.28)	(87.4)	(354 135)	(318 721.5)
Heath Steele Mines Limited, Newcastle	3 200	0.09	47.77	1.59	1.04	116.6	76 144	68 529.6
	(3 200)	(0.09)	(47.78)	(1.73)	(0.88)	(101.8)	(69 181)	(62 262.9)
Quebec								
Falconbridge Copper Limited, Lake Dufault Division, Noranda	1 400	0.11	51.97	—	0.69	0.4	22 208	24 428.8
	(1 400)	(0.11)	(52.59)	(—)	(0.76)	(0.6)	(22 152)	(24 367.2)
Lemoine Mines Limited, Lemoine Mine, Chibougamau	300	0.285	53.41	—	0.60	57.9	17 498	49 869.3
	(300)	(0.27)	(. .)	(. .)	(. .)	(. .)	(17 140)	(46 270)
Louvem Mining Company Inc. Louvem & Manitou Div., Louvicourt	900	—	55.14	0.67	0.58	207.7	20 811	—
	(900)	(0.17)	(53.14)	(. .)	(. .)	(. .)	(30 334)	(51 567.8)
Mattagami Lake Mines Limited, Matagami	3 500	0.125	53.03	—	0.44	46.6	116 102	145 127.5
	(3 500)	(0.12)	(53.33)	(—)	(0.39)	(50.1)	(108 518)	(130 221.6)
Orchan Mines Limited, Orchan and Norita Mines, Matagami	2 200	0.11	50.70	—	—	—	40 476	44 523.6
	(1 700)	(0.11)	(51.53)	(—)	(0.50)	(—)	(54 787)	(60 265.7)

Ontario								
Falconbridge Copper Limited,	1 100	0.13	53.00	0.99	0.41	0.5	54 800	71 240.0
Sturgeon Lake Joint Venture,	(1 100)	(0.13)	(53.22)	(. .)	(. .)	(. .)	(57 805)	(75 146.5)
Sturgeon Lake								
Mattabi Mines Limited,	2 700	0.14	54.57	0.34	0.27	47.0	97 714	128 399.6
Sturgeon Lake	(2 700)	(0.14)	(54.88)	(0.29)	(0.20)	(49.4)	(127 707)	(178 789.8)
Noranda Mines Limited,	4 550	0.37	50.78	—	1.19	70.6	50 565	187 091.2
Geco Division,	(4 550)	(0.38)	(51.93)	(—)	(0.98)	(60.3)	(60 309)	(229 174.2)
Manitouwadge								
Selco Mining Corporation	450	0.234	53.05	—	0.29	55.5	24 807	58 048.4
Limited,	(450)	(0.234)	(53.62)	(—)	(0.37)	(54.3)	(27 442)	(64 214.3)
South Bay Division,								
Uchi Lake								
Texasgulf Canada Ltd.,	9 050	0.25	50.69	0.39	0.78	115.6	313 348	783 370.0
Kidd Creek	(9 050)	(0.25)	(52.59)	(0.47)	(0.60)	(143.0)	(395 782)	(989 455.0)
Manitoba and Saskatchewan								
Hudson Bay Mining and Smelting	7 250	0.12	49.8	0.5	0.77	58.1	72 899	87 478.8
Co., Limited,	(7 250)	(0.12)	(47.8)	(1.1)	(0.77)	(65.1)	(63 764)	(76 516.8)
Flin Flon								
Sherritt Gordon Mines Limited,	2 700	0.13	51.12	—	1.24	—	22 368	29 078.4
Fox mine,	(2 700)	(0.13)	(51.10)	(. .)	(0.98)	(. .)	(22 051)	(28 666.3)
Lynn Lake								
Ruttan mine,	9 050	0.15	51.63	—	1.41	—	53 810	80 715.0
Ruttan Lake	(9 050)	(0.15)	(50.63)	(—)	(1.22)	(—)	(70 244)	(105 366.0)
British Columbia								
Cominco Ltd.,	9 050	0.15	49.52	4.22	—	79.7	119 163	178 744.5
Sullivan mine,	(9 050)	(0.13)	(48.60)	(5.70)	(. .)	(85.7)	(150 420)	(195 546.0)
Kimberley								
H.B. mine,	1 100	0.442	50.01	1.69	. .	31.1	15 364	67 908.9
Salmo	(1 100)	(0.42)	(54.20)	(1.70)	(. .)	(27.4)	(22 561)	(94 756.2)
Silvana Mines Inc.,	100	0.385	51.23	1.37	—	2 278.2	970	3 734.5
Silmonac mine,	(100)	(0.383)	(49.47)	(. .)	(. .)	(2 009.9)	(1 405)	(5 381.2)
Sandon								
Northair Mines Ltd.,	250	0.284	45.96	3.59	—	305.2	2 161	6 137.2
Alta Lake,	(250)	(0.315)	(53.9)	(2.55)	(—)	(526.3)	(2 347)	(7 393.1)
Brandywine area								

Table 4. (cont'd)

Company	Daily Mill Capacity	Grade of Zinc Concentrates Cadmium	Zinc	Lead	Copper	Silver	Zinc Concentrate Produced	Cadmium Content
	(tonnes ore)	%	%	%	%	(grams/tonne)	(tonnes)	(kilograms)
Teck Corporation, Beaverdell mine, Beaverdell	100 (100)	0.265 (0.29)	26.1 (32.5)	3.09 (1.60)	— (. .)	2 239.0 (2 180.6)	403 (245)	1 068.0 (710.5)
Western Mines Limited, Lynx and Myra Falls	900 (900)	0.23 (0.23)	51.47 (52.67)	0.81 (0.86)	0.59 (0.56)	169.6 (176.9)	35 581 (31 247)	81 836.3 (71 868.1)
Yukon Territory								
Cyprus Anvil Mining Corporation, Faro	9 050 (9 050)	0.065 (0.06)	50.41 (50.29)	1.90 (1.72)	. . (0.85)	. . (31.3)	246 376 (220 831)	160 144.4 (132 498.6)
United Keno Hill Mines Limited, Elsa	450 (450)	0.56 (0.67)	38.32 (. .)	2.83 (. .)	— (. .)	1 556.9 (. .)	30 (454)	170.5 (3 041.8)
Northwest Territories								
Pine Point Mines Limited, Pine Point	10 000 (10 000)	0.10 (0.10)	58.52 (56.66)	1.78 (2.13)	— (. .)	— (. .)	273 705 (264 801)	273 705.0 (264 801.0)
Nanisivik Mines Ltd., Baffin Island	2 200 (1 350)	0.17 (0.19)	56.82 (57.60)	0.49 (. .)	— (. .)	233.3 (230)	128 472 (116 500)	218 402.4 (221 350.0)

Source: Annual survey of mines, Minerals and Metals Division, Department of Energy, Mines and Resources, Ottawa.
— Nil; . . Not available.

Table 5. Canada, cadmium production, exports and domestic shipments, 1965, 1970 and 1975-78

	Production			
	All Forms[1]	Refined[2]	Exports Cadmium Metal	Producers' Domestic Shipments
	(kilograms)			
1965	796 474	812 152	618 993	206 891
1970	1 954 055	836 745	702 630	157 307
1975	1 191 674	1 142 502	637 797	104 898
1976	1 313 723	1 342 269	1 555 772	123 389
1977	1 185 446	1 374 675	869 683	89 586
1978[p]	965 000	1 270 341	1 259 283	150 859

Source: Statistics Canada.
[1] Production of refined cadmium from domestic ores plus recoverable cadmium content of ores and concentrates exported. [2] Refined metal from all sources and cadmium sponge.
[p] Preliminary.

Table 6. Cadmium metal prices, 1978

	Northern Miner	Metals Week		Metal Bulletin	
Month	Cominco	U.S. Producer	New York Dealer	Commonwealth Producer	European Sticks, free market
	($ Cdn./lb)	($ U.S./lb)		($ U.S./lb)	
January	2.25	2.438	1.800-1.950	3.00	1.653-1.703
February	2.25	2.450	1.700-1.850	3.00	1.594-1.644
March	2.25	2.450	1.850-1.950	3.00	1.750-1.800
April	2.25	2.450	1.900-2.000	3.00	1.853-1.903
May	2.25	2.450	1.900-2.150	3.00	1.905-1.955
June	2.25	2.450	2.100-2.180	3.00	1.987-2.053
July	2.25	2.450	2.050-2.150	3.00	1.900-1.950
August	2.25	2.450	2.050-2.150	3.00	1.968-2.015
September	2.25	2.450	2.000-2.150	3.00	2.006-2.056
October	2.25	2.450	1.970-2.300	3.00	1.993-2.072
November	2.25	2.450	2.200-2.330	3.00	2.083-2.183
December	2.25	2.450	2.100-2.310	3.00	2.043-2.121
Average 1978	2.25	2.449	1.968-2.123	3.00	1.895-1.955

Sources: *Northern Miner; Metals Week; Metal Bulletin.*

Tariffs

Canada

Item No.		British Preferential	GSP [1]	GATT [2]	General
32900-1	Cadmium in ores and concentrates	free	free	free	free
35102-1	Cadmium metal, not including alloys in lumps, powders, ingots or blocks	free	free	free	25%

United States

TSUS No.		GSP	GATT
601.66	Cadmium in ores and concentrates	free	free
632.14	Cadmium metal, unwrought, waste and scrap	free	free
632.84	Cadmium alloys, unwrought	9%	9%
633.00	Cadmium metal, wrought	free	9%

European Economic Community

Brussels Tariff Nomenclature Number		GSP	GATT
26.01	Cadmium in ores and concentrates	free	free
81.04	Cadmium metal, unwrought, waste and scrap	4%	4%
	Other	6%	6%

Japan

Brussels Tariff Nomenclature Number		GSP	GATT
26.01	Cadmium in ores and concentrates	free	free
81.04	Cadmium metal, unwrought, waste and scrap, powders, flakes	free	8%
	Other	free	12%

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978); Official Journal of the European Communities, Common Customs Tariff; Customs Tariff Schedules of Japan, 1978.
[1]GSP — Generalized System of Preferences, extended to most developing countries. [2]GATT — General Agreement on Tariffs and Trade.

Calcium

D. PEARSON

Calcium, the fifth most abundant element in the earth's crust, is present in every land area and in the sea. This element is an essential constituent to both plant and animal life. It is never found uncombined in nature but occurs abundantly in limestone, gypsum, fluorite and apatite. Metallic calcium was first prepared by Sir Henry Davy in 1808 by electrolysis of fused calcium salts. The principal sources of calcium today are high-calcium limestone and dolomite deposits.

There are only three producers of metallic calcium in the non-communist world: Chromasco Limited in Canada; Planet-Wattohm S.A., a subsidiary of Compagnie de Mokta, in France; and Charles Pfizer and Co. Inc. in the United States. Russia is also a producer and exports limited quantities to Western Europe and the United States. The process now used exclusively to recover metallic calcium is the aluminothermic reduction of lime in a noncontinuous process.

Canada continued to be a major producer and supplier of calcium in 1978. Production increased 19.7 per cent to 588 000 kilograms (kg) in 1978, compared to 490 856 kg in 1977. The United States Bureau of Mines estimates that the non-communist world annual production is between 1 300 and 1 500 tonnes*. Canada exported 280 000 kg or 47.6 per cent of its production. Exports to the United States were 199 300 kg.

Canadian industry

Chromasco Limited produces calcium metal at its metallurgical plant at Haley, near Renfrew, Ontario. The company utilizes the same vacuum retort process that is used to produce its principal product, magnesium. Other products

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, calcium production and exports, 1977 and 1978

	1977		1978^p	
	(kilograms)	($)	(kilograms)	($)
Production (metal)[1]	490 856	1 801 506	588 000	2 708 000
Exports (metal)				
United States	227 600	800 000	199 300	905 000
South Africa	200	4 000	35 100	319 000
Mexico	900	4 000	32 800	128 000
France	—	—	9 400	33 000
United Kingdom	7 600	57 000	2 600	25 000
Other countries	32 400	112 000	1 000	8 000
Total	268 700	977 000	280 200	1 418 000

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

from the Haley operation, in addition to magnesium and calcium metals, are magnesium and calcium alloys, and barium, strontium and thorium metals. To make calcium, high-purity quicklime (CaO) and commercially pure aluminum are briquetted and then charged into horizontal electric retorts. Under vacuum, the aluminum reduces the quicklime to form a calcium vapour. This vapour crystallises at between 680° and 740°C in a water-cooled condensor section of the retort. The initial product, known as "crowns", contains about 98 per cent calcium. Higher purities are obtained by subsequent refining operations.

Chromasco makes four main grades of calcium: Grade 1, chemical standard, 99.7 per cent calcium, with up to 0.2 per cent magnesium and minor amounts of other elements; Grade 2, nuclear quality, 99.4 per cent calcium, with a maximum magnesium content of 0.5 per cent; Grade 3, battery grade, 98.5 per cent calcium, with a maximum of 0.5 per cent magnesium, 0.15 per cent nitrogen maximum, and 0.45 per cent aluminum maximum; Grade 4, commercial crowns, 98.0 per cent calcium, 0.5 to 1.5 per cent magnesium, 0.15 per cent nitrogen maximum and 0.45 per cent aluminum maximum.

Table 2. Canada, calcium production and exports, 1965, 1970 and 1975-78

	Production[1]	Exports
	(kilograms)	
1965	72 318	67 300
1970	201 194	79 000
1975	428 288	309 800
1976	513 964	298 000
1977	490 856	268 700
1978[p]	588 000	280 200

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

Uses

Advantage is taken of calcium's powerful reducing properties in the preparation of many of the less common metals such as columbium, tantalum, titanium, thorium, uranium, vanadium and zirconium. Calcium is used extensively to remove bismuth, antimony and arsenic from lead. A large number of organocalcium compounds find uses as special lubricants, corrosion inhibitors and detergents. Calcium is added to some alloys of magnesium, aluminum, lead and lithium. Calcium metal and ferrosilicon alloys containing calcium are widely used in the steel industry to control grain size, inhibit carbide formation, improve ductility and reduce internal flaws. A recent development in the battery industry in which the traditional antimony-lead grid is replaced by one of calcium-lead has produced the "maintenance-free" battery which is claimed to have a longer life and lighter weight.

Outlook

Demand for calcium in both the ferrous and nonferrous industries, as well as for the other uses mentioned above, should remain at about the same level as in 1977. Problems of recycling and development of other electrodes may reduce the use of calcium in automobile batteries in the long term. However, for the next year, it is expected that calcium will continue to find major use in the battery industry.

Prices

Price of calcium crowns throughout most of 1978 was $U.S. 1.60 per pound. On October 16 the price increased to $U.S. 1.80 per pound. The annual prices for 1978, as quoted by *Metals Week* in United States currency, for crowns and calcium-silicon alloys were as follows:

	($/lb)
Calcium metal full crowns (10-16-78)	1.80
Calcium silicon, 32% calcium (10-01-78)	0.57

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(% ad. valorem)			
92805-1	Calcium metal	10	15	25	10

United States

Item No.		Non-communist countries	Communist countries except Yugoslavia
		(% ad valorem)	
632-16	Calcium	7.5	25
633-00	Other base metals, wrought	9	45

Duty on waste and scrap temporarily suspended.

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978) T.C. Publication 843.

Cement

D.H. STONEHOUSE

Canadian developments

Despite poor performance in construction in many parts of the country, the Canadian cement industry in total maintained a high level of production activity and, in fact, showed a significant increase over 1977 shipments as a result of aggressive marketing of portland cement and cement clinker in the United States. At the end of 1978 the industry's total theoretical capacity was just under 16 million tonnes* per year.

One new plant was brought into production – the 1-million-tonne-per-year Vancouver plant of Inland Cement Industries Limited. A new plant at Woodstock, Ontario – Federal White Cement – was just about ready to begin production at year-end. There were no plant closures; market conditions resulted in the need to keep Inland's Bamberton, British Columbia plant operative instead of phasing it out with the opening of the new plant as had been originally planned. The expansion program under way at the company's Edmonton, Alberta plant was reassessed early in 1978, after the first two phases, at a total cost of $16 million, were completed. Phase 3, including a new dry-process kiln, will increase clinker production capacity by 758 000 tonnes per year compared with 435 000 tonnes planned in the original proposal. Phase 3 will cost $59 million.

In a three-to-one vote September 19, 1978 the United States International Trade Commission (ITC) determined that imports of portland cement from Canada were not injuring the industry in the United States. The subject action was initiated September 8, 1977. The United States Treasury subsequently determined that sales of cement from Canada were made at less than fair value and withheld appraisement for six months from March 17, 1978 while referring the case to the ITC for injury determination. The fact that during the period when dumping was alleged to have taken place portland cement was in extremely short supply in the western and mid-western states and that many congressmen, on behalf of a desperate construction industry, raised a cry for cement at any price from any source, undoubtedly had an influence on the ITC decision. The action resulted in the U.S. Treasury Department dismissing its Antidumping Act investigations involving cement imports.

Genstar Limited of Montreal, which also controls Inland Cement Industries Limited, sold its subsidiary operation, Miron Company Ltd., to Interedec of North Vancouver. Miron, operating in the St. Michel district of Montreal, has been one of the largest cement producers in Quebec and also includes major concrete products and construction branches. The construction division will continue to operate under the name of Ronmir Inc.

In its first move outside of Ontario, St. Marys Cement Limited acquired all the assets of Wyandotte Cement Inc., of Michigan, U.S.A., in September, affording the company access to U.S. markets. Wyandotte will grind clinker from St. Marys' Bowmanville, Ontario plant and other sources to produce about 350 000 tonnes of cement per year for the Detroit regional market.

Early in 1978, St. Lawrence Cement Company leased a 750 000-tonne-per-year plant from Colonial Sand & Stone Co., Inc., Kingston, New York, with an option to purchase (for $U.S. 7 million) within six years.

The cement industry's goal of a 9 to 12 per cent reduction in energy consumption by 1980, compared with the base year of 1974, appears to be realistic. In 1977 the industry consumed 5 715 mega joules (MJ) of energy per tonne of production, a reduction of 8.1 per cent below 1974 levels. Unit energy consumption in 1978 was 5 741 MJ per tonne.

A change in the fuel mix from 1974 to 1978 is noted. In 1974 natural gas accounted for 49.5 per cent, petroleum products 39.7 per cent and coal and coke 10.8 per cent. By 1978 natural gas usage was 44.0 per cent of the total energy requirements while petroleum products dropped to 30.0 per cent and coal and coke rose to 26.0 per cent.

Canadian industry

Atlantic region. The three cement-manufacturing plants in Atlantic Canada serve markets in the immediate area. Although it is not common practice, clinker and/or cement

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, cement production and trade, 1977 and 1978

	1977		1978p	
	(tonnes)	($)	(tonnes)	($)
Production[1]				
By province				
Ontario	3 657 213	139 893 692	3 952 730	183 110 158
Quebec	2 549 758	98 032 245	2 809 119	130 146 752
Alberta	1 087 392	55 941 659	1 167 313	113 537 250
British Columbia	909 527	45 307 590	1 019 488	56 106 764
Manitoba	590 779	29 411 362	681 260	34 544 160
Saskatchewan	345 235	20 367 070	352 997	24 689 373
New Brunswick	..	14 712 011	..	12 643 491
Nova Scotia	..	11 244 766	..	12 127 508
Newfoundland	..	5 175 463	..	5 685 020
Total	9 639 679	420 085 858	10 558 279	572 590 476
By type				
Portland	9 292 651	..	10 191 261	..
Masonry[2]	347 028	..	367 018	..
Total	9 639 679	420 085 858	10 558 279	572 590 476
Exports				
Portland cement				
United States	1 273 689	40 355 000	1 622 725	62 346 000
Guatemala	921	53 000	6 225	382 000
Bermuda	—	—	5 485	141 000
Other countries	42	4 000	176	15 000
Total	1 274 652	40 412 000	1 634 611	62 884 000
Cement and concrete, basic products				
United States	..	17 317 000	..	32 373 000
Other countries	..	521 000	..	317 000
Total	..	17 838 000	..	32 690 000
Imports				
Portland cement, standard[3]				
United States			97 849	4 583 000
Japan			1 251	91 000
Other countries			276	24 000
Total	..	..	99 376	4 698 000
White cement				
United States	21 077	1 406 000	12 818	913 000
Japan	656	37 000	1 171	83 000
Belgium and Luxembourg	487	33 000	727	59 000
Spain	13	1 000	—	—
Total	22 233	1 477 000	14 716	1 055 000
Aluminous cement[3]				
United States			8 544	1 551 000
Yugoslavia			35	6 000
Total	..	..	8 579	1 557 000

Table 1. (cont'd)

	1977		1978[p]	
	(tonnes)	($)	(tonnes)	($)
Cement, nes[3]				
United States	234 126	13 147 000	95 920	6 603 000
Japan	911	31 000	879	37 000
United Kingdom	306	34 000	254	36 000
Denmark	—	—	87	10 000
West Germany	51	12 000	63	4 000
Other countries	185	33 000	54	5 000
Total	235 579	13 257 000	97 257	6 695 000
Total cement imports	257 812	14 734 000	219 928	14 005 000
Refractory cement and mortars				
United States		7 794 000		7 481 000
United Kingdom		152 000		1 103 000
Ireland		106 000		359 000
Austria		113 000		133 000
Belgium and Luxembourg		109 000		13 000
Other countries		115 000		28 000
Total	..	8 389 000	..	9 117 000
Cement and concrete basic products, nes				
United States		1 525 000		1 408 000
West Germany		48 000		216 000
United Kingdom		15 000		94 000
France		40 000		40 000
Denmark		—		26 000
Other countries		25 000		7 000
Total	..	1 653 000	..	1 791 000
Cement clinker				
Japan	—	—	29 692	867 000
United States	5 715	197 000	6 997	220 000
United Kingdom	—	—	108	23 000
Total	5 715	197 000	36 797	1 110 000

Source: Statistics Canada.
[1] Producers' shipments plus quantities used by producers. [2] Includes small amounts of other cement. [3] Standard portland and aluminous cement are new classes in 1978, and are included in cement, nes for 1977.
[p] Preliminary; .. Not available; — Nil; nes Not elsewhere specified.

Table 2. Canada, cement production shipments, trade and consumption, 1974-78

	Production	Shipments[1]	Exports[2]	Imports[2]	Apparent Consumption[3]
			(tonnes)		
1974	10 640 001	10 553 233	1 148 393	251 300	9 656 140
1975	9 740 502	9 719 959	934 981	420 430[r]	9 205 408[r]
1976	9 898 024	9 803 020	921 031	314 680	9 196 669
1977	9 933 135	9 639 679	1 274 652	257 812	8 622 839
1978[p]	10 472 724	10 777 000	1 634 611	219 928	9 362 317

Source: Statistics Canada.
[1] Producers shipments plus quantities used by producers. [2] Does not include cement clinker, but does include exports from other than producer plants. [3] Producers shipments plus imports, less exports.
[r] Revised; [p] Preliminary.

have been shipped out of the region on occasion, principally in the form of in-company shipments designed to help maintain efficiency at regional plants. The plants represent 6.0 per cent of Canadian cement production capacity in a region having 9.5 per cent of the total population of Canada.

A plant, established in 1951, at Corner Brook, Newfoundland is operated by North Star Cement Limited. Limestone and shale, raw materials for the dry-process plant, are quarried in the immediate area and gypsum is purchased from Flintkote Holdings Limited, which quarries gypsum at Flat Bay, about 95 kilometres (km) south of Corner Brook.

Nova Scotia's only cement manufacturing facility, a two-kiln, dry-process plant, was established in 1965 by Canada Cement Company, Limited (now Canada Cement Lafarge Ltd.) at Brookfield. Limestone at the plant site is chemically very close to a natural cement rock; but variations in lime, alumina and iron content necessitate the addition of iron oxide, coal ash and high-calcium limestone, all of which are available nearby. Gypsum is purchased from the Milford quarry of National Gypsum (Canada) Ltd., about 40 km south of Brookfield. Portland cement is marketed in bulk or packaged under the brand name "Maritime" cement. The company also operates a two-kiln, dry-process plant at Havelock, New Brunswick which obtains its raw materials locally.

Quebec. Five companies operate five cement-manufacturing plants in Quebec province. The Montreal East plant of Canada Cement Lafarge Ltd., at Pointe-aux-Trembles, has been operated as part of the Canada Cement complex since it was acquired in 1909. Material from the adjacent quarry approximates a natural raw mix and requires only minor amounts of sand, iron oxide and high-calcium limestone for corrective purposes. Its location, 1.6 km from docking facilities on the St. Lawrence River, affords access to water transportation. Rehabilitation of the Montreal East plant began in 1976. Plans to replace seven old, wet-process kilns with two dry-process, preheater-equipped kilns have been delayed because of poor market conditions in the Quebec region, despite major engineering construction such as the James Bay project.

Canada Cement Lafarge's plant at St. Constant, south of Montreal, is modern, technically efficient and, with a capacity of over 950 000 tonnes per year, is currently supplying product to fill the company's sales contracts in the Quebec region. The company's Hull operation, on the site where cement was first produced in Canada, was closed as a producing facility at the end of 1975. The plant has been partially dismantled and is currently serving as a distribution terminal with grinding capability.

Miron Company Ltd., operates a dry-process plant at St. Michel. The company also supplies concrete and other building materials to the construction industry, and maintains a contracting division. The plant is now operated by Interedec of North Vancouver.

St. Lawrence Cement Company has a plant at Villeneuve, near Quebec City, capable of manufacturing about 700 000 tonnes of cement per year. Limestone and shale are available at the site; iron oxide and gypsum are brought in. Finished products include normal portland cement, medium-heat-of-hydration cement and masonry cement. During 1976 St. Lawrence acquired the Joliette cement plant of Independent Cement Inc., together with its construction, ready-mix and crushed-stone divisions. Early in 1977 St. Lawrence purchased Universal Atlas Cement's Hudson, New York plant to be used initially as a distribution terminal and eventually modernized to a fully integrated cement producer. The company continued its acquisition program in 1978 by obtaining an option to purchase another New York plant – Colonial Sand & Stone Co., Inc., of Kingston. The company exports cement and clinker to the United States market through its U.S. holdings.

Ciment Quebec Inc., was established in 1952 at St. Basile, 60 km west of Quebec City, as a single-kiln operation. Two additional kilns were installed to boost production capacity to about 345 000 tonnes per year. During 1978 the company announced plans to install what will be the first Fuller suspension preheater with a precalciner flash furnace system in Canada. The 2 000-tonne-per-day output will replace production from the existing wet plants.

Table 3. Cement plants, approximate annual capacities, end of 1978

Company	Plant Location	Process	Fuel	Capacity
				(tonnes per year)
Atlantic region				
North Star Cement Limited	Corner Brook, Nfld.	dry	oil	159 000
Canada Cement Lafarge Ltd.	Brookfield, N.S.	dry	oil, coal	474 000
Canada Cement Lafarge Ltd.	Havelock, N.B.	dry	oil, coal	327 000
Total Atlantic region				960 000
Quebec				
Canada Cement Lafarge Ltd.	Hull[1]			
Canada Cement Lafarge Ltd.	Montreal East[1]			
Canada Cement Lafarge Ltd.	St. Constant	dry	oil, gas, coal	953 000
Ciment Quebec Inc.	St. Basile	wet	oil	345 000
Independent Cement Inc.	Joliette[2]	dry	oil	1 089 000
Miron Company Ltd.	St. Michel	dry	oil	953 000
St. Lawrence Cement Company	Villeneuve	wet	oil	714 000
Total Quebec region				4 054 000
Ontario				
Canada Cement Lafarge Ltd.	Woodstock	wet	gas	540 000
Canada Cement Lafarge Ltd.	Bath	dry	oil, gas	998 000
Federal White Cement	Woodstock	dry	gas	100 000
Lake Ontario Cement Limited	Picton	dry	gas, coal	1 515 000
Medusa Products Company of Canada, Limited	Paris[1]			
St. Lawrence Cement Company	Clarkson	635 000 wet 953 000 dry	oil, coal	1 588 000
St. Marys Cement Limited	Bowmanville	wet	coal	680 000
St. Marys Cement Limited	St. Marys	dry	gas	935 000
Total Ontario region				6 356 000
Manitoba				
Canada Cement Lafarge Ltd.	Winnipeg	wet	oil, gas	572 000
Inland Cement Industries Limited	Winnipeg[3]	wet	oil, gas	295 000
Saskatchewan				
Canada Cement Lafarge Ltd.	Floral[1]			
Inland Cement Industries Limited	Regina[3]	dry	gas	204 000
Alberta				
Canada Cement Lafarge Ltd.	Exshaw[4]	dry	gas	726 000
Canada Cement Lafarge Ltd.	Edmonton[1]			
Inland Cement Industries Limited	Edmonton[3,4]	wet	gas	570 000
Total Prairie region				2 367 000
British Columbia				
Canada Cement Lafarge Ltd.	Lulu Island	wet	oil, gas	558 000
Canada Cement Lafarge Ltd.	Kamloops	dry	gas	190 000
Inland Cement Industries Limited	Bamberton[3]	wet	oil	500 000
Inland Cement Industries Limited	Tilbury Island[3]	dry	oil, gas	1 000 000
Total British Columbia region				2 248 000
Total capacity				15 985 000

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Grinding plants only. [2] Controlled by St. Lawrence Cement Company. [3] Controlled by Genstar. [4] Expansion program under way.

Table 4. Canada, cement plants, kilns and approximate capacity utilization, 1973-78

	Plants	Kilns	Approximate Capacity (tonnes per year)	Portland Cement Production (tonnes) (1)	Cement Clinker Exports[1] (tonnes) (2)	Total (1) & (2)	Approximate Capacity Utilization (%)
1973	24	58	14 268 000	10 052 902	1 243 400	11 296 302	79
1974	24	58	14 404 000	10 640 001	789 758	11 429 759	79
1975	24	57	15 064 000	9 740 502	658 954	10 399 456	69
1976	22	51	14 987 000	9 898 024	645 377	10 543 401	70
1977	22	49	14 885 000	9 933 135	775 145	10 708 332	72
1978	24	51	15 985 000	10 472 724	1 077 274	11 549 998	72[2]

Source: Statistics Canada.
[1] Interplant shipments of clinker are not reported by Statistics Canada. [2] Capacity utilization can be misleading, 1-million tonnes of capacity came on stream late in 1978 and was essentially ineffective for that year. A more practical utilization figure would be 77 per cent.

Ontario. Five companies operate a total of seven cement-manufacturing plants in the Ontario region, serving southern Ontario and shipping to points in Quebec and northern Ontario as well as to the United States. Both cement and clinker have been shipped as far west as Alberta during the past two years. The Ontario cement producers represent 39.6 per cent of total Canadian production capacity in a province occupied by about 36 per cent of the total Canadian population. Steady growth is indicated by continued investment in additional capacity.

Lake Ontario Cement Limited enjoyed record shipments again in 1978 from its Picton plant. The company ships into New York and Michigan as well as to Ontario centres. A plant expansion program was completed in 1975 with the addition of a new preheater kiln which doubled plant capacity.

Canada Cement Ltd. brought its 1-million-tonne-per-year Bath, Ontario plant on stream late in 1973 at a cost of $50 million, and subsequently phased out its Belleville plant, one of the original operations grouped to form Canada Cement Company in 1909. Limestone for the plant is quarried on site from the Trenton-Black River formation, Potsdam sandstone is obtained from Pittsburgh, about 65 km east of Bath, and iron oxide mill scale comes from Hamilton. The company also operates a plant at Woodstock, Ontario capable of producing about 540 000 tonnes per year from a two-kiln, wet process.

St. Lawrence Cement Company built its Clarkson, Ontario plant in 1957 and, with the expansion to 1.58 million tonnes per year in 1968, it became Canada's largest producing plant. The plant now combines a wet and a dry process.

Table 5. Canada, distribution of domestic cement sales[1] from producers' plants, 1974-78

	1974	1975	1976	1977	1978
			(tonnes)		
Quebec					
Portland	2 486 495	2 509 057	2 006 578	1 991 607	1 818 456
Masonry	79 206	81 191	87 379	89 899	80 672
Total	2 565 701	2 590 248	2 093 957	2 081 506	1 899 128
Ontario					
Portland	3 459 307	3 089 953	3 051 287	2 920 972	2 819 248
Masonry	207 845	186 296	194 355	182 809	171 622
Total	3 667 152	3 276 249	3 245 642	3 103 781	2 990 870
Other provinces					
Portland	3 070 564	2 966 838	3 383 503	3 369 219	3 720 725
Masonry	61 017	60 318	65 495	70 709	63 273
Total	3 131 581	3 027 156	3 448 998	3 439 928	3 783 998

Table 5. (cont'd)

	1974	1975	1976	1977	1978
			(tonnes)		
Canada					
Portland	9 016 367	8 565 849	8 441 368	8 281 798	8 358 429
Masonry	348 069	327 805	347 229	343 417	315 567
Total	9 364 436	8 893 654	8 788 597	8 625 215	8 673 996
Exports					
Portland	864 665	660 864	734 421	1 071 889	1 390 243
Masonry	27 483	19 610	24 053	24 887	38 595
Total	892 148	680 474	758 474	1 096 776	1 428 838
Clinker[2]	789 758	658 954	645 377	775 195	1 077 724
Total sales					
Portland	9 881 032	9 226 714	9 175 789	9 353 687	9 748 672
Masonry	375 522	347 415	371 282	368 304	354 162
Total cement	10 256 554	9 574 129	9 547 071	9 721 991	10 102 834
Total clinker[3]	789 758	658 954	645 377	775 195	1 077 274

Source: Statistics Canada.
[1] Does not include amounts used at producers' plants sites. [2] United States Bureau of Mines, Division of Non-Metallic Minerals for years 1974 to 1977 inclusive. Statistics Canada for 1978. [3] Interplant shipments are not reported by Statistics Canada for 1978.

Limestone for the plant is brought by boat from Ogden Point, 160 km east of Toronto on the north shore of Lake Ontario. An overhead, covered conveyor is used to transport stone from the Lake carriers to the plant. Gypsum is trucked from producers in southwestern Ontario. The market area for finished cement products is mainly the Toronto-Hamilton strip and Southern Ontario. Large quantities of clinker are exported to United States points.

St. Marys Cement Limited operates two plants in Ontario. A new and highly automated plant, built at Bowmanville during 1967-68, was expanded during 1973 with the addition of a second kiln. With the acquisition of Wyandotte Cement Inc., the company began shipments of clinker through a newly constructed lakefront loading facility at Bowmanville. The original plant at St. Marys was constructed in 1912 to serve the Toronto area. It has been expanded and modernized over the years, most recently with the installation of a 680 000-tonne-per-year kiln and four-stage suspension preheater.

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

Federal White Cement completed the construction of a new plant at Woodstock, under the guidance of Lafarge Consultants Ltd. Limestone will be purchased from Canada Cement's Woodstock plant and capacity is designed to be about 100 000 tonnes per year of white cement with startup scheduled for 1979.

Table 6. Canada, mineral raw materials[1] used by the cement industry, 1976 and 1977

Commodity	1976	1977[p]
	(tonnes)	
Limestone	12 469 582	11 861 135
Shale	850 386	588 260
Clay	804 921	869 580
Gypsum	468 485	482 370
Sand	244 037	197 021
Iron oxide	348 334	111 135
Sandstone	. .	164 277

Source: Statistics Canada.
[1] Includes purchased materials and material produced from own operations.
[p] Preliminary; . . Not available.

Prairie region. Two companies, Canada Cement Lafarge Ltd., and Inland Cement Industries Limited, operate a total of five clinker-producing plants in the Prairie region along with two clinker-grinding plants. The region accounts for nearly 15 per cent of Canadian cement-producing capacity exclusive of the grinding plants and during 1978 produced at over 90 per cent of capacity.

Canada Cement Lafarge Ltd. operates a cement-manufacturing plant at Fort Whyte, near Winnipeg, Manitoba.

Table 7. Capacity changes, cement plants, 1978

Company	Plant Location	Net Capacity Increase Compared with End of 1977	Approximate Cost	Remarks
		(tonnes per year)	($ million)	
Ontario				
Federal White Cement	Woodstock	100 000	. .	New plant to use stone from Canada Cement Lafarge's Woodstock quarry.
British Columbia				
Inland Cement Industries Limited	Vancouver	1 000 000	90	New plant under construction on Tilbury Island.
Total		1 100 000		

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
. . Not available.

The original facility has been enlarged and rebuilt several times and is today a highly efficient plant capable of producing about 570 000 tonnes of cement per year. High-calcium limestone is obtained from the company's quarry at Steep Rock on the shore of Lake Manitoba, gypsum from Amaranth, silica from Beausejour and clay from Fort Whyte. Products include portland cement, sulphate-resisting cement, oil well cement and masonry cement for a market area extending from the United States border to the most northerly populated areas, and eastward halfway across northern Ontario.

At Exshaw, Alberta a cement plant has been operated by the Canada Cement group since 1910. Recent expansions included installation of a new kiln and development of a new quarry. A current program will nearly double the present capacity of 726 000 tonnes per year with the addition of a second new kiln.

Large quantities of clinker are shipped to the company's grinding, storage and distributing plant at Edmonton, Alberta. A facility at Floral, near Saskatoon, Saskatchewan was built in 1964 as a distribution terminal and in 1966 was expanded to include clinker-grinding equipment. When the demand for cement warrants, the Floral establishment can be expanded further to become a fully integrated cement-manufacturing and distributing plant.

Inland Cement Industries Limited, a Genstar Limited subsidiary, operates three cement-manufacturing plants in the Prairie region, one in Winnipeg, Manitoba; one in Regina, Saskatchewan and one in Edmonton, Alberta. The Winnipeg plant came on stream in 1965 to increase the company's total production capacity to over 900 000 tonnes per year. A limestone quarry at Mafeking, Manitoba, near the Manitoba-Saskatchewan border, supplies limestone to the Regina plant, while the Winnipeg plant is supplied from Steep Rock, Manitoba. The Edmonton plant is supplied from Cadomin, Alberta using a 4 500-tonne unit train and an automated materials-handling system. Other raw materials are obtained close to the plant site. A $60 million expansion of the Edmonton plant began in 1976 with the addition of new environmental-control facilities. The program was reassessed and strengthened in 1977 and, when completed in the early 1980s, will result in a production capacity of over 1.3 million tonnes per year. A market area stretching east to the Lakehead and west to, and including, British Columbia is served by Inland's facilities.

Houg Cement, Limited produces cement from marl near Clyde, some 100 km north of Edmonton, from a $5 million, 60 000-tonne-per-year plant. Local markets consist principally of ready-mix operations.

Pacific region. Genstar's decision to construct a 1-million-tonne-per-year cement-manufacturing plant in the Vancouver region reflects confidence in the future for construction in western Canada as well as confidence in export markets for cement and clinker in western United States. The new plant, on Tilbury Island, was completed in 1978 and incorporates a four stage preheater with a kiln 115 metres (m) in length, at a cost of over $100 million. The Company's cement plant at Bamberton on Vancouver Island, has not been phased out with the completion of the new facility on the mainland as was planned. Market conditions throughout 1978 dictated that the plant be kept operative.

Canada Cement Lafarge Ltd., produces cement at Richmond, on Lulu Island near Vancouver, British Columbia, using limestone barged down the Strait of Georgia from a quarry at Vananda on Texada Island.

The plant was built in 1958, and later the capacity was doubled to the present 558 000 tonnes per year. A new plant with a capacity of over 190 000 tonnes per year began production in 1970 at Kamloops, British Columbia.

Table 8. Planned capacity changes as of 1978

Company	Plant Location	Net capacity Change Compared with Table 3	Expected Date of Completion	Approximate Cost	Remarks
		(tonnes per year)		($ million)	
Quebec					
Canada Cement Lafarge Ltd.	Montreal East	. .	. .	. .	Plans for plant conversion delayed.
Ciment Quebec Inc.	St. Basile	300 000	1981	. .	A 2 000-tonne-per-day suspension pre-heater, flash calciner system will replace existing wet process plant.
Prairie region					
Canada Cement Lafarge Ltd.	Exshaw, Alta.	600 000	1980	70	Expansion to include one new kiln.
Inland Cement Industries Limited	Edmonton	758 000	1980	75	Original project reassessed and enlarged during 1977.
	Bamberton	(500 000)		. .	Clinker production to be phased out.
Total		1 158 000			

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
. . Not available.

Technology

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

The three basic types of portland cement: Normal Portland, High-Early-Strength Portland, and Sulphate-Resisting Portland, are produced by most Canadian cement manufacturers. Moderate Portland Cement and Low-Heat-of-Hydration Portland Cement, designed for use in concrete to be poured in large masses, such as in dam construction, are manufactured by several companies in Canada. Masonry cement (generic name) includes such proprietary names as Mortar Cement, Mortar Mix (unsanded), Mason's Cement, Brick Cement and Masonry Cement. The latter product, produced by portland cement manufacturers, is a mixture of portland cement, finely ground high-calcium limestone (35 to 65 per cent by weight) and a plasticizer. The other products do not necessarily consist of portland cement and limestone, and may include a mixture of portland cement and hydrated lime and/or other plasticizers.

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

Table 9. Canada, house construction, by province, 1977 and 1978

	Starts			Completions			Under Construction		
	1977	1978	% Diff.	1977	1978	% Diff.	1977	1978	% Diff.
Newfoundland	3 719	2 865	−23	4 292	3 561	−17	2 878	3 483	+21
Prince Edward Island	824	1 210	+47	652	1 036	+59	347	528	+52
Nova Scotia	7 495	4 853	−35	7 521	5 745	−24	6 479	5 463	−16
New Brunswick	4 308	5 167	+20	5 313	5 896	+11	2 709	1 888	−30
Total (Atlantic provinces)	16 346	14 095	−14	17 778	16 238	−9	12 413	11 362	−8
Quebec	57 580	43 671	−24	61 979	54 129	−13	35 366	24 053	−32
Ontario	79 130	71 710	−9	80 717	80 429	−1	75 518	66 106	−12
Manitoba	9 410	12 121	+29	8 720	10 550	+21	6 479	8 048	+24
Saskatchewan	12 825	9 527	−26	11 485	11 383	−1	10 097	8 138	−19
Alberta	38 075	47 925	+26	37 879	43 025	+13	27 305	31 323	+15
Total (Prairie provinces)	60 310	69 573	+15	58 084	64 958	+12	43 881	47 509	+8
British Columbia	32 358	28 618	−12	33 231	30 779	−7	18 421	15 672	−15
Total Canada	245 724	227 667	−7	251 789	246 533	−2	185 599	164 702	−11

Source: Statistics Canada.

Concrete research has generally been confined to strength determination, durability, placement and curing. Currently, great emphasis is being placed on researching the use of superplasticizers in concrete. Superplasticizers, a group of admixtures described chemically as naphthalene or melanine sulphonate polymers, have been found to provide greatly increased workability over short time spans or to provide high strength by permitting lower water-cement ratios.

Specifications

Portland cement used in Canada should conform to the specifications of CSA Standard A5 – 1971, published by the Canadian Standards Association. This standard covers the five main types of portland cement. Masonry cement produced in Canada should conform to the CSA Standard A8 – 1970.

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

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

Regulations governing the design and application of these and other associated materials of construction are generally covered by CSA Standards or by those of the American Concrete Institute.

Table 10. Canada, production of concrete products, 1977 and 1978

	1977	1978p
Concrete bricks (number)	135 559 586	97 837 116
Concrete blocks (except chimney blocks)		
Gravel (number)	157 907 588	143 797 619
Other (number)	33 901 282	34 599 594
Concrete drain pipe, sewer pipe, water pipe and culvert tile (tonnes)	1 351 032	1 196 800
Other precast products (tonnes)	260 770	525 463
Concrete, ready-mix (cubic metres)	13 757 545	13 495 908

Source: Statistics Canada.
p Preliminary.

Although individual companies continue to conduct research in relation to cement production, much experimentation concerning the use of cement and concrete is done through the Portland Cement Association (PCA), an industry-supported, nonprofit organization whose purpose is to improve and extend the uses of cement and concrete through scientific research and engineering fieldwork. The Association is active in all parts of Canada, and can offer detailed information on concrete use, design and construction, from regional offices of the Canadian Portland Cement Association.

Markets and trade

Cement markets are regional in scope and are centred in developing urban areas where construction activity is concentrated, or in areas where mining or heavy engineering construction projects are being carried out. The normal market area of a given cement-producing plant depends on the amount of transportation cost that the selling price can absorb. A potential large volume of sales could warrant a secondary distribution terminal; water transportation to a distribution system could extend a plant's market area even farther. Because raw materials for cement manufacture are generally widespread, most countries can supply their own cement requirements if the market volume warrants a plant. Few countries rely entirely on imports for their cement needs. However, some countries rely heavily on export markets for their surplus cement production in order to operate facilities economically.

Specialty cements, such as white cement, can be transported greater distances than ordinary grey portland cement because the transportation costs do not represent as high a proportion of the landed price, and because quantities required are generally much smaller than for portland cement. Cement shortages in countries experiencing a buoyant surge in construction have led to exceptions to the norm and resulted in cement being shipped unusual distances. During recent years the state of the portland cement industry in the United States, coupled with a surprisingly large demand for cement by construction projects, particularly in the west and mid-west, has created export opportunities for Canadian portland cement. Whether this will develop into a trend in the face of high energy costs and changing priorities in the utilization of fossil fuels remains to be seen. The opportunity to import energy in the form of cement clinker, while also avoiding the environmental problems associated with kiln operations, could become attractive.

A typical feature of the cement-manufacturing industry is its diversification and vertical integration into related construction material industries. Many cement companies also supply ready-mix concrete, stone, aggregates and

Table 11. World production of cement, 1967, 1977 and 1978

	1967	1977	1978[p]
		(000 tonnes)	
U.S.S.R.	84 804	127 000	132 000
Japan	42 218	75 176	77 000
United States (including Puerto Rico)	63 001	68 657	77 000
People's Republic of China	14 200	51 500[e]	41 000
Italy	26 312	38 439	39 000
West Germany	31 086	31 871	33 000
France	24 807	30 352	30 000
Spain	13 101	29 422	29 000
Poland	11 136	21 298	. .
Brazil	6 407	21 123	. .
India	11 304	19 084	. .
United Kingdom	17 789	16 054	16 000
Republic of Korea	2 441	14 418	. .
Turkey	4 249	13 869	. .
Romania	6 336	13 700	. .
Mexico	5 592	13 227	. .
East Germany	7 188	12 103	. .
Greece	3 733	10 467	. .
Canada	7 249	9 640	10 777
Other countries	102 618	176 307	318 223
Total	485 571	793 707	803 000

Sources: Statistics Canada; *Cembureau Statistical Review 1977*; U.S. Bureau of Mines, Mineral Commodity Summaries, January 1979.
[p] Preliminary; [e] Estimated; . . Not available.

Table 12. Apparent consumption of cement by the leading producers, 1977

	Production[p]	Apparent Consumption	Apparent Consumption
	(000 tonnes)		(kg/capita)
U.S.S.R.	127 000	124 198	480
Japan	75 176	69 381	608
United States (including Puerto Rico)	68 657	70 508	320
People's Republic of China	51 500[e]	49 900[e]	58
Italy	38 439	37 800	669
West Germany	31 871	31 022	505
France	30 352	27 893	523
Spain	29 422	21 694	597
Poland	21 298	20 498[e]	591[e]
Brazil	21 123	21 123	189
India	19 084	18 277	29
United Kingdom	16 054	14 498	259
Republic of Korea	14 418	11 177	305
Turkey	13 869	12 924	306
Romania	13 700	10 700	497
Mexico	13 227	12 030	186
East Germany	12 103	11 603	692
Greece	10 467	5 915	635
Canada	9 640	8 623	371
Other countries	176 307		
Total	793 707		

Source: Statistics Canada; *Cembureau Statistical Review 1977*.
[p] Preliminary; [e] Estimated.

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

In Canada, construction is categorized broadly as building construction and engineering construction, and the values of each type, discounted by inflationary factors, provides a basis for comparison of annual construction in place. Historically, building construction has represented about 60 per cent of the total value of construction, and one element within this general category – residential construction – has normally accounted for 30 per cent of total value, or one half of building construction. In current dollars, construction is credited with about 17 per cent of gross national expenditure. In 1978 capital and repair expenditure on construction was $38.4 billion, up 7 per cent over expenditures in 1977.

Although buoyancy was evident in western Canada, particularly in Alberta, slower growth in the nonresidential building sector and in engineering construction was experienced again throughout the country. Spending constraints by governments reduced capital works expenditures on such projects as schools, hospitals, and highways. Because of this, governments at all levels have been cited as contributing to the depressed condition of the construction industry. Housing starts were down 7 per cent in 1978, at 227 667, following a record of 273 203 starts in 1976. The construction industry experienced an extremely high rate of unemployment, which indicates an underutilization of capacity.

In the United States the total value of construction put in place in 1978 was estimated at $197.8 billion. Cement shipments (portland and masonry) were 80.4 million tonnes, up 8 per cent from 74.7 million tonnes in 1977.

Outlook

Construction expenditures in Canada in 1979 will be in the range of $42 billion, with the greatest percentage increases expected in Alberta and Ontario. Housing starts will likely be in the 200 000 range. Construction in Canada will continue to show an annual increase in value, but cement producers will have to compete with producers of all other building materials to obtain a share of the construction dollar. Not only is practical research in the use of cement and concrete needed, but effective advertising and public relations must be used to encourage acceptance of modular construction at a time when reasonably priced, attractive and convenient housing units are in short supply. In general, modest gains are expected in the near-term, with activity across the country expected to range from promising to cautious, a situation which has changed little over the past three years.

The availability of other construction materials has at times played a major role in determining the amount of cement required for construction. Projects have been delayed because of shortages of steel, rebar, gypsum products and other items. Of particular concern in this regard will be sources of energy. The cement industry recognizes the importance of fuel conservation, if for no other reason than that fuel costs have long represented a major portion of its total operating costs and undoubtedly will continue to do so.

The already-established trend to dry processing and the use of preheaters will continue for new plants, and the rehabilitation of older plants will continue to benefit from new technology. Rebuilding programs are costly, especially when they must be accomplished with no loss in

Table 13. Canada, value of construction by province, 1977-79

	1977[1]			1978[2]	1979[3]
	Building Construction	Engineering Construction	Total	Total	Total
			($ million)		
Newfoundland	390.0	233.1	623.1	664.0	838.1
Nova Scotia	522.2	392.3	914.5	1 015.8	1 066.8
New Brunswick	449.3	424.4	873.7	921.8	977.5
Prince Edward Island	78.6	40.4	119.0	144.8	150.7
Quebec	5 223.3	3 366.6	8 589.9	8 736.2	9 199.2
Ontario	7 078.4	3 535.2	10 613.6	10 914.5	11 758.3
Manitoba	854.2	543.4	1 397.6	1 532.3	1 546.1
Saskatchewan	976.3	587.7	1 564.0	1 663.2	1 840.7
Alberta	2 940.9	3 183.9	6 124.8	7 387.8	8 316.2
British Columbia, Yukon and Northwest Territories	2 793.6	2 189.6	4 983.2	5 404.7	5 821.3
Canada	21 306.8	14 496.6	35 803.4	38 385.1	41 514.9

Source: Statistics Canada.
[1]Actual. [2]Preliminary. [3]Forecast.
Note: 1978 preliminary and 1979 forecast data are not available by type of construction.

Table 14. Canada, value of construction by type, 1977

	($ million)
Building construction	
Residential	13 126
Industrial	1 729
Commercial	3 639
Institutional	1 662
Other building	1 152
Total	21 308
Engineering construction	
Marine	242
Highways, airport runways	2 691
Waterworks, sewage systems	1 669
Dams, irrigation	154
Electric power	3 401
Railway, telephones	1 356
Gas and oil facilities	2 724
Other engineering	2 259
Total	14 497
Total construction	35 804

Source: Statistics Canada.
Note: 1978 preliminary and 1979 forecast construction data are not available by type of construction.

production. The obvious incentives of cost savings and greater profits must be attractive enough to warrant the additional expense and effort. The expense of adapting older facilities to meet newly imposed environmental-control regulations can contribute to a decision in favour of a new plant – such decisions have forced a number of plant closures in the United States. Continued diversification and vertical integration by cement producers will eventually result in the write-off of some comparatively inefficient production capacity as the emphasis on the cement and concrete industry increases. Work stoppages have seriously delayed many construction projects. In general, labour relations in the construction industry have shown improvement, with a mature and rational approach to labour-management problems which, hopefully, will continue and thereby do much to reduce the cyclical aspects of the industry. The shortage of skilled labour could reach problem proportions for the construction industry; if not generally, then certainly in some regions, as more and larger projects are undertaken.

The cement industry in Canada is capable of meeting immediate demands and is also capable of expansion to meet even greater demand from domestic and foreign markets should opportunities be presented.

Cement manufacture is energy-intensive. It is obvious that research should be concentrated in this area, and specifically within the pyroprocessing sector, where over 80 per cent of the energy is consumed. Raw material grinding and finish grinding are being studied to determine optimum particle size for energy consumed.

In terms of the energy required to make concrete components and to build concrete structures, along with energy requirements to service and maintain them, they are not so energy-intensive as the nearly 6 giga joules required per tonne of cement would at first indicate.

World review

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

World production of cement is estimated at 803 million tonnes, up from about 794 million tonnes in 1977 but still below estimates made a few years ago, and on which many capacity increases were considered timely. Excess capacity in some developed countries will not be fully utilized for some time. Developing countries, particularly oil-producing countries, continue to show increasing demand for cement and cement-manufacturing facilities. Involvement of corporations with highly specialized expertise in the building of cement production facilities in developing countries has become quite common.

Conservation of energy and raw materials within the cement industry is of worldwide concern and provides a theme around which major developments in the industry have taken place. Of particular note is the emphasis on blended cements and the utilization of slag, ash and other byproducts. Even greater additions to production capacities than those witnessed during the past few years will be needed to meet demand in many developing countries.

A review of the international cement scene is provided in the April 1979 issue of *Rock Products*, a publication of MacLean-Hunter Publishing Corp., Chicago, Illinois.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(¢ per 100 lb)			
29000-1	Portland and other hydraulic cement, nop; cement clinker	free	free	6	free
29005-1	White, nonstaining Portland cement	4	4	8	$2^2/_3$

United States

Item No.		
511.11	White, nonstaining Portland cement, per 100 pounds including weight of container	1¢
511.14	Other cement and cement clinker	free
511.21	Hydraulic cement concrete	free
511.25	Other concrete mixed, per cubic yard	7.5% ad valorem

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978), USITC Publication 843.

Cesium

J.G. GEORGE

Cesium is a soft, silvery white, ductile metal with a melting point of 28.5°C, a boiling point of 705°C, a density of 1.87 grams per cubic centimetre at 20°C and an atomic weight of 132.91. It is the eighth-lightest metallic element, but the heaviest of the alkali metals. It is one of the three metals (the others are mercury and gallium) that are liquid at room temperature. Cesium is the most electropositive of the alkali metals, has the highest density, highest vapour pressure, lowest boiling point and lowest ionization potential. Because of these properties, cesium is used in preference to other alkali metals in such space-age applications as space propulsion and energy conservation.

Cesium emits electrons when exposed to visible light, ultra-violet light or infrared light. It is an efficient scavenger for traces of oxygen in highly evacuated containers. Precautions must be taken in handling, transporting and storing cesium metal because in air or water it is very reactive chemically, and when exposed to a combination of the two it reacts violently, liberating hydrogen. Cesium is usually packed under argon, or in vacuum in Pyrex glass vials, or in returnable shock-proof stainless steel cylinders. Cesium compounds are not as dangerous as the metal, but they must be handled carefully and shipped in closed containers. Their toxicity is usually low, but cesium fluoride is toxic and should be handled with care.

Occurrences and recovery

Cesium occurs in certain granites and granitic pegmatites, with granites having been estimated to contain an average of about one part per million of cesium. Cesium also occurs in brines and in saline deposits. Although commercial quantities of cesium have been obtained from lepidolite and carnallite, the most important economic source of the metal is the rare mineral pollucite. Pollucite is usually found in complex, generally well-zoned, pegmatite dykes that are rich in lithium minerals, especially lepidolite and spodumene.

Pollucite, a mineral that resembles quartz in lustre and in transparency, is a hydrated silicate of aluminum and cesium ($H_2O\ 2Cs_2O\ 2Al_2O_3 \cdot 9SiO_2$) with the theoretically pure mineral containing 45 per cent cesium oxide (Cs_2O). Naturally occurring pollucite usually contains from 6 to 32 per cent Cs_2O.

The current small demand for pollucite or other cesium-containing minerals does not encourage exploration for such minerals *per se*, and they are usually found in conjunction with exploration for associated minerals. Pollucite ore is generally mined on market demand. Depending on grade, the valuable minerals are sometimes recovered by hand sorting.

The largest known reserves of pollucite are: 372 000 tonnes* at the Bernic Lake mine in Manitoba, Canada; some 135 000 tonnes in the Bikita district of Rhodesia; and 45 000 tonnes in the Karibib area in Namibia (South-West Africa). A second Canadian occurrence is at the Valor property in Lacorne Township, northwestern Quebec. Mozambique also has pollucite deposits, but reserves and grade are not known. Other occurrences are found in the island of Elba and at Veratrask, Sweden. Occurrences in the United States are in Oxford County, Maine and in the Black Hills near Custer, South Dakota. In recent years there has been no commercial production of cesium-bearing minerals in the United States and the likelihood of any future domestic production of such minerals remains remote. Pollucite imported from Canada is, and will likely for some time continue to be, the main source of the United States production of cesium and its compounds. In fact, the world itself is believed to be dependent on the known deposits of pollucite in Canada and southern Africa for its cesium requirements.

The only known Canadian cesium-bearing deposit of economic importance is at Bernic Lake in southeastern Manitoba, about 177 kilometres (km) northeast of Winnipeg. This property is operated by Tantalum Mining Corporation of Canada Limited (Tanco). Late in 1978 International Chemalloy Corporation's 50.1 per cent interest in Tanco was sold under arrangements whereby Hudson Bay Mining and Smelting Co., Limited and Kawecki Berylco Industries, Inc. of New York each became owners of 37.5 per cent of Tanco.

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

The remaining 25 per cent interest is held by the Manitoba Development Corporation (MDC), the investment agency of the Manitoba Government. Chemalloy had been in receivership for several years prior to November 1978, when its interest in Tanco was purchased by Hudson Bay and Kawecki Berylco. The pollucite ore zones at the Bernic Lake mine are separate from the company's tantalum and lithium orebodies (although these do contain low cesium values) which are contained in the same deposit. The pollucite unit consists of three gently dipping, sheet-like bodies, the largest of which ranges up to 14 metres (m) in thickness and lies in the southeast quadrant of the pegmatite. As of December 31, 1978 the company's cesium ore reserves consisted of 270 000 tonnes of pollucite averaging almost 23.9 per cent Cs_2O in the main zone, 47 000 tonnes averaging almost 23.9 per cent Cs_2O in one westerly zone and 55 000 tonnes of somewhat lower grade in the second westerly zone. These reserves estimates do not include allowances for dilution or pillars. The main zone is open to the south and could likely be extended by additional drilling. Also, there are large areas of the pegmatite body containing quantities of pollucite averaging 500 to 1 500 grams (g) of Cs_2O per tonne that have not yet been included in ore reserves. Also, drilling below the main pegmatite body has indicated a second sill, approximately 30 m below the main body, that contains pollucite, tantalite and spodumene mineralization.

Ores naturally rich in pollucite have been upgraded experimentally with some success, but satisfactory methods for the concentration of pollucite economically from low-grade ores have not yet been developed. The United States Bureau of Mines has, however, developed experimentally a froth flotation process for concentrating pollucite ore. When applied to a low-grade cesium ore from Maine, grading about 8 per cent Cs_2O, the ore was upgraded to over 21 per cent Cs_2O with a cesium recovery of almost 87 per cent. Commercial concentrates and direct-shipping ore usually grade in excess of 20 per cent Cs_2O.

Production and consumption

Minimal statistical data are available on the production and consumption of pollucite, cesium metal and cesium compounds. Annual world mine production of pollucite ore was estimated to be only 20 tonnes in 1968. Since then, an increasing demand has resulted in a significantly greater output of pollucite. From late 1969, when Tanco's Bernic Lake mine began operations, until the end of 1975, shipments of pollucite ore totalled about 1 400 tonnes with an average Cs_2O content of almost 27 per cent. Of these total pollucite shipments, almost 86 per cent were exported to Russia, approximately 8 per cent to the United States, with the remainder going to the United Kingdom, West Germany and Japan. All of the company's shipments of pollucite made to the end of 1975 were in the form of crushed ore. In 1976 the Bernic Lake mine did not make any shipments of pollucite ore and only a minor quantity was shipped in 1977. In 1978, shipments of pollucite ores totalled about 254 tonnes, all of which were exported to the United States. Late in 1976 the Canadian government placed cesium in all forms, including ores, concentrates, chemical compounds, cesium metal and alloys containing cesium, on the Export Control List established under the Export and Import Permits Act. This legislation banned shipments of cesium in all the above-mentioned forms to all communist countries.

Until 1968, world consumption of cesium metal and cesium compounds was probably less than 10 tonnes per year. In the past few years there has been a major increase in consumption, mainly because of the increasing quantities of cesium compounds used in experimental magnetohydrodynamics (MHD) electrical power generators. The U.S.S.R. is probably the largest consumer of cesium in the world. It imported over 1 200 tonnes of pollucite from Canada between late 1969 and the end of 1975, which suggests an annual consumption in the range of about 52 000 kilograms (kg) of cesium metal equivalent, unless some of these imports were put into stockpile. The U.S.S.R. has for several years been doing extensive research in cesium-based MHD generation of electricity.

Uses

At present there are no large-scale commercial uses for cesium; the largest portion of consumption occurs in the field of research and development. The largest use is in thermionic power conversion units, ion propulsion and MHD electrical power generators. In MHD pilot plants, which make use of cesium's ionization potential, a fuel (coal, oil or gas) is burned, usually with preheated or oxygen-enriched air. The hot combustion gases, at temperatures as high as 2 760°C (5 000°F), are then seeded with an easily ionized element such as a cesium or potassium compound, or a mixed cesium-potassium compound, to increase electrical conductivity. The extremely hot ionized gases (plasma) are then accelerated through a high-velocity nozzle into a cooled chamber, usually called the MHD channel, which is surrounded by a magnetic field produced by a super-conducting electromagnet. The gases, acting much like a rotating armature in a conventional generator, produce electricity which is bled off at high voltages by electrodes fixed to the inside walls of the channel. The electrodes are connected to inverters which convert the current from DC to AC. The amount of power generated depends mainly on the degree of ionization, the velocity of the plasma, and the magnetic field strength.

In an "open cycle" MHD power plant the gases exiting from the power generator are sufficiently hot (about 2 050°C) to heat water for a conventional steam turbine and thereby generate additional electricity. The exhaust gases then flow through heat exchangers, pass through cleaning equipment that recovers the expensive seed material and removes pollutants, including nitric oxide, and finally exit from a stack. Seed recoveries of up to 99.5 per cent have been reported. Sulphur dioxide emissions are greatly reduced, as sulphur in the coal combines with potassium vapour during the MHD cycle to form potassium sulphate. Research indicates that up to 99 per cent of the sulphur can be contained, depending on the amount of potassium compound used in the seeding material. The MHD process is thus suitable for use of high-sulphur coal (up to about 4 per cent sulphur) as its basic feed. Another advantage is that MHD generators greatly reduce mechanical unreliability in power generation, as virtually no moving parts are required. A major advantage of the combined MHD-turbine "open cycle" system is that it can operate at an overall efficiency of 50 to 60 per cent, while standard coal-fired power plants and conventional nuclear plants have efficiencies of about 40 and 32 per cent, respectively. While alternative materials such as rubidium, potassium and sodium may be used in the MHD process, under present technology compounds containing both cesium and potassium appear to be the most efficient.

In thermionic converters, heat from a nuclear reaction radiates to a surrounding metal (cathode) which emits large masses of electrons. The electrons travel through a space, filled with a gas such as cesium vapour, to an anode, which then has an electrical potential with respect to the cathode, and electricity can flow through a circuit joining the anode and cathode. The most important factor limiting the efficiency of thermionic generators is the "space charge" effect, caused by the mutual repulsion of electrons, wherein electrons in the space between the electrodes repel those emerging from the cathode and thereby return them to it. Ionized cesium gas is used to electrically neutralize the space charge. Nuclear heating is used in thermionic converters, as it can serve as the source for the high temperature (1 900°C) required.

In spacecraft, cesium is used in the ion-propelled engines. Vaporized cesium is ionized while passing through a heated porous tungsten disc. The cesium ions become positively charged and an electric field accelerates the positive ions to a velocity of some 483 000 km per hour. The high-velocity ions are neutralized by the injection of electrons and then exhausted through a nozzle to provide thrust. Since ion propulsion is essentially a low-thrust system, one of its potential uses lies either in holding orbiting space vehicles in orbit, or in the movement of such vehicles from one orbit to another. An ion engine could be used to move a vehicle from Earth orbit to Mars orbit, for example, but could not be used for takeoff from, or for landing on, either planet.

Other commercial applications for cesium include its use in photomultiplier tubes, vacuum tubes, scintillation counters, magnetometers, spectrophotometers, infrared lamps and pharmaceutical products, and as reagents in microanalysis. Another commercial use is in photoelectric cells, in which the photoemissive properties of cesium are utilized. An alloy of cesium and silver is used in the emitron or "electric eye" used in television. Cesium is used as an absorbent to remove impurities at carbon dioxide purification plants and as a catalyst in various hydrogeneration and polymerization processes. The metal may also act as a scavenger of gases and other impurities in chemical processing, and in ferrous and nonferrous metallurgy.

In biological research, concentrated cesium chloride solutions are used for density gradient ultracentrifuge separation of DNA, viruses and other large molecules. This application could become an important use for cesium. Cesium bromide is used in the manufacture of optical crystals. Cesium fluoride finds applications as a fluoridating agent in organic syntheses, and cesium hydroxide with rubidium hydroxide can be used in place of lithium hydroxide in alkaline storage batteries for operation at temperatures as low as −50°C. Cesium phosphate is used in the form of mixed crystals, with rubidium and/or ammonium salts, for piezoelectric purposes. Substitutes for cesium in some of its applications are potassium, magnesium oxide, and rubidium.

Outlook

So far, the market for cesium metal and cesium compounds has been quite limited, because their high cost and scarcity, as well as the extreme reactivity of cesium metal, restrict their uses to applications where their unique properties are important. The greater availability of less costly substitute materials such as potassium, magnesium oxide and rubidium, with properties similar to those of cesium, is also a factor limiting growth in consumption of cesium and its compounds.

Although accurate data are not available on world production and consumption of cesium and its compounds, currently known world reserves of pollucite ores are thought to be more than adequate to provide for expected world requirements of cesium and its compounds in the foreseeable future. Demand for cesium is expected to increase over the next several years, but changing requirements for research and development purposes could cause significant fluctuations in demand from year to year. Because of impending fuel shortages, rising fuel prices and increasing world demand for energy, the greatest potential for sharply increased consumption of cesium on a commercial basis appears to be in a technological break-through in the development of a power-generating process that uses cesium-containing compounds. Another source of increased demand would be created if the United States government decided to stockpile pollucite or to stockpile further-processed cesium compounds or metal. None of these materials are presently listed for stockpiling in the United States strategic and critical materials stockpile.

Late in 1974 it was reported that $150 million to $200 million had been spent worldwide on MHD research in the previous 15 years, with about 75 per cent of that amount having been spent in the U.S.S.R. Although the United States has spent much less money than the U.S.S.R. on MHD research, it is believed that the current energy crisis has revived support for greater research efforts in this field. Recent reports indicate that United States funding for MHD research in the fiscal year 1978 amounts to $70 million. The United States Department of Energy (DOE) is building an MHD research facility in Montana. A moderate-scale MHD generator will be the subject of initial studies, followed by the construction of an engineering test facility and a large demonstration plant. The first commercial MHD plant is not expected to come on stream in the United States before 1990, whereas such a plant should be in commercial operation in the Soviet Union in the early 1980s. MHD can be powered with any fossil fuel, but the greatest potential contribution toward solving today's energy crisis is that this new power-generating technique permits the use of the abundant available coal supplies, thus conserving the scarcer oil and natural gas.

Grades, specifications and prices

Although cesium metal is produced in 99.0, 99.5, 99.9 and 99.97 per cent purities, the two main grades in which it is usually marketed are: standard, with a minimum cesium content of 99.5 per cent; and high purity, with a minimum cesium content of 99.9 per cent. Cesium salts are also available and include acetate, bromide, carbonate, chloride, chromate, fluoride, hydroxide, iodide, nitrate and sulphate. Cesium salts are similarly available in a high-purity grade of 99.9 per cent minimum purity. Cesium is also available in a series of oxides.

Recent nominal quotations for raw pollucite ore of good grade and quality, typically ranging between 24 and 26 per cent Cs_2O content, vary from about $U.S. 1.32 to $U.S. 2.20 per kilogram (kg) of contained Cs_2O. Cesium compound prices range from about $U.S. 55.00 to $U.S. 176.00 per kg, depending on the type of the compound, purity and quantity purchased, Cesium metal of 99+ per cent purity has been quoted at $U.S. 496.00 to $U.S. 716.00 per kg, depending on the quantity and grade purchased. Four United States companies that produced cesium compounds and metal from imported materials in 1978, were: Callery Chemical Co., Callery, Pennsylvania; Kawecki Berylco Industries Inc. (KBI), Revere, Pennsylvania; Kerr McGee Chemical Corporation, Trona, California; and Great Western Inorganics, Inc. (formerly Rocky Mountain Research, Inc.), Golden, Colorado.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)	(%)	(%)	(%)
92805-1[1]	Cesium	10	15	25	10
93819-1	Compounds of cesium	10	15	25	10

United States

Item No.		Non-communist countries	Communist countries[2]
601.66	Pollucite	Free	Free
415.10	Cesium	8.5% ad valorem	25% ad valorem
418.50	Cesium chloride	6.0% ad valorem	25% ad valorem
418.52	Other cesium compounds	5.0% ad valorem	25% ad valorem

European Economic Community

Item No.				Autonomous	Conventional
				(%)	(%)
28.05	A.	iv	Cesium metal	5	4
28.30	A.	vii	Cesium chloride	12	9.6
28.38	A.	viii	Cesium sulphate	13	8
28.39	B.	vi	Cesium nitrate	14	11.2
28.42	A.	vii	Cesium carbonate	14	8.8

Sources: Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978), T.C. Publication 843; Official Journal of the European Communities, Volume 21, L335, December 1978.
[1]There are certain exceptions applicable to this tariff item. For further information reference should be made to the above-mentioned Canadian Tariff manual or directly to Revenue Canada, Customs and Excise Division, Ottawa. [2]Current exceptions are: Yugoslavia, Romania and, effective July 7, 1978, Hungary.

Chromium

D.G. LAW-WEST

Canada imports all of its chromium requirements. Virtually all imported chromite ores are consumed by the refractory brick industry. The stainless and specialty steel producers must import all of their ferrochromium as there is no longer a domestic producer. Imports of chromium-bearing commodities in 1978 were slightly lower tonnage-wise than in the previous year, reflecting the decreased demand in the steel industry.

Canada has no production of chromite, notwithstanding large resources of the mineral in the Bird River area in Manitoba and the Eastern Townships in Quebec. The Bird River deposits are a continuous band of chromite mineralization, similar in type to the important chrome deposits in Rhodesia and the Republic of South Africa. However, these Canadian deposits are considered uneconomic because most of the mineralization is low-grade – 10 to 20 per cent chromic oxide (Cr_2O_3) – and has a low chromium-to-iron ratio. The Ontario Research Foundation has developed a process for upgrading the Bird River chromite to a marketable product, and partially as a result of this, the Manitoba Department of Mines, Resources and Environmental Management is currently re-evaluating these deposits.

The chromite in the Eastern Townships is found as discontinuous or podiform deposits. These were exploited earlier in the century and during the Second World War, in response to a possible dislocation of supplies. Although these deposits are generally satisfactory in grade and composition, reserves are not large because of inadequate exploration – the large number of claim owners in this area also discourages major efforts to enlarge this resource base.

World developments

South Africa, the largest chromite producer in the western world, increased ore production slightly in 1978. A new joint venture between Vereeniging Refractories Ltd. and Armco Bronne (Pty) Ltd. will mine and market chrome ore from operations owned by Marico Mineral Co., a Vereeniging subsidiary, as well as from property jointly owned by Marico and Armco Bronne. Charge chrome producers operated at just over 50 per cent capacity during the year, reflecting poor world demand.

The U.S.S.R., the second-largest producer of chrome ore, planned to increase ore production capacity by 700 000 tonnes* per year in 1978, and accordingly, produce 30 per cent more concentrates than in the previous year. The Donskoye operation in western Kazakhstan produced 95 per cent of the Soviet output and is the only supplier of high-quality ore. The deposits being mined in the Ural Mountains are of lower grade and are consumed by the refractory and chemical industries.

Rhodesia is believed to have the world's largest deposits of high-grade metallurgical chromite ore. However, during the year several major chrome mines were placed on standby, reflecting in part both the 1977 U.S. repeal of the Byrd Amendment and the recession in the world steel industry.

The Philippines, a major world producer of refractory grade chromite ore, had lower production in 1978. It is reported that increasing silica content is making the refractory grade ores less acceptable to refractory producers. The recession in the world steel industry is another factor accounting for the decrease in Philippine chrome ore production.

In Turkey, crude chromite ore production remained unchanged from the previous year. However, ferrochrome production increased to 500 000 tonnes per year, reflecting the startup of two 18 000 KVA ferrochrome furnaces at Mardin during the year.

The Indian government, through the state-owned Minerals and Metals Trading Corporation (MMTC), has taken control of all exports of chrome ores and concentrates. MMTC will be responsible for enforcing all export ceilings of the various grades of chrome ores and concentrates. The Geological Survey of India announced the discovery of new chromite reserves, totalling some 30 million tonnes in Orissa State.

Uses and technology

There are three commercial grades of chromite, the only ore of chromium: metallurgical, refractory and chemical. Though interchangeable to a limited extent, each has a well-defined field of application.

Metallurgical grade chromite is used primarily in the production of ferroalloys; some is used for the production of

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, chromium imports, 1977 and 1978

	1977		1978[p]	
	(tonnes)	($)	(tonnes)	($)
Imports				
Chromium in ores and concentrates				
Philippines	8 188	1 386 000	12 284	2 591 000
United States	12 389	1 876 000	6 117	1 488 000
Finland	16 103	1 464 000	7 643	741 000
Turkey	—	—	3 421	643 000
Other countries[1]	4 567	658 000	2 623	538 000
Total	41 247	5 384 000	32 088	6 001 000
Ferrochromium				
United States	9 200	6 365 000	11 774	7 836 000
South Africa	9 740	5 493 000	13 500	6 210 000
Brazil	8 498	3 597 000	4 300	1 605 000
Other countries[2]	5 509	2 499 000	852	934 000
Total	32 947	17 954 000	30 426	16 585 000
Chromium sulphates, including basic				
United States	1 508	766 000	1 391	793 000
United Kingdom	289	144 000	469	305 000
West Germany	—	—	56	36 000
Total	1 797	910 000	1 916	1 134 000
Chromium oxides and hydroxides				
United States	1 197	1 949 000	1 270	2 378 000
United Kingdom	120	211 000	265	624 000
West Germany	19	36 000	61	123 000
Other countries[3]	—	—	41	95 000
Total	1 336	2 196 000	1 637	3 220 000
Chrome dyestuffs				
West Germany	8	36 000	7	61 000
United States	9	42 000	10	44 000
Switzerland	2	8 000	4	31 000
Other countries[4]	36	120 000	4	28 000
Total	55	206 000	25	164 000

Source: Statistics Canada.
[1] Includes West Germany, Netherlands, Mozambique and South Africa. [2] Includes Japan, Mozambique, United Kingdom, Sweden and West Germany. [3] Includes Netherlands and Poland. [4] Includes France, Italy, Japan, Netherlands, Poland, People's Republic of China and United Kingdom.
[p] Preliminary; — Nil.

chromium metal. The principal ferroalloys are high-carbon (HC) ferrochromium, low-carbon (LC) ferrochromium and ferrochromium-silicon.

As a constituent of iron castings, steels and superalloys, chromium increases resistance to oxidation and corrosion and the ability to withstand stress at high temperatures. In addition, chromium helps to refine the grain structure in iron castings.

The principal use of chromium ferroalloys is in the production of stainless and heat-resisting steels. Most applications of stainless and heat-resisting steels are in corrosive environments, e.g., petrochemical processing; high-temperature environments, e.g., turbines and furnace parts; and consumer goods areas, e.g., cutlery and decorative trim. Chromium is added to alloy and tool steels to increase their hardening ability and to improve some mechanical properties, such as yield strength. Superalloys containing chromium have a high degree of resistance to oxidation and corrosion at elevated temperatures and are used in jet engines, gas turbines and chemical processing. Chromium-containing castings are usually used for high-temperature applications.

Union Carbide Corporation and Joslyn Stainless Steels Division of Joslyn Mfg. and Supply Co. together developed

Table 2. Canada, chromium trade and consumption, 1965, 1970 and 1975-78

	Imports		Consumption[2]	
	Chromite[1]	Ferrochromium[2]	Chromite	Ferrochromium
	(tonnes)			
1965	32 122	13 913	62 691	11 705
1970	27 619	20 814	56 212	28 356
1975	29 663	41 109	36 790	18 417
1976	39 864	22 493	30 783	32 177
1977	41 247	32 947	30 299	28 435
1978[p]	32 088	30 426	27 472	..

Source: Statistics Canada.
[1] Chromium content. [2] Gross weight.
[p] Preliminary; .. Not available.

the argon-oxygen decarburization (AOD) process now widely used in the production of stainless and heat-resisting steels. It is essentially a refining step after the ferrochrome charge has been melted. Argon, an inert gas, and oxygen are added to the melt so that carbon instead of chromium will be preferentially oxidized. This allows the less expensive high-carbon ferrochrome to be used in place of the high-priced, low-carbon ferrochrome. The overall advantages obtained are lower cost of chromium additions as well as energy savings in the initial production of the ferroalloy. In Europe a similar technology, the Creusot-Loire-Uddleholm (CLU) process, is being commercially developed by the steelmakers.

The refractory industry uses chromium in the form of chromite, principally in the manufacture of refractory bricks. Some chromite is used for refractory purposes in mortars and in ramming, castable and gunning mixes, or directly for furnace repair.

Refractories composed of both chromite and magnesite are used wherever basic slags and dust are used, such as, in the ferrous and nonferrous metal industries. In the ferrous industry, chrome-magnesite brick is used in basic open-hearth and basic electric furnaces. The phasing out of basic open-hearth steelmaking had led to a decline in the amount of chromite used as a refractory in the steel industry. However, this trend has been offset to a certain extent by an increase in electric furnace production and overall, chromite refractory consumption in the steel industry is expected to stabilize in the next few years. In the nonferrous industry, chrome-magnesite brick is used mainly in converters. Oxygen-blowing converters with higher operating temperatures will necessitate a change to a higher-magnesite-content brick, thereby decreasing chromite refractory usage.

The glass industry uses some chrome-magnesite brick in the reheating chambers of glass furnaces, and the kraft paper industry uses a dense chromite brick in recovery furnaces to resist chemical attack by spent liquors.

Chromite mortars and gunning mixes are used in the bonding and coating of basic bricks, or in areas where separation of various types of bricks by a chemically neutral substance is desirable. Castables and ramming mixes are used mainly in open-hearth furnaces.

Chromium chemicals have a wide variety of uses in a number of industries. Most chromium chemicals are produced from sodium dichromate, which is manufactured directly from chemical-grade chromite. Chromium compounds are used as pigments, mordants and dyes in the textile industry; tanning agents for all types of leathers; and for chrome electroplating, anodizing and dipping. Chromium compounds are also used as oxidants and catalysts in the manufacture of various products such as saccarin; in the bleaching and purification of oils, fats and chemicals; and as an agent to promote the water insolubility of various products such as glues, inks and gels.

Table 3. World chromite mine production and reserves, 1977 and 1978

Country	Mine Production		Reserves
	1977	1978[e]	
	(000 gross tonnes)		
Philippines	537	544	2 994
Southern Rhodesia[e]	599	599	977 904
Rep. of South Africa	3 317	3 357	2 267 963
Turkey	635	635	4 990
Other market economy countries	1 611	1 632	46 266
Controlled economy countries	3 103	3 175	20 865
World total	9 802	9 942	3 340 982

Source: Mineral Commodity Summaries, 1979, United States Bureau of Land Management.
[e] Estimated.

Outlook

The short-term outlook for chromium markets and prices is expected to remain unchanged throughout 1979.

The long-term outlook for chromium demand is closely tied to the outlook for the steel industry. About 75 per cent of all chromium produced is consumed in the production of stainless and heat-resisting steels and some carbon steels. The current recession in the steel industry will continue to adversely affect the demand for chromium. At present there are chromite mines and ferrochromium plants operating below capacity.

Historically, chromium has been readily available at fairly low prices. This, however, should not overshadow the fact that chromium is a strategic and critical material. Chromium is irreplaceable for many applications, especially certain stainless steels used in energy-producing equipment. Any disruption in world supply of chromium would affect Canada both directly and indirectly. Canada must be prepared to meet crises situations that may develop with a full array of programs to eliminate or reduce substantially the lead-time necessary to develop alternative supplies.

Prices

Chrome prices published by "Metals Week"

	December 31, 1977	December 31, 1978
	($U.S.)	
Chrome ore, dry basis, fob cars Atlantic ports		
Transvaal, 44% Cr_2O_3, no ratio (per tonne)	55.12-60.04	54.00-58.00
Turkish, 48% Cr_2O_3, 3:1 ratio (per tonne)	129.92-139.76	105.00
Russian, 54-56% Cr_2O_3, 4:1 ratio (per tonne)	150.00	..
Chromium metal		
Electrolytic 99.8% fob shipping point (per kg)	1.19-1.27	1.36
Ferrochrome, fob shipping point (per kg Cr content)		
High carbon, 66-70% Cr, 5.0-6.5% C	18.60	18.6-20.40
Imported, 60-65% charge chrome	15.42-16.56	16.56-17.92
Low carbon, 67-73% Cr, 0.025% C	36.29	36.29

.. Not available.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
32900-1	Chrome ore	free	free	free	free
34700-1	Chromium metal in lumps, powder, ingots, blocks or bars, and scrap alloy metal containing chromium for use in alloying purposes	free	free	free	free
37506-1	Ferrochrome	free	5%	5%	free
92821-1	Chromium oxides and hydroxides	free	15%	25%	free
	With the following exceptions:				
	For use in the manufacture of artificial resins and plastics	free	free	25%	free
	For use in the manufacture of additives for heating, lubricating and fuel oils	free	5%	25%	free
92821-2	Chromium trioxide for use in the manufacture of galvanized and tin-plated steel	free	free	25%	free
92838-8	Chromium potassium sulphate	free	free	10%	free
92838-9	Chromium sulphate, basic	free	free	10%	free

United States

Item No.		
601.15	Chrome ore	free
607.30	Ferrochromium, not containing over 3% by weight of carbon	4%
607.31	Ferrochromium, containing over 3% by weight of carbon, on chromium content	0.28¢ per kg
632.18	Chromium metal, unwrought (duty on waste and scrap suspended)	5%
632.84	Chromium alloys, unwrought	9%
420.98	Chromate and dichromate	0.54¢ per kg
473.10-20	Chrome colours	5%
531.21	Chrome refractories	12.5%

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978) ITC Publication 843.

Clays and Clay Products

G.O. VAGT

Clays are a complex group of industrial minerals, each generally characterized by different mineralogy, occurrence and uses. All are natural, earthy, fine-grained minerals of secondary origin, composed mainly of a group of hydrous aluminum silicates and may contain iron, alkalis and alkaline earths. The clay minerals, formed by the chemical weathering or alteration of aluminous minerals such as feldspar and mica, are generally classified into three major groups based on detailed chemistry and crystalline structure – the kaolinite group, the montmorillonite group and the illite group. Clay deposits suitable for the manufacture of ceramic products may include nonclay minerals such as quartz, calcite, dolomite, feldspar, gypsum, mica, iron-bearing minerals and organic matter. The nonclay minerals may or may not be deleterious, depending upon individual amounts present and on the particular application for which the clay is intended.

The commercial value of clays, and of shales that are similar in composition to clays, depends mainly on their physical properties – plasticity, strength, shrinkage, vitrification range and refractoriness, fired colour, porosity and absorption – as well as on the proximity of any given deposit to growth centres in which clay products will be consumed.

Uses, type and location of Canadian deposits

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

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

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

Most of the surface deposits of common clays in Canada are the result of continental glaciation and subsequent stream transport. Such Pleistocene deposits are of interest to the ceramic industry and include stoneless marine and lake sediments, reworked glacial till, interglacial clays and floodplain clays. Clays from these deposits are characterized by low melting temperatures.

The common shales provide the best source of raw material for making brick. In particular, those found in Cambrian, Ordovician and Carboniferous rocks in eastern Canada, and Jurassic, Cretaceous and Tertiary rocks in western Canada, are utilized by the ceramic industry. In many instances these shales are more refractory than the Pleistocene clays. Several federal and provincial government reports are available describing the physical and chemical properties of ceramic raw materials that offer potential for the manufacture of numerous products.

China clay (kaolin). China clay is a high-quality, white or nearly white, clay formed from the decomposition of crystalline rocks such as graite. Alteration to form primary kaolins may result from hydrothermal or weathering processes or both. The natural decomposition process, known as kaolinization, results in a hydrated aluminum silicate ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$) with the approximate percentage composition as follows: 40 per cent Al_2O_3, 46 per cent SiO_2 and 14 per cent H_2O.

None of the crude kaolins known to exist in Canada have been developed, primarily because of beneficiation

Table 1. Canada, production of clay and clay products from domestic sources, 1976-78

	1976^r	1977	1978^p
		($000)	
Production from domestic sources, by provinces			
Newfoundland	569	550	569
Nova Scotia	3 900	4 547	4 718
New Brunswick	1 369	1 894	2 306
Quebec	14 147	16 989	16 904
Ontario	53 390	56 252	57 655
Manitoba	2 594	2 673	2 693
Saskatchewan	3 540	3 065	3 092
Alberta	10 398	10 518	10 532
British Columbia	8 551	6 873	8 810
Total	98 458	103 361	107 279
Production[1] from domestic sources, by products			
Clay, fire clay and other clay	945	...	...
Brick – soft and stiff mud process and dry press	63 485	70 751	71 298
– fancy and ornamental, sewer brick and paving brick	934	898	976
Structural hollow blocks	232	...	...
Drain tile	3 976	3 554	4 012
Sewer pipe	10 054	na[2]	na[2]
Flue linings	2 733	2 875	2 982
Pottery, glazed or unglazed (including coarse earthenware, stoneware and all pottery)	4 246	na[2]	na[2]
Other products	5 511	20 814	22 239
Small establishments not reporting detail	6 342	4 469	5 772
Total	98 458	103 361	107 279

Source: Statistics Canada.
[1] Producers' shipments, distribution for 1978 estimated by Statistics Section, Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa. [2] Included in "other products".
[p] Preliminary; [r] Revised; ... Insignificant; na Not applicable.

problems and the small size of some deposits. Most occurrences contain a high proportion of quartz particles of varied sizes; mica, feldspar, magnetite, pyrite and colloidal iron have been noted as well. In the crude material the percentage of kaolinite frequently is small and has made the removal of impurities from Canadian kaolins difficult.

China clay is used primarily as a filler and coater in the paper industry, a raw material in ceramic products, and as a filler in rubber and other products. The following properties are required in clays used by the paper industry: low-viscosity characteristics when in clay-water systems, intense whiteness, high coating retention, and freedom from abrasive grit. In the ceramic industry china clay is used as a refractory raw material. In prepared whiteware bodies such as wall tile, sanitaryware, dinnerware, pottery and electrical porcelain, quantities of nepheline syenite, silica, feldspar and talc are used as well.

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

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

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

Various kaolinitic-rock deposits have been investigated in Manitoba. The reported deposits are principally in the northwest at Cross Lake and Pine River, on Deer Island (Punk Island) and Black Island in Lake Winnipeg, and at Arborg.

Several companies have shown considerable interest in Quebec's kaolin-bearing deposits although the deposits, in general, contain an excessive amount of quartz and iron

Table 2. Canada, imports and exports of clay, clay products and refractories, 1977 and 1978

	1977		1978	
	(tonnes)	($000)	(tonnes)	($000)
Imports				
Clays				
Bentonite	358 723	7 885	295 713	7 811
Drilling mud	42 466	8 708	77 356	13 301
China clay, ground or unground	153 775	9 560	181 890	12 935
Fire clay, ground or unground	45 603	1 800	34 877	1 971
Clays, ground or unground, nes	135 052	5 474	164 726	7 294
Clays and earth, activated	120 133	5 750	13 319	4 643
Subtotal, clays	855 752	39 177	767 881	47 955
Clay products	(000 tonnes)		(000 tonnes)	
Building brick, glazed	4 883	614	3 275	413
Building brick, nes	45 976	4 743	128 406	2 269
Building blocks	..	1 387	..	2 048
Clay bricks, blocks and tiles, nes	..	3 226	..	3 585
Ceramic tiles	(m^2)		(m^2)	
under 2½" x 2½"	1 520 465	6 327	1 611 185	7 700
over 2½" x 2½"	5 624 462	21 643	5 935 571	21 931
Subtotal, brick, blocks, tile	..	37 940	..	37 946
Tableware, ceramic	..	61 869	..	80 504
Porcelain, insulating, fitting	..	13 648	..	13 747
Pottery settings and firing supplies	..	749	..	747
Subtotal porcelain pottery	..	76 266	..	94 998
Refractories	(tonnes)		(tonnes)	
Firebrick				
Alumina	48 159	12 649	26 848	12 642
Chrome	2 832	1 491	574	563
Magnesite	15 966	8 403	15 468	9 162
Silica	10 029	3 049	6 948	1 897
nes	165 734	24 250	107 069	28 360
Refractory cements and mortars	..	8 389	..	9 117
Acid-proof brick	..	268	..	251
Crude refractory materials, nes	9 707	1 003	10 663	2 250
Grog (refractory scrap)	15 533	1 756	12 844	1 409
Refractories, nes	..	5 345	..	5 420
Subtotal, refractories	..	66 603	..	71 071
Total clay, clay products and refractories	..	219 986	..	251 970

	1977		1978[p]	
	(tonnes)	($000)	(tonnes)	($000)
Imports				
By main countries				
United States	. .	114 579	. .	127 374
United Kingdom	. .	38 889	. .	53 300
Japan	. .	19 731	. .	22 476
Italy	. .	14 817	. .	15 389
West Germany	. .	7 005	. .	7 680
France	. .	4 905	. .	4 234
Spain	. .	2 806	. .	3 888
Philippines	. .	1 118	. .	2 586
South Korea	. .	2 043	. .	2 439
Greece	. .	2 852	. .	1 562
Other countries	. .	11 241	. .	11 042
Total	. .	219 986	. .	251 970
Exports				
Clays, ground and unground	1 737	145	2 893	240
Clay products	(000 tonnes)			(000 tonnes)
Building brick, clay	6 169	1 768	15 656	2 946
Clay bricks, blocks, tiles, nes	. .	627	. .	1 393
Subtotal, bricks, blocks, tiles	. .	2 395	. .	4 339
High-tension insulators and fittings	. .	2 503	. .	3 523
Tableware, nes	. .	4 958	. .	5 817
Subtotal porcelain tableware	. .	7 461	. .	9 340
Refractories				
Firebrick and similar shapes	40 676	13 017	53 199	19 425
Crude refractory materials	747 938	1 187	1 081 703	2 548
Refractory, nes	. .	6 391	. .	7 062
Subtotal refractories	. .	20 595	. .	29 035
Total clays, clay products and refractories	. .	30 596	. .	42 954
Exports				
By main countries				
United States	. .	22 017	. .	28 251
Venezuela	. .	698	. .	2 090
Zambia	. .	—	. .	1 444
United Kingdom	. .	374	. .	1 099
South Africa	. .	1 178	. .	886
Dominican Republic	. .	986	. .	771
Australia	. .	293	. .	533
Indonesia	. .	59	. .	526
Mexico	. .	171	. .	505
Colombia	. .	229	. .	427
Ecuador	. .	109	. .	427
Greece	. .	84	. .	426
Other countries	. .	4 398	. .	5 569
Total	. .	30 596	. .	42 954

Source: Statistics Canada.
[p] Preliminary; . . Not available; nes Not elsewhere specified; — Nil.

minerals. Kaolin-bearing rock occurs at St-Rémi-d'Amherst, Papineau County; Brébeuf, Terrebonne County; Point Comfort, on Thirty-one Mile Lake, Gatineau County; and Chateau-Richer, Montmorency County.

Extensive deposits of kaolin-silica sand mixtures occur in northern Ontario along the Missinaibi and Mattagami rivers. Distance from markets and the difficult terrain and climate of the area have hindered development, although tests and studies showed some encouraging results. The kaolin has good refractory characteristics and meets specifications for filler-grade material. Potential uses for the silica, which comprises 80 per cent of the deposit, include glass manufacture, abrasive flour and ceramic application.

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

Ball clays obtained in Canada are mineralogically similar to high-grade, plastic fire clay and are composed principally of fine-particle kaolinite, quartz, illite and mica. These clays have less alumina and more silica than kaolin.

Ball clays are extremely refractory materials. In whitewares they impart a high green strength as well as plasticity to the bodies. Although white firing clays are most suitable, fired products which are cream coloured do not interfere with the quality of the whiteware products.

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

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

Canadian fire clays are used principally for the manufacture of medium- and high-duty firebrick and refractory specialties. High-duty refractories require raw materials having a PCE of about 31.5 to 32.5 (approximately 1 699°C 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. Known Canadian fire clays are not sufficiently refractory for the manufacture of super-duty refractories without the addition of a higher refractory material such as alumina.

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

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

Fire clay, associated with lignite as well as with kaolin-silica sand mixtures, occurs in the James Bay watershed of northern Ontario along the Missinaibi, Abitibi, Moose and Mattagami rivers. Considerable exploration has been carried out in some parts of these areas in recent years.

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

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

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

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

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

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

Table 3. Canada, shipments of clay products produced from imported clay[1], 1975-77

	1975	1976	1977[p]
		($000)	
Electrical porcelains	28 138	24 874	21 862
Glazed floor and wall tile	9 036	7 950	8 966
Sanitaryware	. .	18 079	. .
Pottery, art and decorative ware	—	—	. .
All other products	21 905	8 104	31 489
Total	59 079	59 007	62 317

Source: Statistics Canada.
[1] Does not include refractories.
[p] Preliminary; . . Not available; — Nil.

Table 4. Canada, shipments of refractories, 1975-77

	1975		1976		1977[p]	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Firebrick and similar shapes	129 057	36 707	109 573	32 473	99 155	35 976
Cement, mortars, castables	122 886	28 277	na	29 459	na	30 334

Source: Statistics Canada.
[p] Preliminary; na Not applicable.

Table 5. Canada, clay and clay products, production and trade, 1960, 1965, 1970 and 1975-78

	Production					
Year	Domestic Clays	Imported Clays	Total	Refractory Shipments[1]	Imports	Exports
			($ million)			
1960	38.2	21.5	59.7	18.6	46.7	5.3
1965	42.8	31.4	74.2	27.4	59.4	10.3
1970	51.8	33.6	85.4	42.3	81.2	15.6
1975	78.4	59.1	137.5	65.0	177.4[r]	25.1[r]
1976	98.5	59.0	157.5	61.9	178.8[r]	25.2[r]
1977	103.4	62.3	165.7	66.3	220.0	30.6
1978[p]	107.3	. .	. .	. .	252.0	43.0

Source: Statistics Canada.
[1] Includes firebrick and similar shapes, refractory cements, mortars, castables, plastics, etc., plus all other products shipped.
[r] Revised; [p] Preliminary; . . Not available.

Canadian industry and developments

Clay products manufactured in Canada from domestic sources include clay brick, drain tile, structural tile and sewer pipe. The value of clay products produced from domestic sources in 1978 was approximately $107 million, up from the final 1977 figure of $103.4 million. The brick and tile manufacturing industry accounts for nearly 70 per cent of the total value of this group of clay products.

Manufacturers using imported clays include operations primarily involved in the manufacture of electrical porcelains, glazed floor and wall tiles, pottery, chinaware and sanitaryware. The estimated value of shipments during 1978 of this group of products was $65 million.

The value of imported clay brick, blocks, tile tableware, porcelain and pottery was approximately $133 million in 1978. The value of imported refractory products was approximately $71 million during the same period.

Didier Refractories Corp. of Becancour, Quebec began production of high alumina brick, basic brick and a broad range of other refractory products. The plant is designed to produce 40 000 to 50 000 tonnes* of refractories per year, primarily for domestic and United States markets.

Table 6. Canada, consumption (available data) of china clay, by industry, 1976 and 1977

	1976	1977[p]
	(tonnes)	
Paper and paper products[1]	111 973	109 236
Ceramic products	7 267	10 452
Paint and varnish	4 580	4 199
Rubber and linoleum	3 431	3 708
Other products[2]	47 068	47 457
Total	174 319	175 052

Source: Statistics Canada, industry allocation by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Includes paper and paper products and paper pulp. [2] Includes refractory brick mixes, cements, glass fibre and wools, adhesives, foundry, wire and cable and other miscellaneous products.
[p] Preliminary.

World review

United States mine production of clays in 1978 increased to approximately 51 million tonnes, valued at $694 million. A major portion of the increase was attributed to higher levels of construction activity.

Demand for clays in the United States is expected to increase at annual rates of between 2 and 6 per cent through 1985; however, continued growth of the energy intensive clay-based industries could be severely impeded by persistent energy problems and lowered construction rates. Adequate reserves of high-quality clays of all types, together with possession of clay-processing technology, assure the United States a position as a major world supplier of clays. The United States is the world's leading producer of kaolin, accounting for about 35 per cent of total world production. The United Kingdom is the second-largest producer and is the leading exporter of kaolin, mainly to Europe, United States and Japan. Other major producers are U.S.S.R., France, Czechoslovakia, West Germany and Spain.

A development on the Jari River in northern Brazil by National Bulk Carriers Inc., of New York continued production of paper-coating-grade kaolin. Annual production levels are expected to reach about 140 000 tonnes in 1979. A second project to evaluate the feasibility of producing kaolin is being undertaken by Caulim do Para under joint venture with J.M. Huber Corporation of the United States.

In Western Australia, the Gabbon kaolin deposit continues to be evaluated by Engelhard Minerals & Chemicals Corporation.

Emphasis continued to be placed on improved energy efficiency by using lower cost or alternative fuel sources and on improved kiln insulation techniques. Also, processes aimed at producing higher quality products gained much attention and in the United States a trend continued away from dry clay shipments in bulk hopper cars to slurry clay at 70 per cent solids in tank cars.

Outlook

Clay and clay products production is expected to increase as a result of higher projected building construction and engineering expenditures in 1979.

Increased costs of energy will lead to greater emphasis on improving insulation, improving operating practices and increasing the utilization of waste heat. Also, it is expected that research and development will be warranted to utilize lower cost sources of renewable energy in the form of solid fuel. Pulverized coal could also be used where availability and cost effectiveness allow.

The few known deposits of fire clays and ball clays in the developed areas of Canada are being utilized. Much assessment work has been done on deposits containing kaolin but, because of small size, high cost of beneficiation, or remoteness from transportation or industry, none have been developed to date. Ontario and Quebec are particularly deficient in developed deposits of refractory- or kaolin-type clays.

Demand for high-grade, super-duty refractories continued to be high through 1978. Steel processes such as the basic oxygen furnace, pressure pouring and continuous casting, represent relatively new refractory requirements. New products and designs have also been dictated by changes in reducing atmospheres in the chemical and

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

petrochemical industry, by increased demand for high-purity glass and by the need for more economical production of ceramics.

Clay and shale, like other low-cost construction materials, must be produced near the heavily populated areas where the markets are situated. This necessary feature of the industry will continue to produce increasingly complex problems related to rising land costs, land use conflicts, environmental control requirements and cost of land rehabilitation. The situation is particularly acute in southwestern Ontario where suitable reserves of brick-shales and other construction materials are being depleted, with few prospects for the opening of new pits and quarries under present controls.

Bentonite and fuller's earth

Bentonite, a clay which consists primarily of montmorillonite, a hydrous aluminum silicate with weakly attached cations of sodium and calcium, is reviewed in a separate section of the *Canadian Minerals Yearbook, 1978*.

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

Prices

United States clay prices, according to "Chemical Marketing Reporter", December 29, 1978

	($ per short ton)
Ball clay	
Domestic, crushed, moisture-repellent, bulk carlots, fob Tennessee	8.00-11.25
Imported lump, bulk, fob Great Lakes ports	40.50
Imported, airfloated, bags, carlots, Atlantic ports	70.00
China clay (kaolin)	
Water washed, fully calcined, bags, carlots, fob Georgia	175.00-194.00
Uncalcined, No. 1 coating, same basis, bulk	76.00
Dry-ground, airfloated soft, same basis	25.00

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)	(%)	(%)	(%)
29500-1	Clays, including china clay, fire clay and pipe clay not further manufactured than ground	free	free	free	free
29525-1	China clay	free	free	25	free
28100-1	Firebrick containing not less than 90 per cent silica; magnesite firebrick or chrome firebrick; other firebrick valued at not less that $100 per 1 000, rectangular shaped, not to exceed 100 x 25 in.[3] for use in kiln repair or other equipment of a manufacturing establishment	free	free	free	free
28105-1	Firebrick, nop, of a class or kind not made in Canada, for use in construction or repair of a furnace, kiln, etc.	free	free	15	free
28110-1	Firebrick, nop	5	10	22½	5
28200-1	Building brick and paving brick	10	10	22½	6½
28205-1	Manufactures of clay or cement, nop	12½	12½	22½	8
28210-1	Saggars, hillers, bats and plate setters, when used in the manufacture of ceramic products	free	free	free	free
28300-1	Drain tiles, not glazed	free	17½	20	free

Canada (cont'd)

Item No.					
28400-1	Drain pipes, sewer pipes and earthenware fittings therefor; chimney linings or vents, chimney tops and inverted blocks glazed or unglazed, nop	15	20	35	13
28405-1	Earthenware tiles, for roofing purposes	free	32½	35	free
	General Agreement on Tariffs and Trade		17½		
28415-1	Earthenware tiles, nop	12½	20	35	12½
28500-1	Tiles or blocks of earthenware or of stone prepared for mosaic flooring	15	27½	30	13
	General Agreement on Tariffs and Trade		20		
28600-1	Earthenware and stoneware, viz: demijohns, churns or crocks, nop	20	30	35	13
	General Agreement on Tariffs and Trade		20		
28700-1	All tableware of china, porcelain, semiporcelain or white granite, excluding earthenware articles	free	20[1]	35	free
28705-1	Articles of chinaware, for mounting by silverware manufacturers	12½	17½	22½	11½
28710-1	Undecorated tableware of china, porcelain, semiporcelain for use in the manufacture of decorated tableware	free	10	35	free
28800-1	Stoneware and Rockingham ware and earthenware, nop	17½	20	35	13
28805-1	Chemical stoneware	free	10	35	free
28810-1	Hand forms of porcelain for manufacture of rubber gloves	free	10	35	free
	General Agreement on Tariffs and Trade		free		
28900-1	Baths, bathtubs, basins, closets, closet seats and covers, closet tanks, lavatories, urinals, sinks and laundry tubs of earthenware, stone, or cement, clay or other material, nop	12½	20[1]	35	12½

United States

Item No.		(¢ per long ton)
521.41	China clay or kaolin	33
521.51	Fuller's earth, not beneficiated	25
521.54	Fuller's earth, wholly- or partly beneficiated	50
521.61	Bentonite	40
521.71	Common blue clay and other ball clays, not beneficiated	42
521.74	Common blue clay and other ball clays, wholly- or partly beneficiated	85
521.81	Other clays, not beneficiated	free
521.84	Other clays, wholly- or partly beneficiated	50
521.87	Clays artificially activated with acid or other material	0.05¢ per lb. +6% ad valorem

Sources: Customs and Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States annotated (1978), ITC Publication 843.

[1] 15 per cent to June 30, 1978.

nop Not otherwise provided for.

Note: In addition to the above tariffs various duties are in existence on manufactured clay products, viz., brick pottery, artware, etc.

Most of the vast quantity of Alberta and British Columbia coal shipped to Japan during 1978 was off-loaded from unit trains at the Roberts Bank terminal in Vancouver harbour before being loaded onto freighters for the final leg of the journey.

Canadian Pacific photo

Coal and Coke

J.A. AYLSWORTH and H.J. WEYLAND

The Canadian coal industry experienced another year of growth in 1978 based on increased exports of coking coals and increased domestic consumption. For the first time, exports and imports of coal were virtually in balance, and forecasts indicate that exports will continue to grow at a greater rate than imports throughout the 1980s. One new coal mine began production in 1978 and several other potential mines were under study. The new mine is part of a $500 million coal system that, for the first time, will move significant amounts of western Canadian coal to Ontario.

Towards the end of 1978, the Saskatchewan government released a coal policy stressing continued reliance on coal as its major electricity-generating fuel and, Alberta auctioned off 81 000 hectares (ha) of coal-bearing land for future development. The federal government funded coal infrastructure studies, drilling programs and coal-related research and development work in widely separated areas of Canada.

Throughout the year, exploration, drilling, trenching and other predevelopment work was under way on several properties, as a large number of potential producers were comparing future marketing opportunities against the capital and other requirements necessary to bring new mines into production. The most active segment of the Canadian coal industry continued to be the thermal sector as three new electricity-generating units, totalling 1 375 megawatts (MW), came on stream in 1978. In addition, eight other units, with a total capacity of 1 850 MW, were under construction, one 750 MW station received provincial government approval and another 750 MW station was in the final stage of applying for government approval.

Statistical review

Canadian clean coal production rose to a record level of 30.5 million tonnes* in 1978, up 6 per cent from 28.7 million tonnes in 1977. The value of output also grew to a new record level of $776 million, a 15 per cent increase over the previous year's total of $674 million. Increased bituminous coal production was the major factor behind the record output in 1978, growing to 17.1 million tonnes, 12 per cent over the 1977 figure of 15.3 million tonnes. Sub-bituminous production, all from Alberta, reached 8.3 million tonnes, a 5 per cent increase from the previous year, while lignite production fell 7 per cent to 5.1 million tonnes. The average value of all types of coal increased in 1978, with bituminous coal reaching $41.92 per tonne, sub-bituminous coal $4.37 per tonne and lignite $4.25 per tonne, compared with $40.76, $3.79 and $3.79 per tonne respectively for 1977.

Alberta remained the leading coal-producing province in terms of volume, with an output of 13.4 million tonnes. British Columbia produced 9.1 million tonnes, Saskatchewan 5.1 million tonnes, Nova Scotia 2.7 million tonnes and New Brunswick 315 000 tonnes.

Canadian imports have traditionally exceeded coal exports. However, during the last decade the gap has been narrowing and in 1978, for the first time, coal imports and exports were virtually in balance. Exports reached 14.0 million tonnes in 1978, up 13 per cent from 12.4 million tonnes in 1977. Imports dropped to 14.1 million tonnes from 15.4 million the previous year, primarily because of a strike in U.S. coal mines. The values of imports and exports, at points of entry and exit, were also in balance in 1978, for the first time in history, reaching $790 million.

On the consumption side, domestic use grew marginally in 1978. Consumption of thermal coal reached 22.9 million tonnes in 1978, up from 22.4 million tonnes in 1977, while general industry use grew to 1.9 million tonnes from 1.8 million tonnes. Consumption of coking coal reached 7.0 million tonnes, up from 6.7 million tonnes despite a reduction in imports from the United States, the increase was accounted for by greater use of Nova Scotian, Albertan and British Columbian coking coals. Canadian coals accounted for 17 per cent or 1.2 million of the 7.0 million tonnes of coking coal used in Canada in 1978, compared with 13 per cent in 1977.

Government activities and related developments

Throughout the year, the federal government provided support for projects that would facilitate expanded coal production in both western and eastern Canada. Provincial initiatives in 1978 included the release of a coal policy by the Government of Saskatchewan, the sale of Crown coal

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, coal production[1] by rank and province, 1977 and 1978

	1977		1978	
	(000 tonnes)	($ 000)	(000 tonnes)	($ 000)
Bituminous				
Nova Scotia	2 165	81 733	2 650	116 322
New Brunswick	277	6 168	315	10 042
Alberta	4 274	196 026	5 115	212 616
British Columbia	8 585	339 686	9 061	379 489
Total	15 301	623 613	17 141	718 469
Sub-bituminous				
Alberta	7 902	29 962	8 278	36 135
Lignite				
Saskatchewan	5 478	20 762	5 058	21 520
Total, all types	28 681	674 337	30 477	776 124

Sources: Statistics Canada; Energy Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Production represents clean coal output, plus raw coal sales from the mine where there is a preparation plant at the mine, plus raw coal shipments where there is no preparation plant at the mine.

Table 2. Canada, coal production, imports, exports and consumption, 1968-78

	Production	Imports[1]	Exports	Domestic Consumption
		(tonnes)		
1968	9 969 059	15 464 547	1 312 707	24 782 275
1969	9 681 366	15 737 300	1 249 984	23 999 872
1970	15 063 044	17 112 932	3 983 967	26 773 320
1971	16 721 410	16 452 867	7 015 963	25 627 819
1972	18 787 175	17 476 814	7 723 229	25 757 783
1973	20 472 755	14 830 511	10 907 717	24 870 489
1974	21 269 588	12 381 118	10 774 106	24 844 710
1975	25 258 956	15 254 906	11 694 655	26 126 654
1976	25 476 044	14 585 002	11 761 930	28 219 804
1977	28 681 759	15 438 717	12 386 550	30 895 999
1978[p]	30 476 855	14 119 424	14 000 718	31 738 310

Sources: Statistics Canada; Energy Policy Sector, Department of Energy, Mines and Resources, Ottawa for 1978.
[p] Preliminary.

leases in Alberta and amendments to British Columbia's coal act.

The Saskatchewan coal policy emphasized the critical role coal can play in meeting future provincial energy needs and was developed after completion of several coal studies. The policy consists of elements developed under five basic objectives: security of energy supply; economic benefits; environmental protection; social benefits; and research and development. The policy prescribed administrative procedures for licensing new coal mines and for depositing of Crown coal rights; levied a new royalty of 15 per cent of the minehead value of coal and introduced a property tax on freehold coal rights. The government emphasized the dynamic nature of policy development and noted that future circumstances could necessitate amendments to this policy.

In November, Alberta held its first public offering of Crown coal rights and announced plans for two auctions in 1979. The 1978 auction resulted in the sale of 81 000 ha of land to the west and southwest of Edmonton, and transferred to the successful companies the right to explore and, within certain limits, develop these leases. Further provincial approvals are required prior to actual mine development. Earlier in the year, British Columbia had introduced amendments to its provincial coal act, increasing the rental fees and lease charges on its coal-bearing lands and set a new royalty rate at 3.5 per cent of the net minehead value of coal produced.

Federal-provincial studies related to possible coal developments in the northeastern corner of British Columbia were extended for a further two years during 1978. Coal quality, infrastructure, environment and market studies continued to assess the coal supply potential of this area relative to a possible expansion in world coking coal demand in the 1980s. In the east the federal government provided support for coal assessment programs and for a series of other studies that could eventually lead to a doubling of production from the Cape Breton Development Corporation (DEVCO) operations near Sydney, Nova Scotia. Feasibility and engineering studies were under way on plans for development of a new coal mine and rehabilitation of an existing mine, and on improvements to coal transportation, shipping and storage facilities. If final approval is received for this program, expanded production could begin in the mid-1980s. Growing demand for thermal coal in Nova Scotia will provide the major market for this coal.

Production and mine development

British Columbia. Clean coal production rose 6 per cent to 9.1 million tonnes in 1978, up from 8.6 million tonnes in 1977. While all production now comes from three mines in the southeastern corner of the province, several mines in both the southeastern and northeastern regions of the province are in various stages of predevelopment.

Kaiser Resources Ltd. is Canada's largest coal producer. Raw coal output grew to a record level of 7.4 million tonnes in 1978, of which 6.6 million tonnes came from the Harmer Ridge surface mine and 796 000 tonnes from the underground Michel Colliery.

Shipments of clean coking coal from Kaiser's operations reached 5.9 million tonnes in 1978 with Japan again the major customer, taking 4.2 million tonnes. Shipments to other markets rose by approximately 140 per cent to 1.7 million tonnes, reflecting increased sales to existing customers, trial shipments to some European markets and renewed shipments to Mexico. Kaiser marketed coking coal to 11 countries in 1978 and thermal coal to four countries, in addition to its sales to Japan.

Fording Coal Limited was the second-largest producer in British Columbia, with a raw coal output of 4.3 million tonnes in 1978, up 8 per cent from the previous year. Approximately 2.8 million tonnes of clean or saleable coking coal was marketed to overseas customers, with over 95 per cent going to Japan. Small shipments went to Belgium, South Korea and Argentina.

Byron Creek Collieries Limited was the other operating mine in British Columbia in 1978. Raw coal production grew to 536 000 tonnes, up 45 per cent over 366 000 in

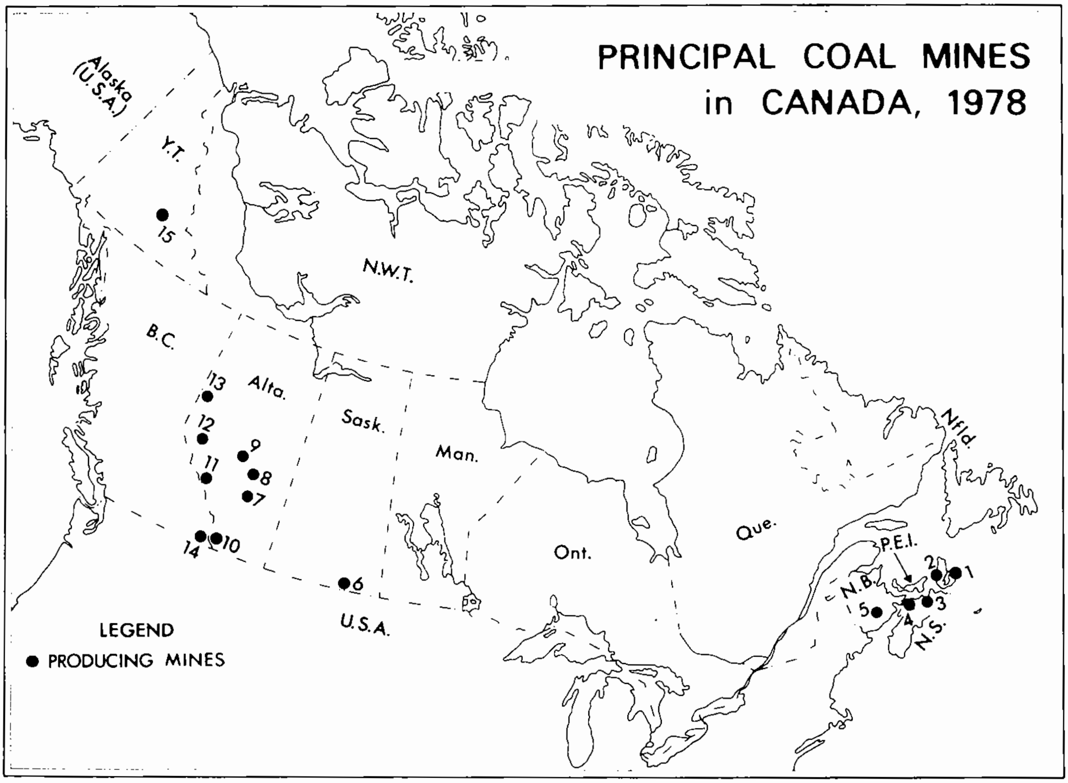


Table 3. Principal coal producers, 1978

Company and Mine Location	1978 Raw Coal Production	Coal Rank	Chief Markets	Remarks
(Numbers refer to map on preceding page)	(000 tonnes)			
Nova Scotia				
1. Cape Breton Development Corporation (DEVCO),				
Lingan Mine, Lingan	1 777	Hvb A	Power generation	Underground
No. 26, Glace Bay Colliery	800	Hvb A	Metallurgical, Industrial, Domestic	Underground
Prince Mine, Point Aconi	170	Hvb A	Power generation	Underground
1. Thomas Brogan Limited, Florence	47		Power generation Residential	Surface
2. Evans Coal Mines Limited, St. Rose	33	Hvb B	Power generation Residential	Underground
3. Thorburn Mining Limited, Stellarton	40		Power generation Residential	Underground
4. River Hebert Coal Company Limited	22	Hvb A	Power generation	Underground
New Brunswick				
5. N.B. Coal Limited, Minto, Chipman areas	315	Hvb A	Power generation Paper mills	Surface
Saskatchewan				
6. Manitoba and Saskatchewan Coal Co. (Limited), M&S Mine, Bienfait	448	Lig A	Power generation Industrial	Surface
Boundary Dam Mine, Estevan	1 700	Lig A	Power generation	Surface, began production in Jan. 1974
6. Manalta Coal Ltd., Klimax Mine, Estevan	674	Lig A	Power generation Industrial	Surface
6. Manalta Coal Ltd., Utility Mine, Estevan	1 893	Lig A	Power generation	Surface
6. Saskatchewan Power Corp., Souris Valley Coal Mine, Estevan	344	Lig A	Power generation	Surface

Table 3. (cont'd)

Company and Mine Location	1978 Raw Coal Production	Coal Rank	Chief Markets	Remarks
	(000 tonnes)			
Alberta				
Sub-bituminous Mines				
7. Manalta Coal Ltd., Roselyn Mine, Sheerness	438	Sub C	Power generation	Surface
8. Manalta Coal Ltd., Vesta Mine, Halkirk	513	Sub C	Power generation Residential	Surface
8. Forestburg Collieries Limited, Diplomat Mine, Forestburg	922	Sub C	Power generation Residential	Surface
9. Manalta Coal Ltd., Whitewood Mine, Wabamun	1 329	Sub A & B	Power generation	Surface
Highvale Mine, Sundance	4 969	Sub C	Power generation	Surface
Bituminous Mines				
10. Coleman Collieries Limited, Vicary Creek, Coleman	348	Mvb	Japan for coke-making	Underground
Tent Mountain, Coleman	1 020	Mvb	Japan for coke-making	Surface
11. The Canmore Mines, Limited, Canmore	122	An	Japan for coke-making	Underground
12. Cardinal River Coals Ltd., Cardinal River Mine, Luscan	2 472	Mvb	Japan for coke-making	Surface
12. Luscar Sterco Ltd., Coal Valley Mine	1 242	Mvb	Ontario Hydro and West Germany	Surface Mine opened in 1978
13. McIntyre Mines Limited, Smoky River Mines, Grande Cache	1 266 907	Lvb	Japan for coke-making	Surface and Underground
British Columbia				
14. Kaiser Resources Ltd., Michel Colliery, Natal	796	Lvb	Japan, European, Latin American and others for coke-making and thermal markets	Surface and Underground (hydraulic mining, room-and-pillar)
Harner Ridge, Sparwood	6 600	Lvg		Surface
14. Fording Coal Limited, Fording Mine, Fording Valley	4 300	Lvb	Japan for coke-making	Surface
14. Byron Creek Collieries Limited, Corbin	536	Mvb	Ontario and Japan for thermal markets	Surface

Table 3. (cont'd)

Company and Mine Location	1978 Raw Coal Production	Coal Rank	Chief Markets	Remarks
	(000 tonnes)			
Yukon				
15. Cyprus Anvil Mining Corporation, Carmacks Coal Mine, Carmacks	17	Hvb B	Anvil lead-zinc mine for heating and concentrate drying	Underground

Sources: Statistics Canada; Energy Policy Sector, Department of Energy, Mines and Resources, Ottawa.
An – Semianthracite; Lvb – Low volatile bituminous; Mvb – Medium volatile bituminous; Sub – Sub-bituminous; Lig – Lignite; Hvb – High volatile bituminous.

1977. Production will increase to the 1.5-million-tonne level by the mid-1980s, based partly on a 700 000-tonne-contract with Ontario Hydro. Shipments to Ontario reached 345 000 tonnes in 1978, while other customers included two Canadian smelters and an iron and steel company in Japan.

Prospects for new coal developments occur in several regions of British Columbia. In the East Kootenay Coalfield, the Sage Creek coal property owned by Rio Algom Limited and Pan Ocean Oil Ltd., and the Elk River coal property owned by Elco Mining Limited have been under study for a number of years. The Line Creek coal property, north of Sparwood, was acquired by Shell Canada Resources Limited from Crows Nest Industries Limited in early 1978. The former owners, in conjunction with a Japanese company, had completed a feasibility study of this property in 1977.

In northern British Columbia, several potential coal producers were involved in exploration, testing or feasibility work in 1978. Some of the companies undertaking work in this area included: Brameda Resources Limited; Brascan Resources Limited; BP Canada Limited; Cinnabar Peak Mines Ltd.; Denison Mines Limited; Gulf Canada Limited; Imperial Oil Limited; Pacific Petroleums Ltd.; Pan Ocean Oil Ltd.; Quintette Coal Limited; and Ranger Oil (Canada) Limited.

Coal deposits in the centre of the province and on Vancouver Island were also under study. Thermal coal deposits capable of supporting substantial electricity-generating capacity were under investigation near Hat Creek, while drilling and mapping were under way on the Quinsam deposit on the eastern side of Vancouver Island.

Yukon and Northwest Territories. Cyprus Anvil Mining Corporation at Carmacks is the only coal mine operating in Canada above the 60th parallel of latitude. Output in 1978 was 16 613 tonnes, up from the unusually low level of 7 732 tonnes in 1977.

Alberta. The Plains and Foothills regions of Alberta support more coal mines and produce more coal than any other region in Canada. Saleable coal output was 13.4 million tonnes, up from 12.2 million tonnes in 1978. Sub-bituminous production rose to 8.3 million, all of which was marketed to private or public utilities for electricity generation, while 5.1 million tonnes of bituminous production went to foreign steel industries and other customers.

Total raw coal production from McIntyre Mines Limited at Grande Cache was 2.2 million tonnes in 1978, down from 3.2 million tonnes in 1977. Japanese steel companies purchased 1.2 million tonnes and shipments to customers in Latin America and South Korea totalled 110 000 tonnes. McIntyre continued to be one of the two Canadian producers marketing coking coal to Canadian steel companies, sending 192 000 tonnes to The Steel Company of

Table 4. Canada, coal production by rank, province and type of mining, 1978

	Production[1] Underground	Surface
	(000 tonnes)	
Bituminous		
Nova Scotia	2 847	47
New Brunswick	—	318
Alberta	1 839	5 569
British Columbia	715	11 540
Sub-bituminous		
Alberta	32	7 872
Lignite		
Saskatchewan	—	5 479
Canada 1978	5 433	30 788
1977	5 131	28 852
Total, all mines		
1978	36 211	
1977	33 983	

Sources: Statistics Canada; Energy Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Raw coal production only.

Canada, Limited (STELCO) in Hamilton and 128 000 tonnes to Nova Scotia's Sydney Steel Corporation (SYSCO) in 1978. In addition, 147 000 tonnes of coal went to the Alberta Power Limited's H.R. Milner thermal power station.

Raw coal output from Cardinal River Coals Ltd.'s Cardinal River mine reached 2.5 million tonnes in 1978, up from 1.9 million tonnes in 1977. Approximately 95 per cent of this coal was marked to Japan, with the remainder sold to South Korea and Chile.

There were two other bituminous coking coal producers in Alberta in 1978. Coleman Collieries Limited produced 1.4 million tonnes of raw coal from its surface and underground operations and sold 973 000 tonnes to Japanese steel mills. The Canmore Mines, Limited produced 122 000 tonnes of raw coal and marketed 89 000 tonnes to Japan.

Alberta remained Canada's major thermal coal producer, with a record 8.3 million tonnes of sub-bituminous coal produced in 1978. Sixteen mines produced thermal coal, with the Highvale Mine of Manalta Coal Ltd. being the largest producer. It produced 5.0 million tonnes of coal for a nearby thermal power station owned by Calgary Power Ltd. Output from the adjacent Whitewood mine at Wabamun was 1.3 million tonnes.

Other major thermal coal producers in Alberta included: the Roselyn and Vesta mines of Manalta Coal Ltd., with outputs of 438 000 and 513 000 tonnes respectively; the Diplomat Mine of Forestburg Collieries Limited, which produced 922 000 tonnes; and the new Luscar Sterco Ltd., Coal Valley Mine, which produced 1.2 million tonnes. This latter mine began production in 1978 to supply Ontario Hydro's requirements and more recently completed a 15-year contract with a West German utility.

Saskatchewan. Coal production in Saskatchewan declined in 1978 to 5.1 million tonnes, from 5.5 million tonnes in 1977, primarily because of reduced shipments to Manitoba. A return to normal electricity production from hydro sources, after two years of low water levels, allowed Manitoba to reduce its coal consumption from 1.1 million tonnes in 1977 to 341 000 tonnes in 1978. Coal consumption in Saskatchewan rose to a record high of 4.6 million tonnes, up from 4.3 million tonnes in 1977.

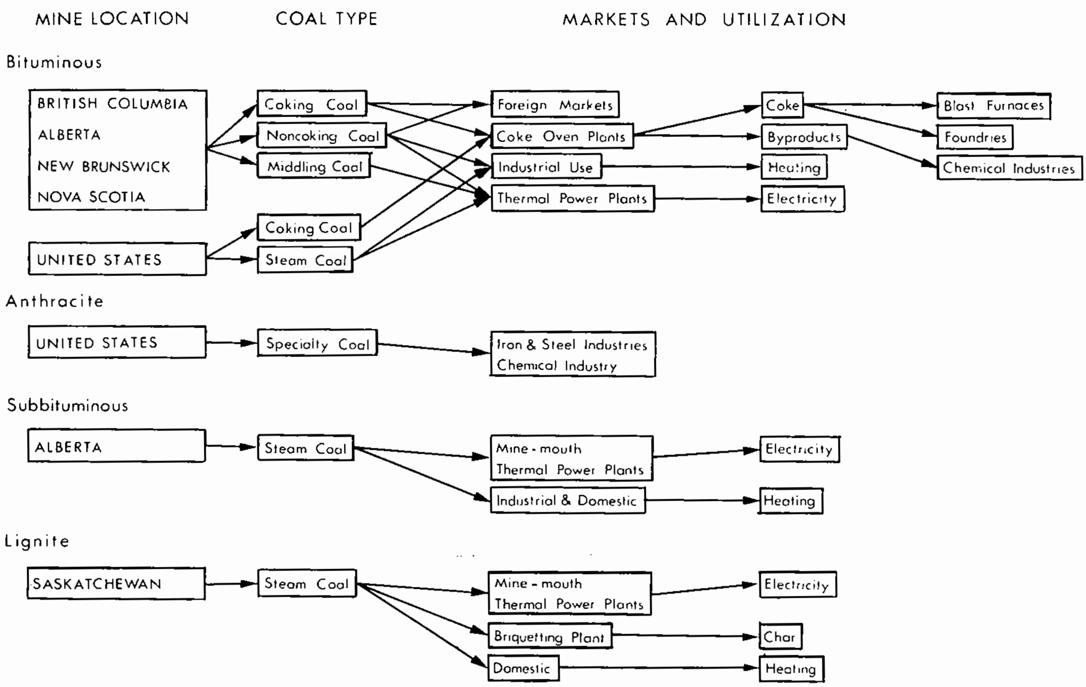
Coal output increased at the Utility Mine of Manalta Coal Ltd. and the Souris Valley Coal Mine of Saskatchewan Power Corporation reaching 1 900 000 and 344 000 tonnes, respectively. Output at the M & S and Boundary Dam mines of the Manitoba and Saskatchewan Coal Company

Table 5. Producers' disposition of Canadian coal[1], 1978

	Originating Province					
Destination	Nova Scotia	New Brunswick	Saskatchewan	Alberta	British Columbia and Yukon	Canada
			(000 tonnes)			
Railways in Canada	—	—	53	—	—	53
Newfoundland	2	—	—	—	—	2
Prince Edward Island	7	—	—	—	—	7
Nova Scotia	1 047	3	—	123	—	1 173
New Brunswick	58	164	—	—	—	222
Quebec	58	149	—	—	—	207
Ontario	715	—	93	505	345	1 658
Manitoba	—	—	482	14	57	553
Saskatchewan	—	—	4 421	439	—	4 860
Alberta	—	—	—	7 937	—	7 937
British Columbia	—	—	—	7	238	245
Total Canada	1 887	316	5 049	9 025	640	16 917
United States	—	—	2	—	4	12
Japan	—	—	—	4 048	6 969	10 017
Other	710	—	—	456	1 806	2 972
Total shipments	2 597	316	5 057	13 529	9 419	30 918

Sources: Statistics Canada; Energy Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Saleable coal (raw coal, clean coal and middling sales).
— Nil.

COAL'S ROUTE TO CONSUMPTION



(Limited) was 448 000 and 1 700 000 tonnes, while production at Manalta's Klimax mine reached 674 000 tonnes. The majority of the coal produced in Saskatchewan is marketed to the Saskatchewan Power Corporation. Exports to Manitoba and Ontario, in addition to some local consumption, account for the rest of the output.

New Brunswick. All coal produced in New Brunswick comes from the Grand Lake coal basin of the Minto-Chipman area in the eastern part of the province. Raw coal production was 315 000 tonnes in 1978 almost equal to the 1977 output. Approximately 160 000 tonnes were delivered to New Brunswick Electric Power Commission stations with the remainder sold to industry and local consumers. A new mine is scheduled to begin production in 1979 to supply coal to the new, coal- and oil-fired Dalhousie power station.

Nova Scotia. Coal production in Nova Scotia grew during 1978, reflecting increased thermal consumption and growing exports. The three mines of Cape Breton Development Corporation (DEVCO) produced 2.7 million tonnes of raw coal, up from 2.5 million tonnes in 1977. Output from the Lingan Mine reached 1.8 million tonnes, the No. 26 Colliery produced 800 000 and the Prince Mine 170 000 tonnes. Several smaller Nova Scotian mines produced nearly 150 000 tonnes for local industry and residential consumption.

Three Nova Scotia Power Corporation stations consumed 711 000 tonnes of DEVCO coal, while 437 000 tonnes of coking and 272 000 tonnes of thermal coal went to European and Latin American customers, 715 000 tonnes of coking coal were shipped to Ontario steel mills and over 100 000 tonnes to other Canadian customers.

Trade

Exports. In 1978 the volume of Canadian coal exports rose by 13 per cent to 14.0 million tonnes, up from 12.4 million tonnes in 1977. The value of exports rose to a record level of $790 million, up 15 per cent over 1977, and for the first time, were equal to the value of imports.

Japan was again the main customer for Canadian coal, receiving 79 per cent of all exports. Two other Asian countries received 4 per cent; seven European countries, 12 per cent; and four Latin American countries, 5 per cent. In terms of volume, 11.0 million tonnes went to Japan, 561 000 tonnes to other Asian countries, nearly 1.7 million tonnes to Europe and 740 000 tonnes to Latin America. Exports to markets other than Japan grew by 72 per cent to 3.0 million tonnes in 1978, up from 1.7 million tonnes the previous year. Continued growth is predicted for the export

Table 6. Canada, exports and imports of coal, 1977 and 1978

	1977r		1978p	
	(000 tonnes)	($000)	(000 tonnes)	($000)
Exports				
Japan	10 651	607 479	11 017	643 365
South Korea	357	20 586	535	30 458
West Germany	315	9 096	492	15 865
Denmark	382	12 509	309	10 766
France	26	721	—	—
Sweden	54	2 397	154	7 891
Mexico	178	9 433	42	2 453
United States	4	34	12	155
United Kingdom	—	—	—	—
Romania	52	2 748	227	12 564
Belgium	81	4 608	174	9 076
Brazil	197	10 264	573	32 669
Argentina	25	1 336	51	2 932
Italy	65	2 925	164	8 421
Others	—	—	250	14 221
Total	12 387	684 361[1]	14 000	790 839[1]
Imports				
Anthracite and Bituminous	15 439	772 000[1]	14 119	790 000[1]

Source: Energy Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Value at port of entry or exit.
[p] Preliminary; [r] Revised.

Table 7. Canada, supply and demand of coal, 1967 and 1977

	1967	1977
	(000 tonnes)	
Supply		
Production	10 338	28 682
Landed imports	14 619	15 439
Total inventory change	+ 571	+ 849
Total supply	24 386	43 272
Demand		
Domestic sales		
Electric utilities	8 267	22 443
Mining and manufacturing	6 107	1 490
Coke-making	5 432	6 664
Subtotal	19 806	30 597

	1967	1977
	(000 tonnes)	
Demand		
Residential	1 224	—
Railways	147	52
Ships bunkers	303	—
Government and institutional	160	—
Subtotal	1 834	52
Coal mine and local use	542	141
Unaccounted for coal	990	95
Total domestic demand	23 172	30 885
Exports	1 214	12 387
Total demand	24 386	43 272

Sources: Statistics Canada; Energy Policy Sector, Department of Energy, Mines and Resources, Ottawa.

sector in 1979 and in the 1980s. Approximately 95 per cent of all exports originated in western Canada, with the remaining 5 per cent coming from Nova Scotia.

Imports. Primarily because of coal strikes in United States, imports to Canada fell by 9 per cent in 1978 to 14.1 million tonnes, down from 15.4 million tonnes in 1977. Thermal coal imports to Ontario Hydro fell by 8 per cent. Coking coal imports dropped 12 per cent, while imports for general industry and other users grew marginally. Virtually all coal imports came from United States sources.

Coke imports grew by 26 per cent in 1978 reaching 483 000 tonnes. Ninety per cent of coke imports came from the United States, with West Germany, France and the United Kingdom supplying the remaining 10 per cent.

Thermal power industry

Thermal coal consumption reached a record level of 22.9 million tonnes in 1978, up 2 per cent over 1977. Ontario was again the largest coal-consuming province, utilizing 9 million tonnes or 40 per cent of total Canadian thermal coal consumption. Alberta consumed 8 million tonnes or 36 per cent; Saskatchewan, 4.6 million tonnes or 20 per cent; Nova Scotia, 711 000 tonnes or 3 per cent; and Manitoba and New Brunswick 1 per cent each.

Ontario Hydro continued to add to its coal-fired, thermal-generating capacity in 1978, with the completion of the last two 500-MW generators at its Nanticoke station. Work also progressed on two new 150-MW units at Thunder Bay, where commercial startup is scheduled for 1981. Preliminary planning for the first of two 200-MW units is also under way at Atikokan in northwestern Ontario. In keeping with Ontario Hydro's recent decision to use Canadian coals, all of the above units have been designed or modified to handle western Canadian coals. By the early 1980s nearly 4 million tonnes of bituminous and lignite coal will be moving from British Columbia, Alberta and Saskatchewan to these generating stations.

Alberta consumed 8 million tonnes of thermal coal in 1978 in five generating stations. One new 375-MW coal-fired unit was added to the Alberta system in 1978 and further additions will soon make Alberta Canada's leading thermal coal-consuming province. Work is under way on doubling the generating capacity of Alberta Power Limited's coal-fired Battle River generating plant. Startup of a new 375-MW unit is scheduled for 1981, with Forestburg Collieries Limited developing a new surface mine to supply the coal. Calgary Power Ltd. began preconstruction work on the 750-MW, Keephills thermal station in 1978. The first 375-MW unit of this $500 million project is scheduled to be in operation by 1983. Applications are before provincial regulating boards for a 750-MW facility at Sheerness in southern Alberta and at Genesee near Edmonton. Each of these stations would consume approximately 3 million tonnes of coal annually.

In Saskatchewan, work continued on the new 300-MW Poplar River generating station and related mine development near Coronach. Startup of this $280 million project is scheduled for 1980, with a second 300-MW addition scheduled for 1982. Coal consumption in Saskatchewan totalled 4.6 million tonnes in 1978 and will increase to approximately 7 million tonnes in the early 1980s.

While thermal coal consumption in New Brunswick fell to 151 000 tonnes in 1978, substantial increases will take place in the 1980s. The most important current project is the 200-MW Dalhousie II coal- and oil-fired generating station scheduled to be operational in late 1979. A new coal mine is being developed to supply nearly 300 000 tonnes of coal annually for this new facility.

Table 8. Coal used by thermal power stations in Canada by province, 1963-78

	Nova Scotia	New Brunswick	Ontario	Manitoba	Saskatchewan	Alberta	Total Canada
				(000 tonnes)			
1963	484	97	2 547	60	956	528	4 672
1964	530	222	2 795	132	1 006	999	5 684
1965	633	334	3 567	175	1 085	1 211	7 005
1966	799	294	3 500	79	1 116	1 360	7 148
1967	758	275	4 435	38	1 334	1 427	8 267
1968	646	240	5 523	179	1 354	2 128	10 070
1969	676	150	6 424	51	1 123	2 378	10 802
1970	548	113	7 696	503	1 969	2 951	13 780
1971	689	271	8 560	446	1 996	3 653	15 615
1972	663	281	7 599	410	2 145	4 113	15 211
1973	585	193	6 615	386	2 806	4 474	15 059
1974	606	292	6 721	132	2 902	4 771	15 424
1975	571	248	6 834	323	3 251	5 345	16 572
1976	730	207	7 612	979	3 521	5 996	19 045
1977	572	198	8 795	1 113	4 304	7 461	22 443
1978	711	151	9 097	341	4 585	8 029	22 914

Sources: Statistics Canada; Energy Policy Sector, Department of Energy, Mines and Resources, Ottawa.

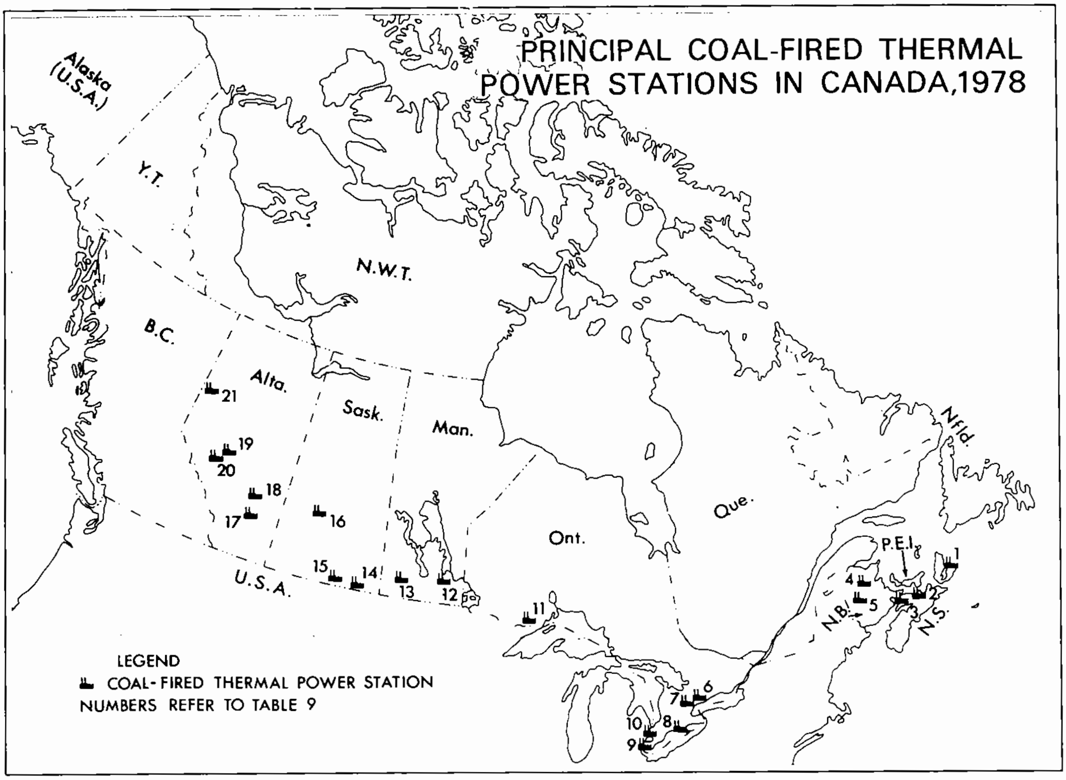


Table 9. Principal coal-fired thermal power stations in Canada, 1978

Utilities	Station	Total Station Capacity	Remarks
(numbers refer to map above)		(kilowatts)	
Nova Scotia			
1. Nova Scotia Power Corporation	Glace Bay	111 000	
2. Nova Scotia Power Corporation	Trenton	210 000	
3. Nova Scotia Power Corporation	Harrison Lake	25 000	Two new 150-MW units to come on stream in 1979 and 1980.
New Brunswick			
4. New Brunswick Electric Power Commission	Chatham	32 500	
5. New Brunswick Electric Power Commission	Grand Lake No. 1	13 750	
New Brunswick Electric Power Commission	Grand Lake No. 2	85 000	One new 200-MW coal- and oil-fired unit to be operational in 1979.

Table 9. (cont'd)

Utilities	Station	Total Station Capacity	Remarks
		(kilowatts)	
Ontario			
6. Ontario Hydro	Richard L. Hearn	1 222 500	
7. Ontario Hydro	Lakeview	2 422 500	
8. Ontario Hydro	Nanticoke	4 022 500	Two 500-MW units added in 1978.
9. Ontario Hydro	J. Clark Keith	271 500	Station was closed down in early 1976 for modification and renovation.
10. Ontario Hydro	Lambton	2 022 500	
11. Ontario Hydro	Thunder Bay	128 300	Two 150-MW lignite-fired units to be added by 1980.
Manitoba			
12. Manitoba Hydro	Selkirk	155 800	
13. Manitoba Hydro	Brandon	237 000	
Saskatchewan			
14. Saskatchewan Power Corporation	Estevan	70 000	Two 300-MW Poplar River Power units to come on stream in 1980 and 1982.
15. Saskatchewan Power Corporation	Boundary Dam	875 000	
16. Saskatchewan Power Corporation	Queen Elizabeth	232 000	
Alberta			
17. Alberta Power Limited	Drumheller	15 000	
18. Alberta Power Limited	Battle River	362 000	One 375-MW addition scheduled for 1979.
19. Calgary Power Ltd.	Wabamun	582 000	
20. Calgary Power Ltd.	Sundance	1 725 000	One 375-MW unit to be added in 1981.
21. Alberta Power Limited	H.R. Milner	150 000	Burns coal preparation plant byproducts.

Sources: Statistics Canada; Energy Policy Sector, Department of Energy, Mines and Resources, Ottawa.

Nova Scotia's thermal coal consumption increased by 24 per cent to 711 000 tonnes in 1978, with further increases assured in the next few years. The first of two new 150-MW, coal-fired units is scheduled to produce steam at Lingan in early 1979 and begin commercial operation in late 1979. A second 150-MW unit is to produce electricity by September 1980. Over 700 000 tonnes of coal will be used to fire these two units. Additional 150- or 300-MW units are under consideration.

Coke industry

In 1978, 7.0 million tonnes of bituminous coking coal was carbonized to produce 5.0 million tonnes of coke, an increase from the 1977 figures of 6.7 and 4.8 million tonnes respectively. The majority of the coking coal imported into Canada was used by the three Ontario steel companies and the Sydney Steel Corporation.

The Algoma Steel Corporation, Limited (Algoma) of Sault Ste. Marie produced 1.5 million tonnes of coke from 2.22 million tonnes of coking coal in 1978. All of Algoma's coking coal came from the United States. The No. 9 coke oven battery, shut down in 1976 because of technical problems, resumed operation during 1978.

The Steel Company of Canada, Limited (Stelco), at Hamilton, produced 1.99 million tonnes of coke from 2.93 million tonnes of coking coal. Startup of Stelco's new Nanticoke steel plant is scheduled for late 1981.

Dominion Foundries and Steel, Limited (Dofasco) of Hamilton produced 1.16 million tonnes of coke from 1.46

Table 10. Canada, coke production and trade, 1968-78

	Production		Imports		Exports	
	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke
			(tonnes)			
1968	4 817 842	216 455	231 700	509 300	130 427	5 207
1969	4 537 988	210 176	254 833	638 279	247 659	2 364
1970	5 142 122	188 376	358 295	706 769	248 469	48 313
1971	4 631 897	187 278	586 430	665 774	288 272	11 171
1972	4 675 866	242 370	481 816	555 710	238 478	881
1973	5 369 861	286 530	357 815	637 664	367 916	1 960
1974	5 443 427	274 412	509 058	746 033	260 892	24 940
1975	5 277 837	270 685	546 456	572 557	96 081	161 576
1976	5 289 185	678 432	287 249	591 859	169 895	136 970
1977	4 845 066	921 363	382 827	986 678	198 727	157 191
1978[p]	4 967 664	1 014 076	482 842	973 985	217 595	134 762

Sources: Statistics Canada; Energy Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[p] Preliminary.

million tonnes of coking coal. Dofasco's coke was a blend of 85 per cent United States coal, 13 per cent western Canadian and 2 per cent eastern Canadian coal. A new No. 6 coke oven battery, consisting of 35 Koppers-Becker Gun Type combination ovens, was commissioned in mid-1978.

Sydney Steel Corporation (Sysco) of Sydney, Nova Scotia, produced 295 000 tonnes of coke from 460 000 tonnes of coking coal, up 35 per cent from the 1977 production of 217 000 tonnes. The 1978 coke oven blend was a mixture of 75 per cent high-volatile eastern Canadian coal, 19 per cent low-volatile western Canadian coal and 6 per cent high-volatile U.S. coal.

Kaiser Resources Ltd.'s coke production at Natal, British Columbia amounted to 100 000 tonnes, from a coal input of 166 000 tonnes. The Manitoba and Saskatchewan Coal Company at Bienfait Saskatchewan, produced 55 000 tonnes of coke from 110 000 tonnes of lignitic coal.

Research and development

Research and development work related to coal conversion and the development of new clean-burning coal systems is receiving increased attention in Canada. Funding commenced early in 1977 for a joint research and development program involving the federal government, provincial governments, public utilities and private industry in projects concerned with coal substitution for oil, more efficient and environmentally acceptable methods of producing electricity from coal, coal gasification, coal liquefaction and coal utilization as a chemical feedstock.

As a result of the rising costs of fuel oil, both the public and private sectors are looking for ways to reduce oil consumption. Since coal is readily available in most regions of Canada, an option under consideration is the replacement of oil with coal in existing oil-fired utility boilers. Two methods of replacing oil in such boilers are currently under study: retrofitting to allow the use of coal only, and firing a mixture of coal-in-oil. Another option is to develop a new generation of coal-fired boilers for industry and utility use. Such an environmentally advanced coal combustion system, based on fluidized bed combustion, is being demonstrated at the Armed Forces Base at Summerside, Prince Edward Island. Coal is burned on a fluidized bed of limestone, which captures the sulphur dioxide and rejects calcium sulphate as a waste byproduct. It is expected that these boilers will meet air pollution objectives without the use of expensive flue gas scrubbers. In addition, the lower combustion temperature of the fluidized bed boiler also reduces the formation of nitrogen oxides, a pollutant, which along with sulphur oxides, contributes toward acid rain. A demonstration plant capable of generating 18 000 kilograms (kg) per hour of steam is currently in the design stage.

In the longer-term, developing coal liquefaction technologies based on the availability of suitable, low-cost western Canadian coal could offer the potential of producing competitive, coal-derived crude oil. The suitability of Alberta sub-bituminous coal for liquefaction will be analyzed in a German pilot plant test in 1979. Further coal process evaluation studies will continue to assess the potential for the application of this technology in Canada.

The production of methanol from low-rank coal also offers the potential for producing a "liquid" fuel through well-known, established technology. In the energy field, methanol could be used as an automobile gasoline blending stock (up to 5 per cent by volume without technical or engine performance difficulties), a turbine fuel or a feedstock in methanol upgrading processes, like the Mobile "M" process. This process, which is currently entering the demonstration phase of development, is capable of converting methanol to a high-octane gasoline substitute.

Table 11. Coke oven and other carbonization plants in Canada, as of 1978

Company	Operating Batteries and No. of Ovens	Oven Type	Year Built	1978 Coal Feed	1978 Coke Production	Byproducts
				(000 tonnes per year)		
The Algoma Steel Corporation	No. 5 – 86	Koppers-Becker Underjet	1943	2 220	1 504	Tars, light oil, gas.
Limited	No. 6 – 57	Koppers-Becker Underjet	1953			
Sault Ste. Marie,	No. 7 – 57	Wilputte Underjet	1958			
Ontario	No. 8 – 60	Wilputte Underjet	1967			
	No. 9 – 60	Wilputte Underjet	1975			
The Steel Company of Canada,	No. 3 – 61	Wilputte Underjet	1947	2 926	1 990	Tars, gas, light oil,
Limited	No. 4 – 83	Wilputte Underjet	1952			anhydrous ammonia.
Hamilton, Ontario	No. 5 – 47	Wilputte Underjet	1953			
	No. 6 – 73	Otto Underjet	1967			
	No. 7 – 83	Otto Underjet	1972			
Dominion Foundries and Steel,	No. 1 – 25	Koppers-Becker Gun Type Comb.	1951	1 455	1 161	Tars, light oil, gas sulphur,
Limited	No. 2 – 35	Koppers-Becker Gun Type Comb.	1956			ammonium sulphate.
Hamilton, Ontario	No. 3 – 45	Koppers-Becker Gun Type Comb.	1958			
	No. 4 – 53	Koppers-Becker Gun Type Comb.	1967			
	No. 5 – 53	Koppers-Becker Gun Type Comb.	1971			
	No. 6 – 35	Koppers-Becker Gun Type Comb.	1978			
Sydney Steel Corporation,	No. 5 – 53	Koppers-Becker Underjet	1949	460	295	Tars, light oil, gas.
Sydney, Nova Scotia						
Kaiser Resources Ltd.	8 units	Curran-Knowles	1949	166	100	Crude tar, gas, coke breeze.
Natal, B.C.	16 units	Curran-Knowles	1952			
Manitoba and Saskatchewan						
Coal Company (Ltd.)	2 units	Lurgi Carbonizing Retort	1925	110	55	
Char Briquetting Div.	1 unit	Lurgi Carbonizing Retort				
Bienfait, Sask.	3 units	Salem Rotary Hearth Calciners	1974			

Source: Energy Policy Sector, Department of Energy, Mines and Resources, Ottawa.

Table 12. World coal production, 1973-77

	1973	1974	1975	1976	1977[p]
			(000 tonnes)		
North America	561 552	571 486	641 291	664 638	627 890
South America	7 074	8 159	8 896	8 598	8 970
Europe	1 646 090	1 651 315	1 056 211	1 080 683	974 000
Africa	66 043	69 550	78 507	74 241	90 260
Asia	538 667	567 489	728 473	628 449	688 940
Oceania	87 797	92 986	76 390	69 633	74 570
World					
Lignite (estimated)	819 437	834 152	727 725	709 874	909 790
Bituminous and anthracite (by subtraction)	2 087 786	2 126 833	1 862 043	1 816 368	1 554 840
Total, all types	2 907 223	2 960 985	2 589 768	2 526 242	2 464 630

Source: United States Bureau of Mines.
[p] Preliminary.

Cobalt

A.J. WEBB

Canadian production of cobalt in 1978 was 1 163 tonnes*, down from 1 485 tonnes the previous year. Cobalt is primarily a byproduct of nickel-copper mining in Canada. Cutbacks in nickel production because of soft markets and a major strike were the principal reasons for reduced cobalt production. In spite of this lower production, the value, at $27.1 million, was up significantly from $18.8 million in 1977. The increased value was a reflection of a rapid run-up in prices resulting from increasing world demand and grave concern over the availability of supply.

The key factor in the cobalt market continued to be the situation in central Africa, where Zaire and Zambia together account for about two thirds of world mine production. Since 1976 the flow of cobalt from these two nations has been hampered by transportation bottlenecks in moving the product through neighbouring countries to coastal ports and by political unrest throughout south-central Africa. In May 1978, rebel forces invaded Zaire's principal cobalt-producing centre of Kolwezi, and as a result, production was temporarily shutdown and expatriate technical personnel forced to flee. While cobalt shipments were quickly resumed, it is not known what proportion represented post-invasion production and what proportion a draw-down of stockpiled material. Between December 1977 and February 1979 the producer price of cobalt increased more than fourfold to $U.S. 55.12 per kilogram (kg) and dealer prices were reportedly as high as $U.S. 99.21 per kg.

Canada

In Canada, cobalt products are primarily produced by Inco Limited and Falconbridge Nickel Mines Limited. Cobalt is a byproduct of their nickel-copper mining operations in the Sudbury Basin of Ontario and the Thompson region of Manitoba. The largest producer, Inco, recovers cobalt in the form of cobalt oxides at its nickel refineries situated in Port Colborne, Ontario and Thompson, Manitoba. Falconbridge produces a cobalt-bearing nickel-copper matte at its Sudbury area smelter for shipment to its refinery in Kristiansand, Norway where electrolytic cobalt is recovered.

Sherritt Gordon Mines Limited recovers cobalt metal powder from nickel feed treated at its hydrometallurgical refinery located in Fort Saskatchewan, Alberta. Sherritt Gordon, which has in recent years been largely dependent upon imports, is now sourcing an increasing proportion of its cobalt feed domestically.

Agnico-Eagle Mines Limited, produces cobalt-bearing silver concentrates at its Penn mill in the Cobalt region of Ontario. In 1978 its concentrates contained 6.6 tonnes of cobalt. These concentrates are treated at the nearby silver refinery of Canadian Smelting & Refining (1974) Limited, where cobalt-bearing precipitates and residues grading 2 to 7.5 per cent cobalt are recovered and stockpiled, pending future extraction or sale.

Cutbacks in nickel output resulted in a concomitant reduction in byproduct cobalt production. Canadian nickel-cobalt producers made strenuous efforts in 1978 to curtail nickel production and hence reduce high inventories. Falconbridge reduced its mining operations by 50 per cent and Sherritt Gordon operated its Fort Saskatchewan facility at 70 per cent of capacity. Inco was in the process of reducing 1978 production by 15 per cent, when, on September 15, its Sudbury facilities were closed by strike action.

During 1978 Canada's major cobalt producers all undertook research into improving the recovery of cobalt, and reportedly new techniques were developed. Inco has indicated that process modifications will be implemented that will improve its ability to increase cobalt production. Implementation of these modifications was delayed by the Sudbury strike; however, production of cobalt could exceed 1 400 tonnes in 1980. Improved cobalt recovery during smelting in Canada and modifications to existing refinery facilities in Norway will enable Falconbridge to increase its cobalt production capability from 1 200 tonnes to 1 800 tonnes in 1979.

Consumption of cobalt in Canada in 1978 was 144.6 tonnes, little changed from 1977 levels. In recent years about three quarters of domestic cobalt consumption has been in the form of metal. The bulk of this metal is

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, cobalt production, trade and consumption, 1977 and 1978

	1977		1978ᵖ	
	(kilograms)	($)	(kilograms)	($)
Production [1] (all forms)				
Ontario	1 263 042	16 052 589	904 000	19 562 000
Manitoba	221 627	2 717 081	259 000	7 578 000
Total	1 484 669	18 769 670	1 163 000	27 140 000
Exports				
Cobalt metal				
United States	618 878	8 401 000	629 536	13 892 000
Netherlands			21 618	769 000
South Africa	25 726	396 000	16 546	515 000
France	8 064	114 000	12 530	302 000
United Kingdom	17 421	111 000	22 043	290 000
Mexico	544	7 000	5 987	246 000
Other countries	3 031	80 000	7 701	392 000
Total	684 171	9 241 000	715 961	16 406 000
Cobalt oxides and hydroxides [2]				
United Kingdom	660 300	4 891 000	748 300	6 955 000
United States	5 000	44 000	—	—
Total	605 300	4 935 000	748 300	6 955 000
Consumption [3]				
Cobalt contained in:				
Cobalt metal	110 804	. .	103 617	. .
Cobalt oxide	27 951	. .	32 452	. .
Cobalt salts	8 008	. .	8 541	. .
Total	146 763	. .	144 610	. .

Source: Statistics Canada.
[1] Production (cobalt content) from domestic ores. [2] Gross weight. [3] Available data reported by consumers.
ᵖ Preliminary; — Nil; . . Not available.

Table 2. Canada, cobalt production, trade and consumption, 1965, 1970 and 1975-78

		Exports		Imports		
	Production [1]	Cobalt Metal	Cobalt Oxides and Hydroxides	Cobalt Ores [2]	Cobalt Oxides [2]	Consumption [3]
	(tonnes)					
1965	1 655	133	641	. .	. .	166
1970	2 069	381	837	. .	. .	148
1975	1 354	431	461	. .	. .	123
1976	1 356	523	471	—	96	160
1977	1 485	684	605	53	. .	147
1978ᵖ	1 163	716	748	. .	. .	145

Source: Statistics Canada.
[1] Production from domestic ores, cobalt content. From 1967, production includes cobalt content of Inco and of Falconbridge Nickel Mines Limited shipments to overseas refineries, but prior years exclude Inco shipments to United Kingdom. [2] Gross weight. [3] Consumption of cobalt in metal and oxide.
ᵖ Preliminary; ʳ Revised; — Nil; . . Not available.

consumed in the production of high temperature, high strength alloys and cutting and wear resistant materials. Cobalt is also consumed in the form of salts and oxides for use as pigments, driers and ground coat frit. Consumer stocks at the end of 1978 were 52.3 tonnes, significantly higher than the 37 tonnes held at the end of 1977.

World review

Western world 1978 cobalt consumption was estimated at about 22 000 tonnes, while recoverable mine production was approximately 19 600 tonnes. Additional quantities of secondary cobalt, which some sources have estimated as being in the order of 1 200 tonnes, were also produced. Overall, the shortage of cobalt in 1978 resulted, in large part, from a dislocation of material due to panic buying, speculation and extended delivery times from the major producers.

In response to the tight supply situation, African Metals Corp., exclusive dealer for Zairian and Belgian cobalt in the United States, announced that effective May 1 it had placed all its cobalt metal customers on allocation equivalent to about 70 per cent of 1977 purchases.

With Zaire holding about 40 per cent of the world's land-based cobalt reserves, it will remain the leading producer for the foreseeable future. Current production capacity is about 16 000 tonnes per year. However, due to political insurrection and inadequate cash flow to maintain refinery and transport facilities, Zaire's production has averaged under 12 000 tonnes per year since 1975. A planned expansion to 20 000 tonnes in 1985 has been postponed and all efforts are now being directed to returning existing facilities to rated capacity operation.

In response to rising prices, Zambia, the world's second-largest cobalt producer, has been making substantial efforts to increase its production. In December 1978, Roan Consolidated Mines Ltd. opened its new Chambishi refinery with a capacity of 2 400 tonnes. Total Zambian production in 1979 should be about 3 000 tonnes. Additional refinery capacity and improved recovery techniques could further increase capacity from the current level of 4 600 tonnes to 6 000 tonnes by 1984.

Table 3. Deliveries of cobalt by major Canadian producers, 1976-78

	1976	1977	1978
	(tonnes)		
Inco	1 102	753	771
Falconbridge	943	678	569
Sherritt Gordon	285	316	626
Total	2 330	1 747	1 966

Sources: Company annual reports.

In the United Staes, Noranda Mines Limited is currently evaluating the Black Bird Mine in Idaho. Preliminary results indicate that a 1981 startup at 1 200 tonnes of cobalt per annum is possible.

The state-owned Finnish mining company, Outokumpu Oy:n increased the production capacity of its Kokkola cobalt plant from 1 000 to 1 350 tonnes per year. The additional cobalt feed required will reportedly come from the German Democratic Republic.

Minerals and occurrences

Cobalt minerals are distributed widely throughout the world, invariably associated with other metallic minerals, such as nickel and copper. The minerals of cobalt can be classified into three broad groups; arsenides, sulphides and oxidized cobalt minerals. Although there are over 70 known or suspected minerals of cobalt, only a few are of economic importance. The most important economic minerals of cobalt are:

skutterudite } smaltite	$CoAS_3$
cobaltite	CoAsS
linneaite	Co_3S_4
carrollite	$CuCo_2S_4$
heterogenite	CoO·OH

There is a distinct relationship between cobalt minerals and the other metallic minerals with which they occur. The principal sources of cobalt are the copper deposits of Zaire and Zambia. In Zaire, cobalt occurs as both sulphides and oxidized minerals in the copper deposits, which are also both sulphides and oxides. In Zambia, cobalt appears primarily as a sulphide. As a constituent of the nickel ores of Canada, Finland and Australia, cobalt is primarily in the form of arsenides. Similarly, in the Cobalt area of Ontario cobalt occurs primarily as an arsenide or sulpharsenide.

The cobalt content of these ores is generally low. The deposits in Zambia and Zaire can grade as high as 3 or 4 per cent cobalt, but more frequently grade below 0.5 per cent. In the Sudbury area of Canada, the ores can grade as high as 0.35 per cent, but more commonly are less than 0.1 per cent cobalt.

One potential source of cobalt is the so-called manganese-nickel nodules on the ocean floor. Apparently these nodules typically contain 0.2 per cent cobalt.

Consumption and uses

With the rapid increase in cobalt prices in 1978 and the continuing uncertainty over security of supply, cobalt consumers have begun to examine seriously their material requirements and the prospects for substitution. Currently, cobalt usage is divided approximately as shown in the following listing:

Pattern of Cobalt Consumption[e]

Permanent magnets	25%
High temperature superalloys	20%
Wear and abrasion resistant parts	20%
Pigments and colouring agents	20%
Chemical uses	10%
Miscellaneous	5%
	100%

[e] Estimated.

Cobalt is a component of almost all permanent magnet materials, materials that retain magnetic properties once the original magnetizing field is removed. There are a wide range of permanent magnet materials, varying from iron-cobalt alloys to the Alnicos (aluminum-nickel-cobalt alloys) to rare earth-cobalt alloys.

In the field of permanent magnets, two usage trends are now underway. One is the switch from Alnico (Al-Ni-Co) permanent magnets to the stronger rare earth-cobalt magnets. The rare earth magnets help to limit cobalt consumption and are becoming more important in the field of miniturization where weight, size and energy limitations are critical. The second trend is the switch from Alnico to ceramic ferrites in applications such as loudspeakers.

Cobalt-base, high temperature alloys or superalloys find their principal application in parts for jet engines. Cobalt-base superalloys contain from 20 to 65 per cent cobalt and can withstand temperatures up to about 900°C under conditions of low stress. Smaller amounts of cobalt are also contained in nickel- and iron-base superalloys. Due to expanding world markets for commercial airliners, continuing strength in military aircraft contracts and increased demand for land-based and marine turbines the demand for cobalt-bearing superalloys was especially strong in 1978. Opportunities for substitution in the superalloy sector are limited in the short term. Material specifications are critical and jet engine components are designed with specific superalloy characteristics in mind.

Cobalt is used as a binder or metal matrix in the production of cemented carbide cutting tools. Cobalt content can vary from 3 to 35 per cent in some dies. Nickel is a potential substitute. While considerable research will be required to develop a carbide of comparable quality, the fact that nickel is currently selling at one ninth the price of cobalt indicates that a substantial reduction in material costs may be possible.

Cobalt-base alloys are also used for cutting purposes. The most important group of cobalt-base alloys are the stellite group, containing cobalt, tungsten and chromium as their principal constituents. Stellites are suitable for a variety of uses. For example, their hardness and strength are mainly exploited for cutting tools and hard-wearing parts of machinery, such as that used in agricultural implements and excavating equipment. Coating of a part with a particular cobalt alloy can provide greater resistance to abrasion, heat, impact and corrosion. Demand for these alloys is expected to weaken as consumers switch to iron- and nickel-based alloys.

Table 4. World production of recoverable cobalt, 1976-78

	1976	1977	1978[p]
	(tonnes)		
Zaire	10 686	10 208	13 000
Zambia	2 175	2 000 [p]	1 700
Canada	1 329	1 485	1 163
Finland	890	980	920
Morocco	862	850 [e]	850 [e]
Australia [e]	700	1 000	1 000
Other Western[e]	800	1 000	1 000
Subtotal	17 442	17 523	19 633
U.S.S.R.[e]	1 770	1 770	1 900
Cuba[e]	1 630	1 630	1 630
Grand total	20 842	20 923	23 163

Sources: Company annual reports; U.S. Bureau of Mines; Statistics Canada; Department of Energy, Mines and Resources, Ottawa.
[p] Preliminary; [e] Estimated.

Cobalt is used in high-speed tool steels to increase the red hardness of the steel or its ability to be used at higher rates of speed and for deeper cuts than would be the case if cobalt was not present. The cobalt content can range from 2 to 12 per cent. Cobalt is also used in some abrasion-resistant die steels. Generally, cobalt additions are more costly than other additions, and this has been an important factor in minimizing the usage of cobalt-containing steel.

Cobalt, in the form of cobalt oxide, is an important additive in the glass and ceramics industries. Cobalt oxide additions of from 150 to 4 500 gram (g) per tonne of glass will impart a blue colour to the finished product. Smaller additions, up to 45 g per tonne, are made to neutralize the yellow tint of iron in plate and window glass. Similarly, cobalt is used in ceramics to neutralize the iron colour in pottery tile and sanitary ware. Cobalt oxide is also used to eliminate the iron colour in white porcelain, and in quantities of 0.2 to 2 per cent to promote the adherence of the enamel to steel.

Outlook

It is expected that as a result of substitution, resistance to current high price levels and improved materials management, the growth in world demand for cobalt through 1985 will not be so rapid as earlier forecast. In addition, significant new production capacity and improved recovery at existing facilities will increase cobalt availability and bring the market into balance in the early 1980s.

Barring a disaster situation in central Africa no further quantum leaps should occur in the price of cobalt. Given that over 60 per cent of mine production is centred in a region subject to periodic political upheaval, it is probable that cobalt prices will at times be volatile and unpredictable.

The production of cobalt from Canadian ores should increase by 1980 as a result of the introduction of improved recovery techniques. Canada, which consumes about one tenth of its recoverable mine production should continue to have adequate cobalt available to meet domestic requirements, though prices, which are set internationally, will remain a constant source of concern to the consumer.

Prices

	Dec. 1977	Dec. 1978
	($U.S.)	($U.S.)
Cobalt metal, per lb., fob* New York,		
Shot, 99.5%		
less than 50 kg	6.15	. .
50-kg drums	6.06	. .
250-kg	6.00	20.00
Powder, 99%+		
300 and 400 mesh, 50-kg drums	9.96	26.32
extra fine, 125-kg drums	9.89	26.22
S grade, 10-ton lots	6.40	20.00

Source: *Engineering Mining Journal*, December 1977 and 1978.
* fob Free on board.
. . Not available.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)	(%)	(%)	(%)
33200-1	Cobalt ore	free	free	free	free
35103-1	Cobalt metal, excluding alloys, in lumps, powders, ingots or blocks	free	free	25	free
35110-1	Cobalt metal, in bars	free	10	25	free
92824-2	Cobalt oxides	free	10	20	free
92824-1	Cobalt hydroxides	10	15	25	10
	from January 15, 1971 to February 28, 1979	free	15	25	free

United States

Item No.		Most Favoured Nation
601.18	Cobalt ore	free
632.20	Cobalt metal, unwrought, waste and scrap	free
632.84	Cobalt metal alloys, unwrought	9% ad valorem

Item No.		Most Favoured Nation
633.00	Cobalt metal, wrought	9% ad valorem
418.68	Cobalt compounds other than cobalt oxide and cobalt sulfate	6% ad valorem
418.24 426.26	Cobalt salts	6% ad valorem
418.60	Cobalt oxide	1.2¢ per pound
418.62	Cobalt sulfate	1.2¢ per pound

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978), USITC Publication 843.

Columbium (Niobium) and Tantalum

A.J. WEBB

Columbium markets strengthened in 1978 as prospects for the world steel industry generally improved and columbium-bearing steels found increased application in several industrial sectors. Important end-uses for columbium-bearing steel include the automobile industry, oil and gas pipeline, heavy plates for ships and pressure vessels and structural members in bridges, high-rise buildings and drilling platforms. The increased demand was particularly evident in the U.S. market where ferrocolumbium consumption rose by about 20 per cent. World mine production, of which Canada accounts for about 17 per cent, has so far been able to meet the growing demand and has thereby helped to maintain price stability.

Tantalum demand continued strong in 1978 with apparent consumption exceeding available mine production. In Canada mine production was up about 7 per cent over 1977 levels and represented about 14 per cent of the Western World total. Consumer demand was strong in both major end-use sectors: cemented carbides for cutting tools and capacitors for the electronics industry. The supply imbalance resulted in tantalum prices increasing by about 42 per cent during the year.

COLUMBIUM

Canadian production and developments

Niobec Inc., with a pyrochlore deposit located at St. Honoré, Quebec, is the only Canadian producer of columbium concentrates. Annual plant capacity is approximately 4 173 tonnes* of pyrochlore concentrate with an average grade of about 61 per cent columbium pentoxide. In 1978 Niobec produced concentrates containing 2 535 tonnes of pentoxide. Concentrates were sold under long-term contract to customers in western Europe, 58 per cent; the U.S.A., 22 per cent and Japan, 20 per cent. As of September 30, 1978, ore reserves were 7.6 million tonnes grading 0.69 per cent columbium pentoxide. Results of a feasibility study regarding the expansion of Niobec's operations will be released in 1979.

St. Lawrence Columbium and Metals Corporation at Oka, Quebec had been a significant Canadian columbium producer until 1976. Early that year operations ceased and subsequently the firm was placed under receivership and much of its property sold. Reserves are in the order of 25 million tonnes averaging about 0.4 per cent columbium pentoxide. Attempts to find new financing have to date, been unsuccessful.

Masterloy Products Limited of Ottawa has the capability of producing ferrocolumbium, but none was produced in 1978. This was attributable to the lack of columbium feed and to environmental problems associated with the disposal of radioactive contaminants present in most columbium concentrates.

World production

Brazil, with two major producers, represents about three quarters of world columbium production capacity. Companhia Brasileira Metalurgia e Mineracao (CBMM) is the world's leading producer of columbium pentoxide and ferrocolumbium. CBMM mines pyrochlore ore from open-pit operations at Araxa, Brazil and has a production capacity of approximately 26 000 tonnes of concentrate per year. CBMM's ferrocolumbium production capacity is over 12 000 tonnes per year. Proven ore reserves are about 55 million tonnes containing 3 to 4 per cent columbium pentoxide, but an additional 300 million tonnes are estimated to be available.

The other important Brazilian columbium producer, Mineracao Catalao de Goias, has a production capacity of about 3 800 tonnes of pyrochlore concentrate per year. Reserves are believed to exceed 20 million tonnes averaging 1.3 per cent columbium pentoxide.

Pyrochlore production in Brazil and Canada accounts for about 95 per cent of the world's columbium production. The remainder is recovered from columbite-tantalite concentrates produced in several countries including Nigeria, Australia, Thailand, Mozambique and Zaire. Expansion of columbite supply from these countries is limited since the columbite is either recovered as a byproduct of tin-slag operations or as a coproduct of combined tantalite-columbite operations.

Uses

The steel industry is the largest consumer of columbium. It is used in the form of ferrocolumbium as an additive element in high-strength, low-alloy steels (HSLA), carbon steels, low-alloy steels, stainless steels and superalloys. The HSLA steels consume the largest amount of columbium.

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Although the quantity of columbium added to the HSLA steel may be as low as 0.02 per cent, the mechanical properties and tensile strength are significantly improved. This characteristic is particularly important in applications like pipeline steels, automotive manufacture and structural steels where the strength-to-weight ratio is critical. In stainless steels, low-alloy steels, superalloys and columbium-based alloys the columbium also imparts resistance to corrosion at elevated temperatures.

Use of columbium for superconductors is currently very small, but substantially greater demand may develop in the future. For example, columbium alloys could be used directly as electrical power transmission lines or formed into coils for use in the high-intensity magnets required in electrical generators, fusion reactors and electrical propulsion devices. The U.S.-based Electric Power Research Institute and Westinghouse Electric Corporation have agreed to collaborate in a program to design and build a 300 MW superconducting generator by 1983. If successful, this type of generator, which makes use of columbium-titanium alloys, could be the prototype for larger on-line power generators.

Prices

Pyrochlore prices remained unchanged in 1978 at $U.S. 2.55 per pound of contained pentoxide. Columbite prices, which were quoted as low as $U.S. 2.85 per pound of pentoxide in 1977, increased due to associated tantalum values to $U.S. 3.75 per pound.

Outlook

The demand for pyrochlore in 1979 is expected to remain firm, but because of the large production capacity in Brazil, no price increase is expected. However, the demand for columbite, which is converted into high-purity ferrocolumbium for use in carbide cutting tools, will increase appreciably in 1979. Columbite prices will rise accordingly.

TANTALUM

Production in Canada

The Tantalum Mining Corporation of Canada Limited (Tanco) at Bernic Lake, Manitoba is the only producer of tantalum in Canada. In 1978, Hudson Bay Mining and Smelting Co., Limited purchased a 37.5 per cent interest in Tanco. Kawecki Berylco Industries, Inc. holds another 37.5 per cent, with the remaining 25 per cent being held by the Manitoba Development Corporation.

Tanco's mine production increased to 150 tonnes of tantalum pentoxide, up from 139.8 tonnes in 1977. The increased production resulted from overall recovery being improved from 62 per cent to 69 per cent. The bulk of the Tanco concentrates are sold under long-term contracts, mainly in the U.S.A.

Exploration activities at Tanco have identified new reserves which, at current prices, should be sufficient to permit the mine to maintain current levels of production until the mid-1980s. Tanco is also reviewing the feasibility of recovering tantalum from old tailings.

Tantalum in 1978

Western World mine production in 1978 was about 1 100 tonnes of tantalum pentoxide. Tantalum is extracted directly from tantalite-columbite ores, recovered from tin mining operations or recovered from tin slags. However, the availability of tantalum is limited as almost two thirds of world production is a byproduct or coproduct of other operations.

Thailand and Malaysia continue to be the major producers of tantalum, together accounting for over one half

Table 1. Canada, columbium (niobium) and tantalum production, trade and consumption, 1965, 1970 and 1975-78

	Production[1]		Imports					Consumption
			Primary forms and fabricated metals				Exports[2]	Ferrocolumbium and Ferrotantalum-Columbium,
	Cb_2O_5 Content	Ta_2O_5 Content	Columbium	Columbium Alloys	Tantalum	Tantalum Alloys	Columbium Ores and Concentrates to U.S.	Cb and Ta-Cb Content
	(kilograms)							
1965	1 058 670	—	..	..	..	..	843 968	26 308
1970	2 129 271	143 800	..	..	..	..	576 227	132 449
1975	1 661 567	178 304	..	..	..	..	9 682	215 910
1976	1 498 634	139 833	1 767	—	2 619	655	542 604	189 602
1977	2 508 909	139 757	..	..	7 043	2 407	757 090	132 449
1978[p]	2 535 000	150 000	..	..	..	..	552 657	163 293

Source: Statistics Canada, unless otherwise noted.
[1] Producers' shipments of columbium and tantalum ores and concentrates and primary products, Cb_2O_5 and Ta_2O_5 content. [2] From U.S. Department of Commerce, *Imports of Merchandise for Consumption*, Report FT 135. Quantities in gross weight of material.
[p] Preliminary; — Nil; .. Not available.

of the world total. Throughout Southeast Asia tantalum is primarily recovered from tin slags. In recent years tantalum has also been recovered by reworking tailing dumps. The concentrates produced, known as struverite, contain 25 to 30 per cent combined tantalum and columbium together with some titanium.

In Zaire, two companies – Zairetain and Société Zairoise Minière et Industrielle du Kivu (SOMINKI) produce small quantities of tantalum along with tin. While production is presently very small, Zaire's reserves are speculated to be among the largest known.

Western World consumption of tantalum in 1978 was about 1 300 tonnes, indicating a production shortfall of about 15 per cent. Principal end-uses for tantalum are in capacitors, cutting tools and dies and chemical-processing equipment.

The most important usage of tantalum in the electronics industry is in capacitors. Tantalum oxides' high capacitance per unit value and excellent reliability make it a preferred dielectric. However, as tantalum prices increase designers are reducing the physical size of capacitors and substituting ceramic and aluminum capacitors to minimize tantalum requirements. However, in many industrial and military applications, where performance requirements are stringent, tantalum is preferred. Demand is strong for tantalum capacitors used in miniaturized electric components and in systems operated at extreme temperatures.

The superior physical characteristics of tantalum carbide make it the preferred carbide for use in high-performance, high-speed machining applications. The aerospace industry is a very important market for such cutting tools. In Europe the mixed tantalum-columbium double carbides have been increasingly employed rather than the pure, but more expensive, tantalum carbide favoured in the U.S. As tantalum prices continue to escalate, the demand for mixed carbides will grow in the U.S. For certain grades of machining steels, hafnium-nickel carbides are now available which can substitute for tantalum.

Due to tantalum's excellent corrosion resistance and heat transfer characteristics it is finding increased application in the chemical processing sector. It is used either as a pure metal or is alloyed with tungsten and/or columbium.

Prices

In response to the market imbalance, prices increased steadily throughout 1978 from $U.S. 24.00 to $U.S. 34.00 per pound of contained pentoxide.

Outlook

The continued strong demand for tantalum in the capacitor and machining sectors, combined with limited capability to expand production will result in further significant price increases in 1979. While there are prospects for slightly improved production at some existing facilities and for improved materials management and substitution, the supply-demand imbalance is expected to continue until sizeable new tantalum production capacity is developed.

Prices

The prices below are in U.S. currency and were quoted in "Metals Week" of December 29, 1978

	1977	1978
	$	
Columbium ore		
Columbite, per pound of pentoxide, cif U.S. ports	2.85-3.50	3.25-3.75
Brazilian pyrochlore, per pound Cb_2O_5 fob shipping point, contract only	2.55	2.55
Ferrocolumbium, per pound Cb, fob shipping point		
Low alloy	5.12	5.12
High-purity alloy	13.45	16.95-17.64
Columbium metal, per pound 99.5-99.8%, fas shipping point		
Reactor ingot	26.00-33.00	29.00-35.00
Reactor powder	29.00-37.00	31.50-39.50
Tantalum ore		
Tantalite, per pound of pentoxide, Tanco price	24.00	34.00
Tantalum metal, per pound, fob shipping point depending on size of lot		
U.S. powder	40.00-58.25	48.75-65.00
U.S. rod 99.9% Ta	52.00-80.00	44.95-88.80

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
32900-1	Columbium and tantalum ores and concentrates	free	free	free	free
35120-1	Columbium (niobium) and tantalum metal and alloys in powder, pellets, scrap, ingots, sheets, plates, strips, bars, rods, tubing or wire for use in Canadian manufacturing (expires June 30, 1979)	free	free	25%	free
37506-1	Ferrocolumbium ferrotantalum, ferro-tantalum-columbium	free	5%	5%	free

United States

Item No.		
601.21	Columbium ore	free
601.42	Tantalum ore	free
628.15	Columbium metal, unwrought and waste and scrap (duty on waste and scrap suspended to June 30, 1981)	5% ad valorem
628.17	Columbium, unwrought alloys	7.5% ad valorem
628.20	Columbium metal, wrought	9% ad valorem
629.05	Tantalum metal, unwrought and waste and scrap (duty on waste and scrap suspended to June 30, 1981)	5% ad valorem
629.07	Tantalum, unwrought alloys	7.5% ad valorem
629.10	Tantalum metal, wrought	9% ad valorem

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978), USITC Publication 843.

Copper

G.E. WOOD

Canadian mines

Production of primary copper in Canada in 1978 was 657 521 tonnes* compared with 759 422 tonnes in 1977. This sharp reduction resulted from a combination of production cutbacks and strikes at Canadian mines and smelters.

Production cutbacks resulted, in some cases, from depressed prices in the world copper market, but also from high stocks, low prices and oversupply conditions for the important coproduced metals – nickel and zinc.

Strikes and lockouts at such important producers as Gibraltar Mines Ltd.; the Sudbury, Ontario operations of Inco Metals Company; and Gaspé Copper Mines, Limited resulted in lost production of about 20 000 tonnes of copper a month in the final quarter of the year.

Refined copper production, which totalled 446 278 tonnes in 1978 compared with 508 767 tonnes in 1977, was particularly affected by the Gaspé and Inco strikes, as copper production from both locations is entirely smelted and refined in Canada.

Quebec. In Quebec the government signed agreements with Campbell Chibougamau Mines Ltd. and Orchan Mines Limited under which mine closures were averted through government financial assistance. Mine development was continued by both companies, and in August, Orchan reported that deep level diamond drilling at the Norita mine had indicated a significant enlargement of the new "A" ore zone.

Exploratory talks held by Quebec with the French government, French copper consumers and Quebec-based mining companies were initiated late in 1977, with a view to concluding a price stabilization scheme for Quebec-produced copper. However, no news was forthcoming during 1978, and no agreement had been reached by year-end.

At Murdochville, Quebec the labour contract of mine and smelter workers at Gaspé Copper Mines, Limited expired on October 16, and a strike began the following day. The strike was still in progress at the end of the year. About one third of the copper produced in the Gaspé smelter is from custom concentrates. Most of this material was diverted to other smelters.

Ontario. At Texasgulf Canada Ltd.'s Kidd Creek concentrator, the fourth circuit started to operate in May 1978 and performed satisfactorily during the second half of the year. All four circuits were expected to be operable by year-end. Installation of the shaft steel work in the Kidd Creek No. 2 mine was completed at 1 555 metres (m) during the fourth quarter of the year. Construction of the copper smelter and refinery continued, with completion scheduled for 1981. The project was about 50 per cent complete at year-end. Copper output is expected to increase by more than 50 per cent at the Kidd Creek mine by 1981.

Falconbridge Nickel Mines Limited substantially reduced its operating rate in 1978 in the Sudbury area. Two mines, the Lockerby and the North mine, were closed and a seven-week vacation shutdown of the entire operation began on July 1. Only two mines, the Falconbridge and the Strathcona, operated for the full year. In addition, only one of the two new electric furnaces was put into operation at the company's modernized smelter in Sudbury. Reduced copper production at Falconbridge's Sudbury operations resulted directly from the extremely depressed condition of the world nickel market and the need to control nickel inventory levels. In the final quarter of 1978 Falconbridge successfully negotiated a new labour agreement for its mine, mill and smelter workers, thus averting total shutdown of Sudbury area copper and nickel production.

Inco also undertook severe production curtailments late in 1977 and throughout 1978. The company's Sudbury district operations were to resume after a six-week summer shutdown that ended on September 16, but a strike followed immediately and was still in effect at year-end. Copper production was affected immediately, as Sudbury ores provide almost all of Inco's copper production. *Force majeure* was declared on copper shipments to Europe. Inco is Canada's largest copper producer, with an average monthly output of about 13 000 tonnes.

Manitoba. A new mine, the Westarm, was brought into production by Hudson Bay Mining and Smelting Co., Limited on January 3, 1978. Proven ore reserves at the Westarm mine, which was discovered in 1973, total

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, copper production, trade and consumption, 1977 and 1978

	1977		1978^p	
	(tonnes)	($)	(tonnes)	($)
Production [1]				
British Columbia	275 226	421 718 776	274 632	450 524 000
Ontario	279 936	427 980 593	194 340	318 807 000
Quebec	109 632	167 994 171	88 704	145 515 000
Manitoba	60 132	92 143 259	60 580	99 378 000
Newfoundland	9 119	13 972 817	11 101	18 211 000
Yukon	5 843	8 953 814	11 012	18 066 000
New Brunswick	12 017	18 413 508	10 711	17 570 000
Saskatchewan	7 227	11 074 713	6 123	10 045 000
Northwest Territories	291	445 850	318	520 000
Total	759 423	1 162 697 501	657 521	1 078 636 000
Refined	508 767	. .	446 277	. .
Exports				
Copper in ores, concentrates and matte				
Japan	206 856	205 788 000	213 765	213 315 000
U.S.S.R.	5 871	5 230 000	20 468	18 912 000
Norway	19 210	15 198 000	13 795	12 264 000
Yugoslavia	—	—	8 285	11 371 000
West Germany	14 833	15 702 000	11 137	9 569 000
United States	20 672	19 271 000	5 766	4 822 000
Spain	6 478	6 192 000	3 539	2 994 000
Finland	—	—	1 292	2 578 000
Belgium and Luxembourg	935	809 000	1 736	1 827 000
South Korea	3 068	3 433 000	1 490	1 292 000
Other countries	1 660	2 096 000	889	966 000
Total	279 583	273 719 000	282 162	279 910 000
Copper in slag, skimmings and sludge				
United States	203	37 000	54	19 000
United Kingdom	40	13 000	12	7 000
Total	243	50 000	66	26 000
Copper scrap (gross weight)				
United States	10 276	11 466	8 966	8 493 000
South Korea	1 997	2 253	2 691	3 591 000
Japan	252	274	1 493	2 007 000
Belgium and Luxembourg	912	977	815	1 043 000
Hong Kong	696	816	447	506 000
Hungary	—	—	326	429 000
Taiwan	584	685 000	549	418 000
Spain	137	82 000	788	395 000
West Germany	613	791 000	293	372 000
United Kingdom	653	245 000	351	176 000
India	187	251 000	123	144 000
East Germany	—	—	36	44 000
France	—	—	13	40 000
Other countries	493	533 000	—	—
Total	16 800	18 373 000	16 891	17 658 000

Table 1. (cont'd)

Exports (cont'd)	1977 (tonnes)	1977 ($)	1978p (tonnes)	1978p ($)
Brass and bronze scrap (gross weight)				
United States	11 454	11 432 000	9 668	9 728 000
Japan	1 814	1 589 000	3 219	3 065 000
Belgium and Luxembourg	604	532 000	2 081	2 121 000
South Korea	513	485 000	1 221	1 232 000
India	858	765 000	831	763 000
Angola	35	36 000	407	451 000
Taiwan	218	197 000	381	365 000
West Germany	18	9 000	188	224 000
Spain	198	47 000	327	119 000
Brazil	—	—	115	117 000
Netherlands	31	30 000	72	96 000
Other countries	812	658 000	185	182 000
Total	16 555	15 780 000	18 695	18 463 000
Copper alloy scrap, nes (gross weight)				
United States	2 302	1 942 000	3 370	2 662 000
Belgium and Luxembourg	18	4 000	950	921 000
Japan	574	502 000	717	791 000
South Korea	778	249 000	301	113 000
Other countries	105	75 000	272	175 000
Total	3 777	2 772 000	5 610	4 662 000
Copper refinery shapes				
United Kingdom	82 772	117 444 000	69 680	111 227 000
United States	87 178	136 906 000	64 175	102 601 000
West Germany	36 370	50 740 000	19 384	29 700 000
France	17 044	24 213 000	17 711	28 968 000
Belgium and Luxembourg	16 917	23 738 000	18 371	28 861 000
Japan	4 638	7 396 000	14 641	22 329 000
Italy	12 965	18 666 000	11 998	19 192 000
Sweden	11 665	16 266 000	7 574	12 315 000
People's Republic of China	4 500	6 059 000	6 000	8 155 000
South Korea	1 100	1 733 000	2 803	5 056 000
Greece	1 736	2 457 000	2 698	4 307 000
Philippines	900	1 243 000	1 935	3 466 000
Portugal	4 170	6 038 000	2 050	3 228 000
Taiwan	300	488 000	2 005	3 228 000
Other countries	11 985	17 147 000	6 707	11 115 000
Total	294 240	430 534 000	247 732	393 748 000

Table 1. (cont'd)

	1977		1978^{p}	
Exports (cont'd)	(tonnes)	($)	(tonnes)	($)
Copper bars, rods and shapes, nes				
United States	2 031	4 527 000	4 431	9 635 000
Venezuela	2 489	3 671 000	2 503	3 952 000
Bangladesh	1 204	1 826 000	1 671	2 596 000
Iran	2 140	3 654 000	1 054	1 769 000
Nigeria	252	463 000	780	1 550 000
Pakistan	2 468	3 558 000	999	1 414 000
Switzerland	990	1 370 000	647	922 000
Dominican Republic	638	911 000	182	280 000
Israel	426	616 000	130	198 000
Colombia	—	—	100	171 000
Other countries	184	355 000	156	259 000
Total	12 822	20 951 000	12 653	22 746 000
Copper plates, sheet, strip and flat products				
United States	5 750	13 533 000	6 519	16 602 000
Venezuela	169	413 000	80	220 000
Dominican Republic	—	—	90	132 000
New Zealand	8	21 000	13	36 000
Australia	—	—	12	31 000
Peru	—	—	...	2 000
Other countries	200	320 000	—	—
Total	6 127	14 287 000	6 714	17 023 000
Copper pipe and tubing				
United States	4 215	9 448 000	5 951	14 522 000
Israel	620	1 362 000	955	2 166 000
Venezuela	204	552 000	451	1 359 000
Spain	515	1 185 000	551	1 335 000
West Germany	1 294	2 476 000	213	556 000
United Kingdom	105	249 000	156	439 000
Algeria	96	197 000	46	134 000
Netherland Antilles	31	76 000	54	132 000
Sweden	41	84 000	44	99 000
Mexico	—	—	6	96 000
Other countries	394	1 133 000	257	691 000
Total	7 515	16 762 000	8 684	21 529 000
Copper wire and cable (not insulated)				
Saudi Arabia	24	45 000	1 109	2 149 000
United States	237	383 000	217	337 000
Australia	—	—	4	21 000
Nicaragua	—	—	3	7 000
Nigeria	38	88 000	—	—
Other countries	120	190 000	—	—
Total	419	706 000	1 333	2 514 000

Table 1. (cont'd)

	1977		1978p	
Exports (cont'd)	(tonnes)	($)	(tonnes)	($)
Copper alloy refinery shapes				
United States	10 917	22 322 000	14 395	31 614 000
Venezuela	136	294 000	66	175 000
United Kingdom	—	—	32	45 000
Ecuador	27	68 000	17	38 000
Japan	51	64 000	18	19 000
Australia	—	—	4	14 000
New Zealand	3	8 000	—	—
Other countries	38	99 000	—	—
Total	11 172	22 855 000	14 532	31 905 000
Copper alloy pipe and tubing				
United States	2 783	6 733 000	5 940	14 454 000
Venezuela	33	96 000	175	546 000
West Germany	—	—	46	154 000
Netherland Antilles	—	—	17	38 000
Indonesia	—	—	14	37 000
Emirates, U.A.	1 006	4 095 000	6	29 000
New Zealand	22	61 000	8	27 000
Panama	10	22 000	7	22 000
Jordan	—	—	5	13 000
Other countries	27	59 000	7	21 000
Total	3 881	11 066 000	6 225	15 341 000
Copper alloy wire and cable, not insulated				
United States	304	476 000	268	505 000
New Zealand	13	50 000	24	83 000
South Africa	—	—	14	47 000
Saudi Arabia	—	—	11	39 000
Australia	3	13 000	11	35 000
Other countries	8	43 000	5	15 000
Total	328	582 000	333	724 000
Copper alloy fabricated materials, nes				
United States	840	2 422 000	765	2 392 000
Colombia	2	9 000	361	1 038 000
United Kingdom	158	330 000	228	400 000
Taiwan	—	—	10	31 000
Philippines	4	15 000	8	30 000
South Korea	—	—	3	23 000
Other countries	429	1 519 000	35	84 000
Total	1 433	4 295 000	1 410	3 998 000

Table 1. (cont'd)

	1977		1978p	
Exports (cont'd)	(tonnes)	($)	(tonnes)	($)
Wire and cable insulated[2]				
United States	4 379	12 043 000	9 195	26 728 000
Saudi Arabia	1 491	3 056 000	5 997	15 452 000
Pakistan	2 352	4 969 000	472	956 000
Trinidad-Tobago	314	803 000	259	695 000
Chile	60	245 000	158	662 000
Jamaica	41	120 000	270	643 000
Iran	2 367	6 674 000	186	519 000
Singapore	370	737 000	393	490 000
Venezuela	38	117 000	140	383 000
Libya	638	1 310 000	133	336 000
United Kingdom	25	102 000	168	331 000
Nigeria	—	—	142	305 000
Dominican Republic	574	1 617 000	105	305 000
Israel	3	13 000	118	295 000
Panama	129	312 000	105	278 000
Brazil	210	435 000	120	276 000
South Africa	56	262 000	48	254 000
Togo	—	—	103	218 000
Bermuda	103	254 000	88	202 000
Peru	40	114 000	66	194 000
France	5	56 000	19	183 000
Emirates, U.A.	180	246 000	145	168 000
Other countries	1 663	4 405 000	984	2 465 000
Total	15 038	37 890 000	19 414	52 338 000
Total exports of copper and copper products		870 662 000		882 585 000
Imports				
Copper in ores, concentrates and scrap	16 487	15 035 000	18 398	17 659 000
Copper refinery shapes	18 821	28 560 000	21 439	37 682 000
Copper bars, rods and shapes, nes	2 397	4 052 000	2 089	2 579 000
Copper plates, sheet strip and flat products	912	2 146 000	1 016	2 482 000
Copper pipe and tubing	2 187	5 366 000	1 985	5 556 000
Copper wire and cable, except insulated	1 314	3 848 000	1 974	3 616 000
Copper alloy scrap (gross weight)	3 765	3 147 000	7 586	6 212 000
Copper powder	604	1 321 000	710	1 775 000
Copper alloy, refinery shapes, rods and sections	8 069	14 357 000	9 940	17 802 000
Brass plates, sheet and flat products	3 816	7 431 000	4 387	8 520 000
Copper alloy plates, sheet, strip and flat products	1 433	4 497 000	1 054	3 792 000
Copper alloy pipe and tubing	2 477	6 704 000	2 491	8 164 000
Copper alloy wire and cable, except insulated	594	1 880 000	496	1 879 000
Copper and alloy fabricated material, nes	2 533	7 230 000	1 732	6 546 000
Insulated wire and cable	. .	40 450 000	. .	39 460 000
Copper oxides and hydroxides	259	508 000	302	596 000
Copper sulphate	2 411	1 315 000	886	606 000
Copper alloy castings	345	1 182 000	399	1 501 000
Total imports of copper and products	. .	149 029 000	. .	166 427 000
Consumption[3]				
Refined	200 372	. .	228 694	. .

Source: Statistics Canada.
[1] Blister copper plus recoverable copper in matte and concentrate exported. [2] Includes also small quantities of noncopper wire and cable, insulated. [3] Producers' domestic shipments, refined copper.
p Preliminary; — Nil; . . Not available; nes Not elsewhere specified; . . . Insignificant.

907 000 tonnes above the 510 m level, grading to 3.85 per cent copper and 0.9 per cent zinc. Ore is trucked to Flin Flon at present for milling and smelting. A $26 million concentrator is being built by Hudson Bay near Snow Lake, Manitoba.

At the Ruttan mine of Sherritt Gordon Mines Limited, underground stope development and initial blasthole drilling began during the third quarter. Production from the 427 m level was expected to begin early in 1979. An exploration program below the 427 m level gave very encouraging results during 1978. Engineering studies were under way late in 1978 for an exploration shaft to provide access for exploration of the orebody down to the 914 m level.

British Columbia. The Afton mine, concentrator and smelter near Kamloops, British Columbia officially opened at the end of April 1978, following several months of tune-up operations. In its first five months of commercial operation the concentrator processed an average of 7 485 tonnes of ore per day, with an average grade of 0.96 per cent copper. The mine operated profitably during this period with sales of 11 800 tonnes of copper, 778 kilograms (kg) of gold and 4 510 kg of silver.

The Granduc mine in northern British Columbia closed on June 30, 1978. The mine, jointly leased by Newmont Mining Corporation and ASARCO Incorporated, had been operating at a loss and both companies had previously written off their assets at the mine. Granduc had been producing about 15 000 tonnes of copper per year during 1976 and 1977.

Gibraltar Mines Ltd. announced that it would suspend operations at its open-pit mine near Williams Lake on May 26, subsequent to a strike notice delivered by the union on May 10. The shutdown continued throughout the rest of 1978 and was unresolved at year-end.

Smelters and refineries

Production of refined copper in Canada in 1978 was 446 278 tonnes, compared with 508 767 tonnes in 1977. Smelter production in 1978 showed a similar decline, to 432 945 tonnes from 508 767 tonnes in 1977. Canada's six copper smelters and two refineries and highlights from their 1978 operations are described in the accompanying tables.

World supply and demand

World mine production of copper in 1978 was 7 743 600 tonnes, compared with 7 980 300 tonnes in 1977. This drop in production was primarily accounted for by reduced output in Canada.

In March, Zaire, Zambia and Peru announced an agreement to cut back overall copper production by 15 per cent.

During May, Zaire's Shaba province was invaded by rebels fighting under the flag of the Congo National Liberation Front. Kolwezi, the main copper mining town in Shaba, was quickly seized by the insurgents. A 50 per cent *force majeure* was declared by Sozacom, the Zairian state copper marketing agency, on July shipments as a result of production losses resulting from the fighting. Order was restored in June with the assistance of French, Belgian and Moroccan troops, and immediate production losses were much less than initially expected. Copper production in Zaire in 1978 amounted to 424 000 tonnes, compared with 480 000 tonnes in 1977. Longer-term effects of the invasion may result in even lower production in future years, owing to the exodus of skilled labour in the areas of mining, metallurgy and maintenance.

Transportation problems continued to plague Zambian copper producers. At mid-year some observers estimated that copper shipments were 2½ months behind schedule. The backlog, estimated to be about 130 000 tonnes, was distributed throughout the mine-to-port delivery system. This problem became so critical later in the year that Zambia agreed to start shipping copper through Rhodesia in mid-October, a route that was closed in 1972 for political reasons.

Two major new sources of primary copper production, La Caridad in Mexico and Sar Chesmeh in Iran both encountered construction delays in 1978. In September, sales discussions between a group of six Japanese copper smelters and Industrial Minera Mexico SA were reported to have been broken off as a result of these delays. La Caridad is not now expected to start operating before mid-1979. The violence and unrest in Iran, which erupted late in the year, will delay the Sar Chesmeh startup until late 1979.

(text continued on page 21)

Table 2. Canada, copper production, trade and consumption, 1960, 1965, 1970 and 1975-78

	Production		Exports			Imports	Consumption[2]
	All forms[1]	Refined	Ore and Matte	Refined	Total	Refined	Refined
				(tonnes)			
1960	398 492	378 322	43 212	252 257	295 469	23	106 718
1965	460 738	393 839	78 925	181 283	260 208	5 214	203 830
1970	610 279	493 261	161 377	265 264	426 641	13 192	215 834
1975	733 826	529 197	314 518	320 705[r]	635 223[r]	10 908	185 198
1976	730 930	510 469	294 715[r]	318 207[r]	612 922[r]	9 124	206 205
1977	759 423	508 767	279 583	294 240	573 823	18 821	200 372
1978[p]	657 521	446 277	282 162	247 732	529 894	21 439	228 694

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

Table 3. Principal copper mines in Canada, 1978 and (1977)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled: Copper	Zinc	Lead	Nickel	Silver	Gold	Ore Milled	Copper Concentrates Produced	Grade of Copper in Concentrate	Contained Copper Produced[1]	Destination of Copper Concentrate[2]
	(tonnes)	(%)	(%)	(%)	(%)	(grams/ tonne)	(grams/ tonne)	(tonnes)	(tonnes)	(%)	(tonnes)	
Newfoundland												
ASARCO	1 100	1.04	10.78	6.07	—	104.91	0.79	183 251	4 436	25.97	1 775	11
Incorporated,	(1 100)	(0.99)	(10.76)	(6.12)	(—)	(106.95)	(0.75)	(174 180)	(3 744)	(26.88)	(1 621)	(11)
Buchans												
Consolidated Rambler	1 100	4.70	—	—	—	26.47	2.88	247 874	41 456	26.27	10 890	1
Mines Limited,	(1 100)	(4.20)	(—)	(—)	(—)	(23.07)	(2.43)	(218 197)	(34 555)	(24.00)	(8 293)	(2,12)
Ming mine,												
Baie Verte												
New Brunswick												
Brunswick Mining and	9 100	0.29	8.88	3.56	—	93.94	—	3 058 300	14 330	22.85	5 484	1
Smelting Corporation	(9 100)	(0.37)	(7.82)	(3.12)	(—)	(84.69)	(—)	(3 134 388)	(17 872)	(21.90)	(6 728)	(1)
Limited,												
No. 6 and No. 12												
mines,												
Bathurst												
Heath Steele Mines	3 650	1.03	4.43	1.53	—	77.49	0.89	1 137 767	26 437	22.56	7 646	1,2
Limited,	(3 650)	(1.19)	(3.83)	(1.50)	(—)	(66.17)	(0.69)	(1 150 318)	(32 156)	(23.26)	(8 816)	(1)
Newcastle												
Quebec												
Campbell	4 000	1.38	—	—	—	8.57	3.46	230 489	14 457	21.12	3 053	2
Chibougamau Mines	(4 000)	(1.43)	(—)	(—)	(—)	(7.51)	(1.94)	(264 308)	(15 235)	(23.38)	(3 562)	(2)
Ltd.,												
Cedar Bay,												
Henderson mines,												
Merrill pit,												
Chibougamau												
Falconbridge Copper	1 400	3.36	3.85	—	—	43.54	0.82	372 722	44 936	26.53	12 075	2
Limited,	(1 400)	(3.27)	(3.74)	(—)	(—)	(38.74)	(0.79)	(389 967)	(46 070)	(26.22)	(12 248)	(2,12)
Millenbach mine,												
Noranda												

Falconbridge Copper Limited, Perry, Springer, Cooke mines, Chapais	3 000 (2 700)	1.99 (2.05)	— (—)	— (—)	— (—)	14.06 (13.89)	1.89 (1.06)	967 823 (926 917)	77 836 (75 598)	23.74 (24.03)	18 478 (18 166)	2 (2)
Gaspé Copper Mines, Limited, Copper Mountain mine, Needle Mountain mine, Murdochville	30 600 (30 600)	0.51 (0.53)	— (—)	— (—)	— (—)	3.19 (3.43)	0.07 (0.01)	7 985 273 (11 051 407)	151 664 (207 444)	23.44 (24.10)	35 561 (50 009)	1 (1)
Louvem Mining Company Inc., Louvem Division, Val d'Or	900 (900)	0.15 (0.12)	5.33 (5.95)	0.29 (0.16)	— (—)	87.77 (41.83)	1.75 (1.03)	248 073 (277 837)	1 029 (754)	12.62 (15.14)	304 (226)	2 (. .)
Mattagami Lake Mines Limited, Mattagami	3 500 (3 500)	0.52 (0.52)	7.56 (6.64)	— (—)	— (—)	32.57 (30.86)	0.51 (0.48)	878 484 (946 342)	13 556 (15 399)	24.33 (24.42)	3 809 (4 184)	2 (2)
Orchan Mines Limited, Orchan and Garon Lake mines, Matagami	1 900 (1 900)	0.61 (0.54)	5.89 (6.35)	— (—)	— (—)	34.29 (31.89)	0.69 (0.41)	368 602 (507 817)	6 324 (7 893)	25.11 (24.30)	1 588 (2 192)	2 (2)
Patino Mines, (Quebec) Limited, Copper Rand, Copper Cliff, Portage mines, Chibougamau	2 500 (2 500)	1.60 (1.74)	— (—)	— (—)	— (—)	9.70 (10.63)	3.39 (3.67)	616 381 (605 092)	44 917 (44 122)	21.04 (22.83)	9 451 (10 073)	2 (2)
Lemoine Mine, Chibougamau	400 (400)	4.97 (4.67)	11.18 (10.64)	— (—)	— (—)	94.63 (100.80)	5.31 (5.31)	105 611 (110 305)	20 044 (19 120)	24.82 (25.32)	5 080 (4 841)	2 (2)
Ontario												
Falconbridge Nickel Mines Limited, Falconbridge, Strathcona, East, Onaping, and Lockerby mines, Sudbury	11 300 (11 200)	0.78 (0.74)	— (—)	— (—)	1.29 (1.45)	. . (. .)	. . (. .)	2 073 500 (2 591 532)			15 491 (18 616)	4,5 (4,5)

Table 3. (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled: Copper	Zinc	Lead	Nickel	Silver	Gold	Ore Milled	Copper Concentrates Produced	Grade of Copper in Concentrate	Contained Copper Produced[1]	Destination of Copper Concentrate[2]
	(tonnes)	(%)	(%)	(%)	(%)	(grams/ tonne)	(grams/ tonne)	(tonnes)	(tonnes)	(%)	(tonnes)	
Ontario (cont'd)												
Falconbridge Copper Limited, Sturgeon Lake Joint Venture, Sturgeon Lake	1 100 (1 100)	2.73 (3.46)	9.14 (10.44)	1.17 (1.26)	— (—)	171.77 (206.40)	0.72 (0.89)	370 087 (383 882)	42 167 (52 149)	22.77 (22.64)	9 955 (12 273)	2 (2)
Inco Metals Company, Coleman, Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood-Stobie, Garson Levack, Levack West and Little Stobie mine, Sudbury and includes Shebandowan mine, Shebandowan	61 200 (61 200)	1.36 (1.15)	— (—)	— (—)	1.48 (1.31)	. . (. .)	. . (. .)	7 021 029 (14 628 651)	. . (. .)	. . (. .)	90 471 (158 566)	3 (3)
Mattabi Mines Limited, Sturgeon Lake	2 700 (2 700)	0.83 (1.01)	6.49 (8.40)	0.67 (0.84)	— (—)	93.26 (121.71)	0.41 (0.34)	871 675 (938 417)	25 056 (31 108)	24.68 (26.35)	6 720 (8 721)	2 (2)
Noranda Mines Limited, Geco Division, Manitouwadge	4 500 (4 500)	1.54 (1.94)	2.19 (2.62)	0.12 (0.11)	— (—)	38.74 (41.83)	0.17 (0.17)	1 572 458 (1 591 673)	79 932 (104 752)	27.55 (27.57)	23 129 (29 498)	2 (2)
Pamour Porcupine Mines, Limited, Schumacher Division, Timmins	2 700 (2 700)	0.23 (0.36)	— (—)	— (—)	— (—)	3.98 (3.22)	3.05 (3.12)	881 357 (909 943)	7 869 (12 115)	21.64 (23.16)	1 702 (2 806)	2 (2)

Selco Mining Corporation Limited, South Bay mine, Uchi Lake	500 (500)	1.43 (1.66)	12.20 (9.87)	— (—)	— (—)	75.77 (76.80)	— (—)	121 635 (164 745)	5 967 (9 462)	26.21 (26.30)	1 636 (2 590)	2 (2)
Teck Corporation Silverfields Mining Division, Cobalt	250 (250)	0.60 (0.60)	— (—)	— (—)	0.26 (0.25)	342.86 (357.60)	— (—)	77 247 (76 628)	— (—)		33 (19)	. . (. .)
Texasgulf Inc., Kidd Creek mine, Timmins	9 100 (9 100)	1.87 (1.83)	6.43 (7.26)	0.20 (0.22)	— (—)	102.71 (103.82)	— (—)	3 002 148 (3 299 051)	200 917 (220 894)	24.81 (24.56)	53 325 (58 191)	2 (2)
Union Minière Explorations and Mining Corporation Limited, Thierry mine	3 600 (3 600)	1.29 (1.26)	— (—)	— (—)	0.13 (0.13)	8.23 (8.23)	0.14 (0.14)	836 119 (875 810)	35 074 (36 563)	28.07 (27.04)	9 845 (10 018)	2 (2)
Manitoba												
Falconbridge Nickel Mines Limited, Manibridge mine, Wabowden	— (900)	— (0.17)	— (—)	— (—)	— (. .)	— (—)	— (—)	— (46 145)	— (. .)[3]	— (. .)	— (. .)	— (4,5)
Hudson Bay Mining and Smelting Co., Limited, Anderson, Chisel, Flin Flon, Ghost, Osborne, Stall and White Lake mines, Centennial and Westarm mines, Flin Flon and Snow Lake	7 700 (7 700)	2.26 (2.18)	3.16 (2.79)	. . (0.22)	— (—)	20.57 (19.27)	1.22 (1.23)	1 679 000 (1 652 526)	192 538 (183 945)	18.00 (18.13)	35 234 (33 849)	6 (6)
Inco Metals Company, Pipe and Thompson mines, Thompson	. . (. .)	. . (. .)	. . (. .)	. . (. .)	. . (. .)	. . (. .)	. . (. .)	2 139 911 (2 982 505)	. .[4] (. .)[4]	. . (. .)	. .[4] (. .)	3 (3)

Table 3. (cont'd)

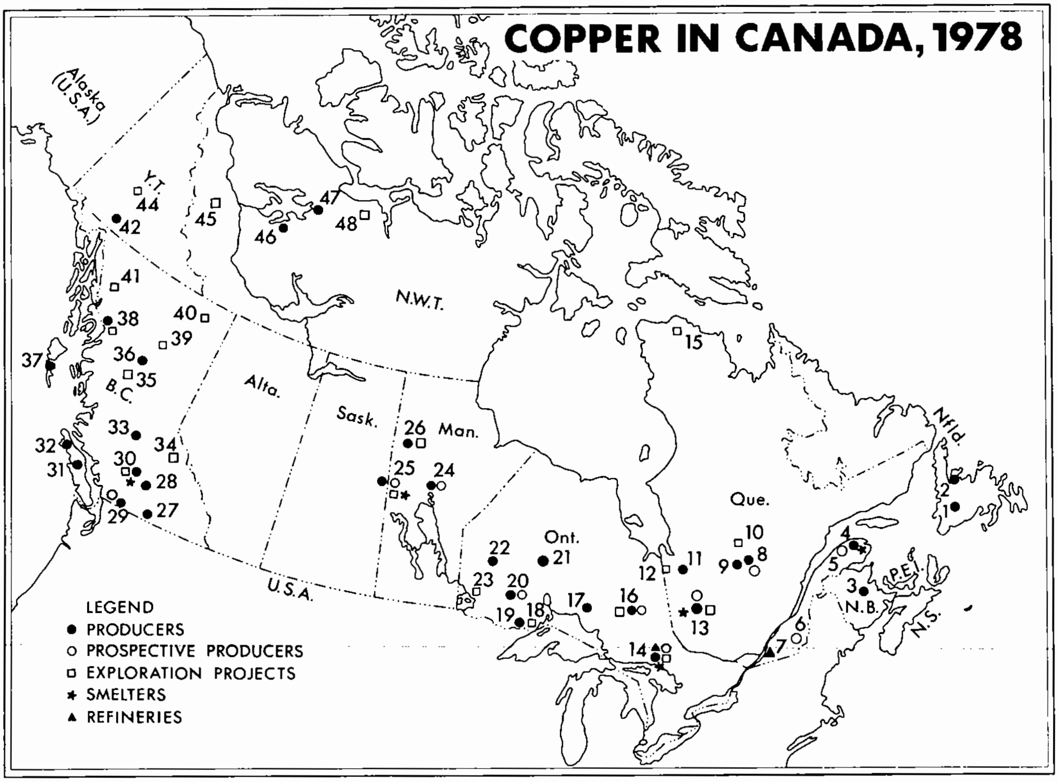
Company and Location	Mill or Mine Capacity	Grade of Ore Milled: Copper	Zinc	Lead	Nickel	Silver	Gold	Ore Milled	Copper Concentrates Produced	Grade of Copper in Concentrate	Contained Copper Produced[1]	Destination of Copper Concentrate[2]
	(tonnes)	(%)	(%)	(%)	(%)	(grams/ tonne)	(grams/ tonne)	(tonnes)	(tonnes)	(%)	(tonnes)	
Manitoba (cont'd)												
Sherritt Gordon Mines Limited, Fox mine, Lynn Lake	2 700 (2 700)	1.24 (1.50)	1.73 (1.91)	— (—)	— (—)	4.80 (6.65)	0.15 (0.21)	874 933 (807 687)	40 095 (43 428)	25.28 (25.11)	10 413 (11 121)	6 (6)
Ruttan mine Ruttan Lake	9 100 (9 100)	1.15 (1.13)	1.53 (1.95)	— (—)	— (—)	5.69 (6.65)	0.22 (0.24)	2 307 069 (2 256 486)	87 612 (92 119)	27.06 (24.79)	24 479 (23 692)	2,6 (2,6)
British Columbia												
Afton Mines Ltd. Dominion pit, Kamloops	7 300 (6 350)	1.01 (0.76)	— (—)	— (—)	— (—)	4.97 (4.11)	0.72 (0.55)	2 456 770 (122 339)	. . (. .)	. . (. .)	21 805 (618)	. . (. .)
Bethlehem Copper Corporation, Iona and Jersey mines, Highland Valley	18 100 (18 100)	0.41 (0.43)	— (—)	— (—)	— (—)	2.74 (1.37)	0.03 (0.02)	6 490 760 (5 554 692)	49 257 (47 091)	44.08 (43.85)	21 713 (20 649)	10 (10)
Brenda mines Ltd., Peachland	21 800 (21 800)	0.16[5] (0.19)[5]	— (—)	— (—)	— (—)	1.37 (0.86)	0.02 (0.01)	9 995 801 (9 634 472)	46 881 (54 838)	30.02 (29.42)	14 074 (16 133)	10,12,13 (2,10,12)
Craigmont Mines Limited, Merritt	5 200 (5 200)	1.36 (1.21)	— (—)	— (—)	— (—)	— (—)	— (—)	1 899 953 (1 884 345)	82 789 (77 052)	28.71 (27.97)	23 769 (21 551)	10,13 (10)
Gibraltar Mines Ltd. (N.P.L.), McLeese Lake, Caribou District	36 300 (36 300)	0.38[5] (0.38)[5]	— (—)	— (—)	— (—)	— (—)	— (—)	5 135 682 (12 765 026)	60 376 (140 185)	26.97 (28.06)	16 283 (39 336)	6,10,13 (10)
Granby Mining Corporation, Granisle mine, Babine Lake	12 700 (12 700)	0.41 (0.44)	— (—)	— (—)	— (—)	2.26 (1.20)	0.21 (0.12)	4 549 288 (4 474 143)	50 371 (50 937)	30.93 (34.76)	15 580 17 706	10,11,13 (10,11,13)

Phoenix Copper Division, Greenwood	2 600 (2 600)	0.44 (0.39)	— (—)	— (—)	— (—)	4.29 (5.07)	0.55 (0.51)	198 640 (833 829)	2 124 (10 083)	25.94 (26.35)	551 (2 657)	9 (9)
Lornex Mining Corporation, Ltd., Lornex mine, Highland Valley	43 500 (43 500)	0.45[5] (0.48)[5]	— (—)	— (—)	— (—)	2.40 (1.20)	— (—)	15 927 148 (15 480 792)	208 962 (204 351)	30.60 (32.14)	63 942 (65 678)	9,10,13 (9,10,13)
Noranda Mines Limited, Bell Copper Division, Babine Lake	9 100 (9 100)	0.44 (0.43)	— (—)	— (—)	— (—)	0.69 (0.69)	0.34 (0.31)	4 470 094 (4 408 918)	61 689 (59 377)	26.69 (26.63)	16 465 (15 812)	2 (2)
Newmont Mines Limited, Granduc mine, Stewart	7 300 (7 300)	1.43 (1.31)	— (—)	— (—)	— (—)	8.23 (8.23)	0.14 (0.14)	740 119 (1 333 143)	35 708 (58 259)	28.33 (28.16)	10 116 (16 406)	10 (10)
Similkameen Division, Ingerbelle pit, Princeton	22 000 (22 000)	0.41 (0.38)	— (—)	— (—)	— (—)	1.37 (0.65)	0.34 (0.16)	6 826 464 (7 144 987)	89 868 (83 513)	27.60 (27.51)	24 804 (22 974)	10 (9,10)
Utah Mines Ltd., Island Copper mine, Coal Harbour	37 200 (34 500)	0.40 (0.42)	— (—)	— (—)	— (—)	1.37 (0.69)	0.21 (0.12)	14 200 278 (13 106 073)	213 795 (201 961)	23.14 (23.59)	49 490 (47 660)	10 (10)
Wesfrob Mines Limited, Tasu Harbour	7 300 (. .)	0.35 (0.81)	— (—)	— (—)	— (—)	4.11 (1.37)	0.10 (0.03)	889 933 (1 002 501)	13 317 (6 000)	19.92 (20.46)	2 653 (1 228)	10 (10)
Western Mines Limited, Lynx and Myra Falls mines, Buttle Lake	900 (700)	1.25 (1.14)	8.24 (7.58)	1.33 (1.34)	— (—)	139.89 (147.09)	2.85 (2.71)	269 035 (269 069)	10 252 (8 670)	27.47 (27.66)	3 296 (2 855)	10 (10)

Table 3. (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled: Copper	Zinc	Lead	Nickel	Silver	Gold	Ore Milled	Copper Concentrates Produced	Grade of Copper in Concentrate	Contained Copper Produced[1]	Destination of Copper Concentrate[2]
	(tonnes)	(%)	(%)	(%)	(%)	(grams/ tonne)	(grams/ tonne)	(tonnes)	(tonnes)	(%)	(tonnes)	
Yukon Territory												
Whitehorse Copper Mines Ltd., Little Chief mine, Whitehorse	2 300 (2 300)	1.40 (1.65)	— (—)	— (—)	— (—)	7.82 (9.60)	0.86 (0.93)	782 984 (817 790)	21 272 (28 260)	44.62 (42.28)	9 491 11 948	6 (6)
Northwest Territories												
Echo Bay Mines Ltd., Port Radium	150 (150)	0.83 (0.90)	— (—)	— (—)	— (—)	2 170.29 (2 213.83)	— (—)	34 232 (31 091)	. . (1 684)	. . (13.50)	234 237	. . (9)
Terra Mining and Exploration Limited, Silver Bear mine, Great Slave Lake	160 (160)	0.29 (0.27)	— (—)	— (—)	— (—)	1 385.14 (1 393.37)	— (—)	33 433 (33 508)	— (—)	— (—)	58 (77)	. . (. .)

Sources: Company reports and technical press.
[1]Total copper in concentrates. [2]Destination of concentrates: 1. Gaspé Copper Mines, Limited; 2. Noranda Mines Limited; 3. Inco, Sudbury; 4. Falconbridge Nickel, Sudbury; 5. Falconbridge Nickel, Norway; 6. Hudson Bay Mining and Smelting Co. Ltd.; 7. Sherritt Gordon Mines Ltd.; 8. Afton Mines Ltd.; 9. United States; 10. Japan; 11. Germany; 12. Korea; 13. Unspecified and other countries. [3]Included in the Sudbury total for Falconbridge Nickel Mines Limited. [4]Included in the Copper Cliff total for Inco. [5]Substantial amounts of molybdenum are coproduced.
— Nil; . . Not available.



Producers
(numbers correspond to those in map above)

1. ASARCO Incorporated
2. Consolidated Rambler Mines Limited
3. Brunswick Mining and Smelting Corporation Limited (No. 6 and No. 12 mines)
   Heath Steele Mines Limited
   Sullico Resources Ltd.
4. Gaspé Copper Mines, Limited
8. Campbell Chibougamau Mines Ltd. (Cedar Bay, Henderson, Merrill pit)
   Patino Mines (Quebec) Limited (Copper Rand, Lemoine mines)
9. Falconbridge Copper Limited, Opemiska Division, (Perry, Springer, Cooke mines)
11. Mattagami Lake Mines Limited
    Orchan Mines Limited (Orchan, Norita mines)
13. Falconbridge Copper Limited, Lake Dufault Division (Millenbach mines)
14. Falconbridge Nickel Mines Limited (Lockerby, Falconbridge, Strathcona East, Onaping mines)
    Inco Limited (Coleman, Copper Cliff North, Copper Cliff South, Creighton, Frood Stobie, Garson, Levack, Levack West, Little Stobie, Crean Hill mines)
16. Texasgulf Inc. (Kidd Creek mine)
    Pamour Porcupine Mines, Limited
17. Noranda Mines Limited, Geco Division
19. Inco (Shebandowan)
20. Sturgeon Lake Mines Limited
    Mattabi Mines Limited
21. Union Minière Explorations and Mining Corporation Limited (Thierry mine)
22. Selco Mining Corporation Limited, South Bay Division
24. Inco (Pipe open pit and Thompson mines)
25. Hudson Bay Mining and Smelting Co., Limited (Anderson, Chisel, Flin Flon, Ghost, Osborne, Stall, White Lake mines, Centennial and Westarm mines)
26. Sherritt Gordon Mines Limited, (Fox and Ruttan mines)
27. Granby Mining Corporation, Phoenix Copper Division
28. Brenda Mines Ltd.
29. Similkameen Mining Company Limited (Ingerbelle and Similkameen deposits)

30. Bethlehem Copper Corporation (Iona and Jersey mines)
    Lornex Mining Corporation Ltd.
    Craigmont Mines Limited
    Afton Mines Ltd.
31. Western Mines Limited (Lynx, Myra mines)
32. Utah Mines Ltd. (Island Copper mine)
33. Gibraltar Mines Ltd.
36. Granby Mining Corporation (Granisle mine)
    Noranda Mines Limited, Bell Copper Division
37. Falconbridge Nickel Mines Limited (Wesfrob mine)
38. Newmont Mines Limited (Granduc mine)
42. Whitehorse Copper Mines Ltd. (Little Chief mine)
46. Terra Mining and Exploration Limited
47. Echo Bay Mines Ltd.

Prospective producers*

5. Madeleine Mines Ltd.
8. Campbell Chibougamau Mines Ltd. (Gwillim, Original, Grandroy mines)
   Patino Mines (Quebec) Limited (Portage mines)
13. Falconbridge Copper Limited, Dufault Division (Corbet mine)
14. Falconbridge Nickel Mines Limited (East, Onaping, Fraser, North, Lockerby mines)
    Inco (Murray, Totten, Levack East, Clarabelle, Fecunis mines)
16. Texasgulf Inc. (Kidd Creek No. 2 mine)
20. Mattagami Lake Mines Limited (Lyon Lake Division)
24. Inco (Soab, Birchtree and Pipe No. 1 mines)
25. Hudson Bay Mining and Smelting Co., Limited (Spruce Point mine)
29. Newmont Mines Limited (Copper Mountain mine)
30. Bethlehem Copper Corporation (J.A., Maggie, Lake zone)

Exploration projects**

10. Selco Mining Corporation Limited and Muscocho Exploration Limited
12. Selco Mining Corporation/Moore McCormack Resources Inc. (Detour Project)
13. Noranda Mines Limited (Magusi River property, New Insco deposit)
14. Falconbridge Nickel Mines Limited (Craig, Onex mines)
    Inco (Cryderman, Whistle mine)
15. New Quebec Raglan Mines Limited
16. Teck Corporation (Montcalm township)
18. Great Lakes Nickel Limited
25. Hudson Bay Mining and Smelting Co., Limited (Hudvam, Rail, Reed, Wim mines, Lost Lake deposit)
    Stall Lake Mines Limited
26. Sherritt Gordon Mines Limited (Lynn Lake)
30. Bethlehem Copper Corporation (J.A., Maggie, Lake zone)
    Highmont Mining Corporation
    LMC Resources Ltd.
    Valley Copper Mines Limited
34. Noranda Mines Limited (Goldstream River)
35. Placer Development Limited (Sam Goosly mine)
39. Falconbridge Nickel Mines Limited (Sustut deposit)
40. Davis-Keays Mining Co. Ltd.
41. Liard Copper Mines Ltd.
    Stikine Copper Limited
    Texasgulf Inc. (Red Group)
44. Silver Standard Mines Limited and Asarco Exploration Company of Canada, Limited
    United Keno Hill Mines Limited
    Falconbridge Nickel Mines Limited
    Canadian Superior Exploration Limited, (Minto copper deposit)
45. Shell Canada Limited (Coates Lake)
48. Texasgulf Inc. (Izok Lake)

Smelters

4. Gaspé Copper Mines, Limited.
13. Noranda Mines Limited
14. Falconbridge Nickel Mines Limited,
    Inco Limited
25. Hudson Bay Mining and Smelting Co., Limited
30. Afton Mines Ltd.

Refineries

7. Canadian Copper Refiners Limited
14. Inco Limited.

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*Only mines with announced production plans and mines placed on standby.

**A more complete inventory is available in the publication *A Survey of Known Mineral Deposits in Canada that Are Not Being Mined*, R.C. Annis, D.A. Cranstone and M. Vallée, Department of Energy, Mines and Resources, Ottawa, 1978, Mineral Bulletin MR 181.

Table 4. Prospective[1] copper producers, 1978

Company and Location	Mill Capacity[2] and Ore Grade[3]	Year Production Expected	Destination of Copper Concentrates	Remarks
New Brunswick				
Brunswick Mining and Smelting Corporation Limited, No. 12 mine, Bathurst	10 000 Cu 0.30 Pb 3.79 Zn 9.22	1981	Murdochville, Noranda	Expanding No. 12 mine to 10 000 tonnes per day from 6 400. Development includes new 8-metre shaft. Pace of development reduced late in 1977.
Quebec				
Orchan Mines Limited, La Gauchetiere Township	700 Zn 4.5 Cu 0.9 Ag 17.14[4]	..	Noranda	Deposit acquired from Phelps Dodge Corporation of Canada, Limited. Will be developed by decline and 550 metre vertical shaft. Development delayed in 1977 pending completion of all-weather access road and improved zinc and copper market conditions.
Ontario				
Falconbridge Nickel Mines Limited,				
Fraser mine	Cu .. Ni ..	..	Falconbridge	Under development.
East mine		..	Falconbridge	On standby.
Onaping mine		..	Falconbridge	On standby.
North mine		..	Falconbridge	On standby.
Lockerby mine, Sudbury area		..	Falconbridge	On standby.
Inco Limited,				
Clarabelle (open pit)	Cu .. Ni ..	..	Copper Cliff	On standby.
Murray mine		..	Copper Cliff	On standby.
Totten mine			Copper Cliff	On standby.
Crean Hill mine			Copper Cliff	On standby.
Copper Cliff north mine, Sudbury			Copper Cliff	On standby.
Mattagami Lake Mines Limited, Lyon Lake mine, Sturgeon Lake	— Cu 1.15 Zn 6.66 Pb 0.63 Ag 116.2[4]	..	..	Development work suspended in November 1977 pending increase in metal prices.
Manitoba				
Hudson Bay Mining and Smelting Co., Limited, Spruce Point mine, Reed Lake	Cu .. Zn ..	..	Flin Flon	Construction started in August. Access road, site clearing and shaft collar completed by year-end.

Table 4. (cont'd)

Company and Location	Mill Capacity[2] and Ore Grade[3]	Year Production Expected	Destination of Copper Concentrates	Remarks
Manitoba (cont'd)				
Inco, Pipe (underground mine) Soab mine Birchtree mine, Thompson district	Cu . . Ni . .	. .	Thompson	On standby.
British Columbia				
Placer Development Limited, Sam Goosly deposit	4 500 Cu 0.33 Ag 97.0[4] Au 0.87[4]	1980	. .	Near Houston, B.C. Cost of project estimated at $85 million.
Newmont Mines Limited, Granduc mine	7 300 Cu 1.30	. .	. .	Mine closed in mid-1978. Esso Resources Canada Limited expressed interest in acquiring and reopening mine.

Sources: Company reports and technical press.
[1]Only mines with announced production plans and mines placed on standby. [2]Mill capacity in tonnes of ore per day. [3]Ore grade in per cent unless otherwise noted. [4]Ore grade in grams per tonne.
— Nil; . . Not available.

Table 5. Canadian copper and copper-nickel smelters, 1978

Company and Location	Product	Rated Annual Capacity	Remarks	Ore and Concentrate Treated	Blister or Anode Copper Produced
		(tonnes)		(tonnes)	(tonnes)
Afton Mines Ltd., Kamloops, British Columbia	Blister copper	22 500	The smelter entered commercial operation on May 1, 1978. The uniquely low-sulphur concentrate is smelted in a top blown rotary converter. SO_2 produced is neutralized with limestone.	..	5 945
Falconbridge Nickel Mines Limited, Falconbridge, Ontario	Copper-nickel matte	590 000[2]	A smelter modernization program was begun in 1975. Construction was completed in the first half of 1978 at a cost of $79 million. Fluid-bed roasters and electric furnaces have replaced older smelting equipment and a 1 180-tonne-per-day sulphuric acid plant treats roaster gases. Refining of copper-nickel matte is carried out in Norway. In 1978 all Sudbury production after the summer shutdown was achieved with one furnace line.	..	13 600[1]
Inco Limited, Sudbury, Ontario	Blister copper, nickel sulphide and nickel sinter for company's refineries; nickel oxide sinter for market, soluble nickel oxide for market	3 630 000[2]	Oxygen flash-smelting of copper sulphide concentrate; converters for production of blister copper. Roasters, reverberatory furnaces for smeltng of copper-nickel ore and concentrate; converters for production of copper-nickel Bessemer matte. Production of matte followed by matte treatment, flotation, separation of copper and nickel sulphides, then by sintering to make sintered-nickel products for refining and marketing. Electric furnace melting of copper sulphide and conversion of blister copper. Also custom smelting. Strike interrupted production from September 16 until after year-end.	...	89 400

Table 5. (cont'd)

Company and Location	Product	Rated Annual Capacity	Remarks	Ore and Concentrate Treated	Blister or Anode Copper Produced
		(tonnes)		(tonnes)	(tonnes)
Noranda Mines Limited, Noranda, Quebec	Copper anodes	1 542 000[3]	Roasting furnaces, 1 hot-charge and 2 green-charge reverberatory furnaces; 5 converters; 1 continuous reactor; one 85-tonne-per-day oxygen plant to supply oxygen-enriched blast. Continuous reactor was modified to produce matte instead of metal.	812 800, of which 666 800 were custom concentrates.	205 000
Gaspé Copper Mines Limited, Murdochville, Quebec	Copper anodes	336 000[2]	Smelter is fed with Gaspé and custom concentrates. A shortage of both was experienced in 1978. Production was halted on October 16 by a labour strike which continued into 1979.	243 000, of which 65 000 tonnes were custom concentrates.	55 900
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Manitoba	Blister-copper cakes	522 000[2]	Roasting furnaces, 1 reverberatory furnace, 3 converters. Treats own and custom copper concentrates, along with zinc plant residues, in conjunction with slag fuming furnaces. A new flue system was completed, including a 251 metre stack. Campaign life in the furnaces extended from 12 to 18 months in 1976. Dampers on furnace uptakes installed in 1977 resulting in a 9 per cent reduction in fuel oil consumption.	293 100 tonnes of concentrate of which 101 100 were purchased and 63 100 tonnes of residues.	63 100

Sources: Company reports.
[1] Deliveries. [2] Ores and concentrates. [3] Ores, concentrates and scrap.
. . Not available.

Table 6. Copper refineries in Canada, 1978

Company and Location	Rated Annual Capacity	Output	Remarks
	(tonnes)	(tonnes)	
Canadian Copper Refiners Limited, Montreal East, Quebec	435 000	352 000	Refines anodes from Noranda and Gaspé smelters, blister copper from Flin Flon smelters, and purchased scrap. Copper and nickel sulphate recovered by vacuum evaporation. Precious metals, selenium and tellurium recovered from anode slimes, produces C.C.R. brand electrolytic copper wirebars, ingot bars, ingots, cathodes, cakes and billets. New shaft furnace to remelt copper anodes was started up in May. Extensive structural rehabilitation of refinery building continued in 1978.
Inco Limited Copper Refining Division, Copper Cliff, Ontario	192 000	89 400	Refines blister copper from Copper Cliff smelter. Precious metals, selenium and tellurium are recovered from anode slimes. Recovers and electrowins copper from Copper Cliff nickel refinery residue. Produces ORC brand electrolytic copper, cathodes, wirebars, cakes, billets, ingots and ingot bars. Operations interrupted by a strike which began on September 16 and extended beyond the year-end.

Sources: Company reports.

Poland, alone among the larger world producers, recorded a substantial production increase in 1978, to 323 000 tonnes compared with 289 000 tonnes in 1977.

World consumption

Consumption of refined copper recorded a healthy increase of 5.1 per cent to 7 242 500 tonnes in 1978, from 6 892 900 tonnes in 1977. North American countries and the industrialized Asian countries accounted almost entirely for this increase. Consumption in the European countries remained static at the 1977 level.

Stocks

World stocks of refined copper declined during 1978. The highly visible London Metal Exchange (LME) and New York Commodity Exchange (Comex) stocks, usually a bellweather of the total stock picture, showed a net decline during the year. LME stocks fell from 640 475 tonnes on January 6 to 372 000 tonnes at year-end. Comex stock showed a small increase from 164 400 tonnes to 162 620 tonnes in the same period.

According to the World Bureau of Metal Statistics, world stocks of unwrought copper fell from 1.961 million tonnes to 1.538 million tonnes during the course of 1978.

Table 7. Canada, consumption of primary copper in the manufacture of semifabricated products, 1976 and 1977

	1976	1977
	(tonnes)	
Copper mill products, plate, sheet, strip, bars, rolls, pipe, tubes, etc.	58 729	48 925
Brass mill products, plate, sheet, strip, rods, bars, rolls, pipe, tubes, etc.	15 386	19 459
Wire and rod mill products	113 689	95 795
Miscellaneous	1 102	685
Total	188 906	164 864

Source: Statistics Canada.

National stockpiles

The United States strategic stockpile goal for copper remained at 1.1 million tonnes, compared with a present holding of 18 000 tonnes. Purchasing for the stockpile was widely hoped for in 1978, as a means to relieve the depressed condition in the U.S. copper market. These hopes were dashed, however, when Senator Gary Hart, Chairman of the Senate Armed Services Subcommittee on Stockpiles, announced on August 3 that he would defer indefinitely any action on two bills which would have authorized copper purchases.

In Japan, the Ministry of International Trade and Industry, (MITI), was reported to have decided to continue the Japanese nonferrous stockpiling program, which was due to expire in August 1979, for a further three years. The extension plan includes provision for the Japanese smelters to take over existing stocks at cost.

In 1978 Japan's priority was placed upon aluminum purchasing. The 1978 budget contained provision for the purchase of only 15 000 tonnes of copper, as a substantial upsurge in demand for aluminum occurred during the year.

By the end of 1978 the Japanese stockpile of copper was 72 000 tonnes.

Table 8. World mine production of copper, 1977 and 1978

	1977	1978[p]
	(000 tonnes)	
United States	1 364.4	1 351.9
U.S.S.R.	1 100.0	1 100.0
Chile	1 056.2	1 035.5
Canada	759.4	657.5
Zambia	656.0	643.0
Zaire	481.6	420.6
Peru	341.0	349.0
Poland	289.3	290.0
Philippine Republic	272.8	264.0
Australia	219.9	218.5
Papua New Guinea	182.4	198.6
Republic of South Africa	205.4	193.8
Yugoslavia	116.2	112.8
Mexico	89.5	80.0
Japan	81.4	72.4
Indonesia	56.2	58.6
Other communist countries	299.7	303.2
Other non-communist countries	408.9	394.2
Total	7 980.3	7 743.6

Sources: World Bureau of Metal Statistics, April 1979; Statistics Canada.
[p] Preliminary.

International developments

CIPEC. Sales policy, a major concern of CIPEC members, was the focus of the CIPEC ministerial meeting held in Paris in October. After the meeting, it was announced that 1979 sales contracts of CIPEC producers would be based on a monthly average LME price, or based on a daily LME price plus a premium. This should result in a slightly higher average realized price than in the past.

Because of the changes that took place in the U.S. producer pricing system during the year, CIPEC's proposed "combined pricing system" no longer appeared to be viable. This system would depend upon the existence of a stable U.S. price, that changed only at intervals of several weeks' duration.

CIPEC continued to be an active participant in the United States Conference on Trade and Development (UNCTAD) copper talks throughout the year. Sacha Gueronik, long-time Secretary General of CIPEC, retired at the end of 1978.

UNCTAD discussions. The intergovernmental discussions on copper between producing and consuming countries continued within UNCTAD during 1978.

Three full-scale Preparatory Meetings were held. At the first of these in February, it appeared that a breakthrough had occurred when partial consensus was reached in setting up a consultative organization called the Standing Intergovernmental Body on Copper (SICB). Unfortunately, between meetings, a number of countries changed their minds, and the consensus was lost at the two Preparatory Meetings that followed in July and October.

Table 9. World production of refined copper, 1977 and 1978

	1977	1978[p]
	(000 tonnes)	
United States	1 698.2	1 780.0
U.S.S.R.	1 440.0	1 440.0
Japan	933.7	959.1
Chile	676.0	749.1
Zambia	649.0	621.1
Canada	508.8	446.3
Belgium	476.4	420.0
West Germany	440.2	403.4
Poland	306.6	306.0
Australia	184.7	179.0
Peru	182.4	174.3
Yugoslavia	132.0	162.8
Spain	160.0	151.4
Republic of South Africa	145.9	148.1
United Kingdom	120.5	125.6
Zaire	98.7	102.8
Mexico	79.0	83.0
Sweden	61.7	65.0
Other communist countries	479.0	483.0
Other non-communist countries	340.5	328.6
Total	9 113.3	9 128.6

Sources: World Bureau of Metal Statistics, April 1979; Statistics Canada.
[p] Preliminary.

Table 10. World consumption of refined copper, 1977 and 1978

	1977	1978^p
	(000 tonnes)	
United States	1 982.9	2 180.0
U.S.S.R.	1 290.0	1 300.0
Japan	1 127.1	1 244.4
West Germany	779.9	832.1
United Kingdom	512.2	501.6
Italy	326.0	330.0
France	326.1	310.0
Belgium	295.4	290.0
Canada	200.4	228.7
Brazil	213.7	190.0
Poland	188.0	188.0
Spain	135.0	132.2
Sweden	81.1	132.2
Yugoslavia	124.0	130.0
Australia	112.7	116.0
East Germany	115.0	115.0
Other communist countries	571.0	576.0
Other non-communist countries	656.8	689.7
Total	9 037.3	9 485.9

Sources: World Bureau of Metal Statistics, April 1979; Statistics Canada.
^{p} Preliminary.

It was agreed, however, that a Sixth Preparatory Meeting on Copper should be held early in 1979 and that copper market experts should be present. (Many countries are often represented by Geneva-based spokesmen who generally attend the UNCTAD copper meetings unaided by advisers with direct knowledge of the industry.)

The net result of all this activity amounted, unfortunately, to total disappointment and no net progress on market stabilization. In fact, the prospects for progress appeared dimmer at the end of 1978 than in March 1976 when discussions began.

U.S. Section 201 action. In the face of rising imports of refined copper into the United States, a group of 12 copper producers filed a petition under Section 201 of the Trade Act during February 1978. The petition, which was submitted to the U.S. International Trade Commission (ITC), sought "temporary relief from serious injury", and recommended the imposition of import quotas based on imports during the most recent representative period.

The ITC recommended to the President of the United States that an import quota should be applied but did not elaborate on whether, or how, the quota should be allocated. The ITC recommended that it should remain in force for five years, from January 1, 1978, and that not more than 25 per cent of the annual quota should be imported in each quarter of the year.

The President rejected this recommendation. His overriding concern was the inflationary impact that would have resulted from the proposed quota. Other factors were: its negative effect on the competitiveness of U.S. copper fabricating industries; its potentially severe impact on a number of developing countries that are heavily dependent on refined copper exports; and its damaging effects on the multilateral trade negotiations at Geneva. It is also likely that the decline in copper imports into the U.S. after producers changed their pricing methods was also a consideration.

The President's decision was good news for Canada, as the United States is the largest single market for Canadian refined copper. In 1978 exports of refined copper to the U.S. amounted to 64 175 tonnes, with an estimated value of $103 million.

The U.S. Congress had 90 legislative days in which it could decide to override the President's action and impose the ITC's recommended relief action. This 90-day period began on January 15, 1979.

Prices

In the period 1975-77, the U.S. producer price exceeded the average LME price by about U.S. 7 cents per pound. This exceptionally large differential was probably a key factor in the rise of refined copper imports into the United States which culminated in a petition for import relief by the United States producers to the International Trade Commission.

Much of the rising tide of imports of refined copper into the United States was sold by merchants at prices well below producer prices. This fact, together with intense market competition among U.S. producers, led to a crack in the producer price system in May 1978.

At that time Kennecott Copper Corporation, the largest U.S. producer, abandoned its traditional pricing method and informed customers that, effective May 26, its daily price would be the previous day's spot price on the Comex, plus 2$^1/_2$ cents per pound. Kennecott also allowed its customers to price future deliveries at a Comex-quoted future price, up to two months in advance, plus 2$^1/_2$ cents per pound. Cities Service Company followed the Kennecott move in June with a switch to a similar pricing method.

The Anaconda Company switched to Comex-related prices, effective August 1. Its new sales agreements differed only in details from the Kennecott formula. Other North American producers reacted to the changed pricing picture by adhering to the producer price, but making price adjustments much more frequently. These changes have been occurring at intervals of days rather than weeks as was the previous practice. In further efforts to compete, Phelps Dodge Corporation and the Canadian producers – Inco Limited, Texasgulf Inc., Noranda Mines Limited and Hudson Bay Mining and Smelting Co., Limited – offered their customers forward pricing options, permitting consumers, for example, to fix the price for deliveries up to a

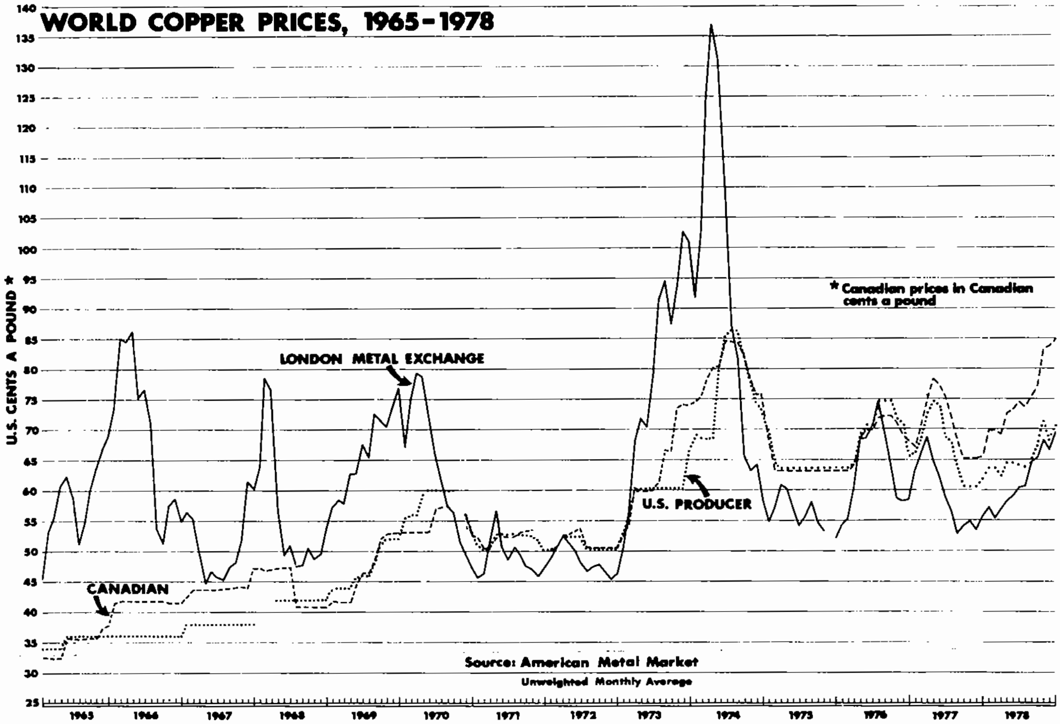


Table 11. World copper production and consumption, 1978[p]

	Mine Production	Refined Production	Refined Consumption
		(000 tonnes)	
United States	1 351.9	1 780.0	2 180.0
U.S.S.R.	1 100.0	1 440.0	1 300.0
Japan	72.4	959.1	1 244.4
CIPEC[1]	3 044.6	1 989.1	312.4
Europe	181.3	1 318.5	2 717.9
Canada	657.5	446.3	228.7
Other communist countries	593.2	789.0	879.0
Other non-communist countries	742.7	406.6	623.5
Total	7 743.6	9 128.6	9 485.9

Sources: World Bureau of Metal Statistics, April 1979; Statistics Canada.
[1] Intergovernmental Council of Copper Exporting Countries includes: Australia, Chile, Indonesia, Mauritania, Papua New Guinea, Peru, Yugoslavia, Zaire and Zambia.
[p] Preliminary.

month in the future at the price in effect on the day of the order.

Another significant change in pricing methods in 1978 was the introduction of premiums by some producers. In October, Zambia informed its United Kingdom customers that it would charge a premium in all future sales contracts. The premium would be £8 per tonne for wirebars and £2 per tonne for cathode over LME wirebar settlement price.

The Zambian pricing move was discussed at the CIPEC ministerial meeting held in Paris later the same month. The ministers agreed that prices of copper on the LME no longer represented the real value of the metal and that individual countries would follow the Zambian move.

In terms of the U.S. and Canadian dollar, copper prices rose steadily throughout 1978. The average LME cash price for wirebars in January was equivalent to U.S. 57 cents per pound. In December the corresponding price was U.S. 69 cents per pound. U.S. producer prices followed a similar course, rising from U.S. 63.625 cents per pound for wirebar and U.S. 63 cents per pound for cathode in January, to U.S. 73.625 and U.S. 73 cents per pound in December.

The corresponding Canadian producer prices for wirebar and cathode were 69.875 and 69.125 cents per pound in January and 86.5 and 87.125 cents per pound at the end of December.

A large part of the increase in North American prices was a reflection of currency exchange rates. This was particularly true in the case of Canadian prices, as the

Canadian dollar declined relative to both sterling and the U.S. dollar.

The pound rose in value from $Cdn. 2.12 in January to $Cdn. 2.37 in mid-December. The U.S. dollar rose from $Cdn. 1.09 to $Cdn. 1.18 in the same period.

Outlook

Provided producers can maintain sufficient discipline, world copper stocks should continue to fall gradually throughout the period 1978-81, except possibly in the second half of 1979 if the Sar Chesmeh mine in Iran and La Caridad mine in Mexico both start producing at that time.

As stocks fall, world prices should continue the firming trend, but the distortions in prices in individual countries arising from shifting currency exchange rates is hard to predict. The Canadian dollar appears to be undervalued and will probably rise. In these circumstances Canadian producers would experience falling prices until a new exchange rate equilibrium is reached – a reversal of the process in effect in 1978.

The UNCTAD copper talks will continue but experience during the past three years does not give grounds for optimism for much tangible progress toward solving the problems of the world copper market.

The price outlook is for a gradual increase at least up to the long-term copper price trend, approximately $U.S. 1.10 per pound in 1978 dollars.

The potential remains for further supply disruptions from African countries. In such an event a rapid upward move in prices could result, as consumers move to secure supplies and build inventories to higher-than-present levels.

Tariffs

Canada

Item No.		GSP[1]	British Preferential	GATT[2]	General
32900-1	Copper in ores and concentrates	free	free	free	free
33503-1	Copper oxides	free	free	15%	25%
34800-1	Copper scrap, matte and blister and copper in pigs, blocks or ingots; cathode plates of electrolytic copper for melting, per pound	free	free	free	1.5¢
34820-1	Copper in bars or rods, for manufacture of trolley, telegraph, telephone wires, electric wires and cables	free	free	5%	10%
34835-1	Electrolytic copper powder (expires June 30, 1979)	free	free	free	10%
34845-1	Electrolytic copper wire bars, per pound (expires June 30, 1979)	free	free	free	1.5¢
35800-1	Anodes of copper	free	free	free	10%

United States

TSUS No.		GSP	GATT
		(¢/pound)	
602.30	Copper ores and concentrates, on Cu content	free	0.8
612.06	Unwrought copper, on Cu content	free	0.8
612.10	Copper waste and scrap, on 99.6% of Cu content	free	0.8

Japan

BTN No.		GSP	GATT
26.01	Copper ores and concentrates	free	free
74.01	(1) Matte, cement copper and native copper	free	free
	(2) Unwrought copper, other than native copper		
	i) containing not more than 99.8% by weight of copper and used for smelting or refining	free	8.5%
	ii) other	free	24 yen/kg
	(3) Waste and scrap	free	2.5%

European Economic Community

BTN No.		GSP	GATT
26.01	Copper ores and concentrates	free	free
74.01	Copper matte, unwrought copper, copper waste and scrap	free	free

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978) ITC Publication 843; Official Journal of the European Communities, December 1, 1978; Customs Tariff Schedules of Japan, 1978.

[1]GSP Generalized System of Preferences extended to all, or most, developing countries; some GSP rates are subject to quotas or withdrawal. [2]GATT General Agreement on Tariffs and Trade.

Crude Oil

R.L. THOMAS

There was little improvement overall in proved oil reserves noted in the Canadian petroleum industry in 1978, with production continuing to exceed new additions to reserves. Production of crude oil and natural gas liquids was approximately 1 per cent lower than in 1977. Consumption of domestic crude oil increased by almost 3 per cent. Additional domestic crude supplies made available to eastern Canada met this increase.

Revenues from the sales of crude oil, condensates and natural gas liquids increased by $973 million to $6 618 million. The 17 per cent growth rate reflects substantial increases in the wellhead price of crude oil, from an average of $64.47 per cubic metre ($m^3$) in 1977 to $77.05/$m^3$ in 1978. Crude oil and condensate accounted for $5 660 million of the total, while the sales of natural gas liquids amounted to $957 million.

Expenditures by the industry for exploration and development for both oil and gas, including royalty payments, increased over 1977 by $1 315 million to an estimated $8 173 million. Three of the major items in this total were: royalties, 38 per cent; exploration, 17 per cent; and land costs, 12 per cent. Most of the land cost can be attributed to the "bidding" system used towards purchasing the rights to explore for and develop oil and natural gas resources.

Another banner year was registered by the Canadian drilling industry, with a record 7 612 wells being completed for an aggregate depth of 7.6 million metres (m). Much of the activity occurred in Alberta, where a total of 6 056 wells were completed for a depth of 6.0 million metres. The number of exploratory wells drilled in Canada exceeded those drilled in 1977 by 50 per cent, with the total metres drilled surpassing last year's figure by 27 per cent. There was a close matching of exploratory wells and development wells. The success ratio of all well completions remained very much the same as that of last year, with 1978 overall being 76.5 per cent successful compared with 76.3 per cent in 1977. The increased drilling activity in western Canada could be attributed to improved drilling techniques, new plays identified in older fields by new seismic technology and discoveries in the West Pembina and Elmworth areas.

Crude oil refining capacity in Canada declined only slightly in 1978, mainly because of a decrease in demand. While some plants came on stream others had to be shut down; for example, Texaco Canada Inc.'s Nanticoke refinery in Ontario, with a capacity of 15 000 cubic metres per day (m^3/d), came into operation late in 1978; however, their Port Credit refinery, which had a capacity of 8 000 m^3/d, was phased out and transformed into a storage facility. There is not expected to be any further expansion to facilities in the near future until demand increases. Only those plants that had been started will be completed, and some older plants may be forced to shutdown.

In oil sands development, construction of the Syncrude Canada Ltd. plant in the Athabasca area was completed and in production in mid-1978, but due to a breakdown on one of the cokers it was not operating at full capacity. The Great Canadian Oil Sands Limited plant, owned by Sun Oil Company, was operating at full capacity in 1978 and had applied to the Alberta Energy Resources Conservation Board to allow for a further expansion of 2 000 m^3/d, at a cost of $158 million. The Alsands Project Group has applied for permission to construct a new facility with an ultimate capacity of 22 258 m^3/d, at a cost of $5 100 million. If everything goes according to schedule, production will commence in 1988 at a rate of 9 500 m^3/d.

Outlook

The outlook for the Canadian oil and gas industry again improved, but only slightly in 1978 as additions to proven reserves did not rise to expectations even though exploration continued at a record pace. West Pembina, Elmworth and the Beaufort Sea were the areas recording major activity by the petroleum industry, with wells being drilled to record depths. In the West Pembina region, mainly an oil discovery, more than 60 successful wells have been drilled to date, many of them producing more than the discovery well. To date, that area had been assumed to contain no more than 80 million m^3 of oil.

Canadian Hunter Exploration Ltd., an operator in the Elmworth area of the Deep Basin on the Alberta-British Columbia border, has been very successful with its drilling program and plans to continue proving up gas reserves of that area. It is believed that Elmworth has the potential to be placed among one of the largest "tight" gas fields in North America. This area also recorded the largest "farm-in" in Canada's history – $179 million by Esso Resources Canada

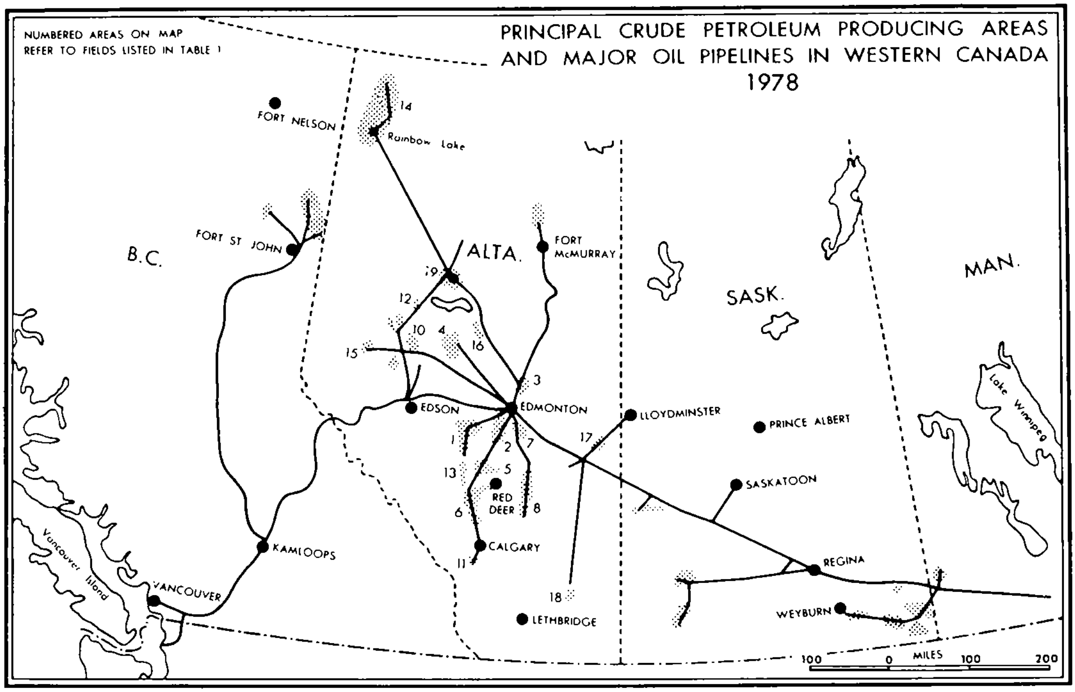


Table 1. Production of crude oil and condensate by province and field, 1977 and 1978
(Numbers in brackets following the names of the producing areas in this table indicate their location on the map above).

	1977		1978^{p}	
	(m^3)	(m^3/day)	(m^3)	(m^3/day)
Alberta				
Swan Hills (4)	5 540 257	15 179	4 801 022	13 153
Pembina (1)	4 732 346	12 965	4 675 304	12 809
Redwater (3)	4 203 083	11 515	4 297 166	11 773
Rainbow (14)	4 327 568	11 856	4 205 773	11 523
Judy Creek	3 284 008	8 997	3 252 250	8 910
Swan Hills South (4)	3 212 604	8 802	3 256 614	8 922
Bonnie Glen (2)	2 636 321	7 223	2 659 468	7 286
Mitsue (16)	2 310 181	6 329	2 294 791	6 287
Nipisi (19)	2 047 724	5 610	2 120 612	5 810
Wizard Lake (2)	2 017 035	5 526	2 033 724	5 572
Golden Spike (2)	1 179 055	3 230	1 106 972	3 033
Fenn Big Valley (8)	1 275 995	3 496	1 353 955	3 709
Virginia Hills	965 626	2 646	816 089	2 236
Carson Creek North (4)	1 087 004	2 978	1 086 803	2 978
Leduc-Woodbend (2)	797 102	2 184	680 278	1 864
Sturgeon Lake South	896 010	2 455	854 593	2 341
Willesden Green (13)	785 068	2 151	808 866	2 216
Kaybob (10)	615 776	1 687	638 569	1 750
Westerose (2)	635 086	1 740	646 999	1 773
Provost	586 164	1 606	528 260	1 447
Countess	744 351	2 039	709 569	1 944
Hartmattan East (6)	530 087	1 452	498 659	1 366
Innisfail (6)	434 300	1 190	449 020	1 230

Table 1. (cont'd)

	1977		1978ᵖ	
	(m^3)	(m^3/day)	(m^3)	(m^3/day)
Alberta (cont'd)				
Zama	452 670	1 240	439 210	1 203
Rainbow South (14)	637 460	1 746	575 796	1 578
Kaybob South (10)	575 760	1 577	589 723	1 616
Joarcam (7)	335 882	920	313 374	859
Medicine River (13)	446 688	1 224	456 288	1 250
Snipe Lake	429 165	1 176	353 382	968
Hartmattan Elkton (6)	442 834	1 213	392 857	1 076
Simonette (15)	342 159	937	327 205	896
Bellshill Lake	339 683	931	308 475	845
Wainwright (17)	443 248	1 214	448 694	1 229
Acheson (2)	603 633	1 654	605 220	1 658
Clive	409 819	1 123	428 123	1 173
Goose River	299 441	820	342 648	939
Bantry (18)	297 096	814	283 225	776
Red Earth	295 961	811	269 705	739
Virgo (14)	214 659	588	203 442	557
Grand Forks	718 814	1 969	874 096	2 395
Gilby (5)	268 533	736	270 270	740
Lloydminster	275 457	755	296 342	812
Ferrier	268 796	736	275 341	754
Sundre	189 053	518	186 739	512
Twining	241 506	662	229 151	628
Stettler	167 362	459	179 158	491
Joffre (5)	238 726	654	232 109	636
Boundary Lake South	202 915	556	204 813	561
Utikuma Lake	223 856	613	321 217	880
Meekwap	167 293	458	169 476	464
St. Albert Big Lake	148 834	408	151 123	414
Turner Valley	190 647	522	184 398	505
Cessford	189 218	518	177 898	487
Sylvan Lake	187 415	513	181 315	497
West Drumheller	148 274	406	141 141	387
Garrington	162 954	444	136 678	374
Other fields and pools	5 195 179	14 233	7 823 012	21 433
Total	60 592 767	166 368	62 147 000	170 266
Total value ($)	3 897 325 000		4 784 520 000	
Saskatchewan				
Total	9 766 609	26 758	9 646 000	26 427
Total value ($)	580 418 000		688 300 000	
British Columbia				
Total	2 199 921	6 026	1 872 000	5 129
Total value ($)	134 696 000		131 086 000	
Manitoba				
Total	630 466	1 728	593 000	1 625
Total value ($)	40 433 000		43 632 000	
Ontario				
Total	98 047	269	94 000	258
Total value ($)	6 627 000		7 246 000	

Table 1. (cont'd)

	1977		1978[p]	
	(m^3)	(m^3/day)	(m^3)	(m^3/day)
Northwest Territories				
Total	156 209	428	149 000	408
Total value ($)	4 295 000		5 610 000	
New Brunswick				
Total	795	2	1 000	3
Total value ($)	40 000		46 000	
Canada				
Total[1]	73 446 415	201 223	74 502 000	204 116
Total value ($)	4 663 834 000		5 660 440 000	

Sources: Provincial government reports; Statistics Canada.
[1] Does not include synthetic crude oil production.
[p] Preliminary.

Limited. Much of Esso's additional funding will be directed towards development of Canadian Hunter's properties.

In the Beaufort Sea area off the Mackenzie Delta, Dome Petroleum Limited had been very active in its drilling and seismic program. It had completed seven wells in 1978 and intends to continue its operations in the 1979 drilling season by starting four new holes.

In 1979, the production of crude oil is expected to surpass that of 1978, because all fields are operating at capacity. With exports of crude slowly being phased out and conservation measures being successful, it is Canada's intention and policy to minimize reliance on imported crude. The demand for imported crude in 1978 declined by almost 10 per cent from the previous year, and the overall domestic oil demand declined by 3 per cent.

The federal government's policy of self-sufficiency is directed towards minimizing the risks to the nation inherent in over-dependency on imported oil. If Canada is to attain this goal, then development of indigenous energy resources in the frontier areas and the heavy oil belt of eastern Alberta and western Saskatchewan must be accelerated. To date, exploratory success for oil in the frontier areas has been below expectations, but substantial amounts of natural gas have been discovered. The National Energy Board, in its recent report "Canadian Natural Gas-Supply and Requirements, February 1979", estimated natural gas reserves in the Arctic frontier to be 411 billion m^3.

At the same time, development of Alberta's oil sands and heavy oil has not proceeded at the pace necessary for major impact on predicted future domestic oil shortages. However, prospects for development in these areas have received a boost, with two heavy oil upgrading facilities being considered, one by Esso Resources' Cold Lake plant, and the other by Husky Oil Ltd. and Pacific Petroleums Ltd. A third mining plant, Alsands Project Group, is in the application stage.

Reserves

According to the Canadian Petroleum Association (CPA) Canada's proved liquid hydrocarbon reserves, which include conventional crude oil and natural gas liquids, amounted to 1.319 billion m^3 at the end of 1978. This is comprised of 1.09 billion m^3 of crude oil and 0.229 billion m^3 of natural gas liquids, after an annual production rate of 80.7 million m^3. Natural gas liquids reserves increased by only 2.1 million m^3, after an annual production rate of 13.1 million m^3. At the 1978 annual production level of 80.7 million m^3, the life index (reserve-to-production ratio for conventional crude oil and natural gas liquids) is 16.3 years, a life-index increase over 1977 of three years.

In Alberta, the gross additions to reserves for crude oil were 29.7 million m^3, yet the net change was -25.5 million m^3, with remaining reserves being 932 million m^3. The net increase in reserves of natural gas liquids was 2.4 million m^3, with remaining reserves being 215 million m^3.

The combination of crude oil and natural gas liquids gave Alberta total recoverable reserves of liquid hydrocarbon of 1 146 million m^3 at year-end. Alberta alone accounted for 86.3 per cent of Canada's proved reserves. In Saskatchewan, reserves of liquid hydrocarbons declined by 2 per cent to 118.8 million m^3, with crude oil accounting for 98.6 per cent of reserves. The provincial total was 9 per cent of Canada's total reserves.

Table 2. Production of natural gas liquids by province, 1977 and 1978

	1977		1978[p]	
	(000 m³)	(m³/day)	(000 m³)	(m³/day)
Alberta				
Propane	5 337	14 622	5 040	13 808
Butane	3 500	9 589	3 211	8 797
Pentanes plus	7 343	20 118	6 560	17 973
Condensate	122	334	143	392
Total	16 302	44 663	14 954	40 970
Saskatchewan				
Propane	80	219	79	216
Butane	38	104	38	104
Pentanes plus	22	60	25	68
Condensate	22	60	19	52
Total	162	444	161	441
British Columbia				
Propane	91	249	84	230
Butane	111	304	105	288
Pentanes plus	191	523	154	422
Condensate	24	66	24	66
Total	417	1 142	367	1 005
Canada				
Propane	5 508	15 090	5 203	14 255
Butane	3 649	9 997	3 354	9 189
Pentanes plus	7 556	20 701	6 739	18 463
Condensate	168	460	186	510
Total	16 881	46 249	15 482	42 416
Returned to formation	19	52	24	66
Total net production	16 862	46 197	15 458	42 350

Source: Statistics Canada.
[p] Preliminary.

Natural gas liquids from the recently discovered, but as yet unproduced, fields in the Mackenzie Delta and Arctic islands are included in the estimates; however, oil from the frontier regions is not, because discovered reserves of crude oil are relatively small and currently beyond economic reach.

Production

Average production of crude oil, including synthetic and natural gas liquids, totalled 251 082 m³/d, a decline of approximately 1.8 per cent or 4 578 m³/d less than in 1977. Crude oil production, including condensates, increased from 201 223 m³/d in 1977 to 204 116 m³/d in 1978, an increase of 1 per cent. Natural gas liquids production decreased slightly to 42 350 m³/d, consisting of 18 463 m³/d of pentanes plus, 14 255 m³/d of propane, 9 189 m³/d of butane and 510 m³/d of condensate.Alberta's crude oil and liquids production of 211 236 m³/d increased by only 205 m³/d and accounted for 84 per cent of total Canadian output. Saskatchewan's liquid hydrocarbon production, at 26 816 m³/d, was down from 27 142 m³/d the previous year and accounted for 11 per cent of the Canadian total.

In British Columbia, production of crude oil and liquids was down by 15 per cent to 6 068 m³/d, a decline of 1 076 m³/d, and accounted for 2 per cent of Canada's production. These three provinces – Alberta, Saskatchewan and British Columbia – in total accounted for 97 per cent of the national production. In western Canada, including the

Table 3. Value of natural gas liquids, 1977 and 1978

	1977	1978ᵖ
	($000)	
Alberta	948 412	928 588
Saskatchewan	8 758	8 129
British Columbia	23 801	20 451
Total	980 971	957 168
Volume (000 m^3)	16 881	14 824

Source: Statistics Canada.
ᵖ Preliminary.

Northwest Territories and Arctic islands, the number of producing oil wells compared with the number of wells capable of producing was 76 per cent, or 20 717 at year-end 1978 as shown in the accompanying table.

In the Athabasca oil sands area, synthetic crude production was 4 616 m^3/d from both Great Canadian Oil Sands Limited and Syncrude Canada Ltd. This amount was below capacity output due to mechanical breakdowns in the two plants. Rapid development of Canada's oil sands resources is a prime concern of Canada's overall energy strategy. To this end, the provincial and federal governments provide greater fiscal incentives for oil sand development.

Exploration and development

Alberta. The level of exploration activity attained in 1976, surpassed in 1977, was again surpassed in 1978, as the number of wells drilled increased by almost 20 per cent. Total number of wells drilled in all categories amounted to 6 056, for an aggregate depth of 6 000 000 m. This is 800 000 m more than was drilled in 1977. Most of the increase occurred in the exploratory category, which increased in metres drilled by 21 per cent.

This year again, the centre of attention was the West Pembina oil play. With over 60 successful wells drilled to date, many of them oil, this location has been the most attractive in terms of discoveries. The opportunities in this area were sufficient to encourage one company to pay $26 000 per acre at a mid-year land sale. To date, estimates of recoverable oil reserves in the West Pembina field have been revised from 54 million m^3 to as much as 190 million m^3. The National Energy Board, through its own evaluations and those of the industry, has estimated the reserves to be in the order of 80 million m^3.

In oil sands development, Syncrude Canada Ltd. had completed its Athabasca oil sands plant late in 1978 but, due to mechanical failure, production capacity was not reached. Once initial problems have been rectified, the plant should produce around 16 000 m^3/d of synthetic crude oil. Great Canadian Oil Sands will be producing 10 000 m^3/d from its operation once an allowed expansion is completed. An application by the Alsands Project Group, headed by Shell Canada Resources Limited, is currently being considered by the Province of Alberta. The new plant is expected to produce 22 000 m^3/d, thus bringing total synthetic oil output in the near future to approximately 48 000 m^3/d or 17.5 million m^3/d per year.

In the development of heavy oils, the next major project scheduled to come on stream is by Esso Resources in the Cold Lake area. The design capacity of this upgrading facility is expected to be 23 000 m^3/d. The project, expected to be completed by the mid-1980s, is estimated to cost over $4 billion, with more than $40 million having been spent on research. In field tests, Esso produced 800 m^3/d, with the oil being trucked to the Strathcona refinery near Edmonton.

Table 4. Canada, crude oil production, trade and refinery receipts, 1966-78

				Refinery Receipts[2]		
	Production	Imports[1]	Exports[1]	Domestic	Imports	Total
			(m^3)			
1966	50 962 233	23 224 372	19 665 353	35 008 467	24 206 931	60 215 398
1967	55 851 019	27 152 643	23 902 877	35 703 749	25 938 587	61 642 336
1968	60 319 190	28 258 178	26 628 460	37 549 362	28 187 357	65 736 719
1969	65 342 179	30 704 398	31 374 672	38 480 450	30 283 755	68 764 205
1970	73 321 772	33 011 020	38 299 028	41 172 360	33 123 391	74 295 751
1971	78 339 251	38 947 402	43 049 070	41 851 685	38 828 645	80 680 330
1972	89 347 195	44 781 024	54 254 874	43 441 393	45 908 256	89 349 649
1973	104 272 315	52 056 975	66 784 203	47 715 892	49 491 498	97 207 390
1974	97 741 735	46 290 090	53 015 317	55 249 631	47 582 182	102 831 813
1975	82 802 176	47 415 986	41 727 024	50 963 152	47 776 787	98 739 939
1976	76 075 000	43 929 995	29 029 963	56 455 301	41 871 323	98 326 624
1977	76 447 000	39 592 771	19 783 048	65 420 176	38 818 721	104 238 897
1978ᵖ	76 001 000	36 820 918	15 578 420	68 054 782	35 691 219	103 746 001

Source: Statistics Canada.
[1] Trade of Canada (SC) data. [2] Includes condensate and pentanes plus.
ᵖ Preliminary.

Saskatchewan and Manitoba. The upward trend in exploration activity continued in 1978 in Saskatchewan, as drilling increased by 85 per cent. The total number of wells drilled in all categories amounted to 981, for an aggregate depth of 719 611 m. This compares with 530 wells and 434 686 m the previous year.

In Manitoba, the number of wells and metreage drilled increased over that of 1977, with 16 wells in all categories and a total metreage of 13 425 m. In the previous year there were 11 wells with an aggregate depth of 9 359 m, thus this year's upswing in activity means an increase in the number of wells of 45 per cent and a metreage increase of 43 per cent.

Table 5. Canada, year-end reserves of crude oil, 1977 and 1978

	1978	Per cent of Total 1977	1978	Net Change 1978 over 1977
	($000\ m^3$)			($000\ m^3$)
Alberta	931 603	86.3	85.5	− 25 549
Saskatchewan	117 214	10.3	10.8	− 2 225
British Columbia	22 812	2.1	2.1	− 1 539
Northwest Territories	10 598	0.6	1.0	− 163
Manitoba	6 330	0.5	0.5	− 144
Eastern Canada	1 501	0.2	0.1	− 601
Total	1 090 058	100.0	100.0	− 30 221

Source: Canadian Petroleum Association.

In the area of heavy oils development in Saskatchewan, the federal government and the Government of Saskatchewan, under a $16.2 million cost-shared program called the Canada-Saskatchewan Heavy Oil Agreement, had approved three proposals designed to develop new techniques in heavy oil production. The projects currently underway are: Eyehill, with Murphy Oil Company Ltd., Canadian Reserve Oil and Gas Ltd. and Canada-Cities Service Ltd.; Meota, with Texasgulf Inc.; and Celtic, with Total Petroleums (North America) Ltd., Saskatchewan Oil and Gas Corporation and Mobil Oil Canada, Ltd. Mobil Oil Canada, Ltd. will act as the operator of the field.

British Columbia. The trend in activity that started last year in British Columbia continued through 1978 with drilling increasing by 27 per cent to 386 wells in all categories and a total depth drilled of 535 841 m, an increase in depth of 9 per cent. Much of the increase occurred in exploration for natural gas. A slight increase in natural gas fields development drilling also occurred.

Table 6. Canada, liquid hydrocarbon reserves at end of 1978

	Natural Gas Liquids	Crude Oil Plus Natural Gas Liquids	Per Cent of Total
	($000\ m^3$)	($000\ m^3$)	
Alberta	214 676	1 146 279	86.9
Saskatchewan	1 620	118 834	9.0
British Columbia	4 985	27 797	2.1
Other Areas	8 381	26 810	2.0
Total	229 662	1 319 720	100.0

Source: Canadian Petroleum Association.

Yukon Territory, mainland Northwest Territories and Arctic islands. In the Territories, there was a sharp decline in exploration activity as the total number of wells completed declined from 26, with a total depth of 80 766 m in 1977, to 17, with a total depth of 51 795 m in 1978, a decrease in activity of 35 per cent.

In the southern Territories, a number of small natural gas discoveries have been made but they are not connected to pipelines. The only significant oil discovery in the Territories to date has been in Esso's Norman Wells field, which has been on production for more than half a century. Recently, through further development drilling on the Mackenzie River, Esso has announced reserves of 80 million m^3 for the field.

Offshore in the Beaufort Sea, off the Mackenzie Delta, Dome has been very active in their drilling program. Some of the wells drilled in 1978 will be reentered for further testing in 1979, including Kopanoar M-13 and Ukalerk 2C-50. Other wells started in 1978, but not completed to projected depth, were the Natsek E-56, Tarsiut A-25 and Kaglulik M-64. Dome, through its subsidiary Canadian Marine Drilling Ltd. (Canmar), will be continuing its extensive programs in the 1979 drilling season.

No major oil finds have been made in the Arctic islands to date. A small oil discovery was made at Bent Horn. Since the early 1970s there have been large natural gas discoveries in Drake and Hecla fields on Melville Island and in five fields on and near Ellef Ringnes Island. If connected by a pipeline the fields could deliver large volumes of gas to southern markets. There have been two delivery methods discussed: the Polar Gas pipeline system (revised to include the Mackenzie Delta) and an LNG pilot project (transportation by ice-breaker tankers) headed by Petro-Canada.

Table 7. Canada, wells completed and metres drilled, 1960 and 1976-78

	1960		1976		1977		1978	
	(no.)	(m)	(no.)	(m)	(no.)	(m)	(no.)	(m)
Western Canada								
Westcoast offshore								
New field wildcats	—	—	—	—	—	—	—	—
British Columbia								
New field wildcats	60	111 501	6	16 305	12	20 406	22	59 413
Other exploratory	11	16 992	77	131 662	118	207 016	179	297 232
Development	72	101 115	90	131 527	175	262 902	185	279 196
Total	143	229 608	173	279 494	305	490 324	386	535 841
Alberta								
New field wildcats	338	663 641	336	475 244	321	470 830	230	352 245
Other exploratory	223	356 945	1 235	1 489 092	1 292	1 844 590	2 154	2 439 698
Development	1 131	2 171 961	3 388	2 832 655	3 465	2 889 527	3 672	3 215 794
Total	1 692	3 162 547	4 959	4 796 991	5 078	5 204 947	6 056	6 007 737
Saskatchewan								
New field wildcats	113	142 801	51	56 876	62	57 331	144	117 635
Other exploratory	28	30 237	89	73 650	200	143 173	319	224 059
Development	461	547 411	111	95 771	268	234 182	518	377 917
Total	602	720 449	251	226 297	530	434 686	981	719 611
Manitoba								
New field wildcats	10	9 298	10	7 400	1	762	4	4 360
Other exploratory	3	1 942	3	3 011	9	7 987	3	2 699
Development	54	33 550	1	750	1	610	9	6 366
Total	67	44 790	14	11 161	11	9 359	16	13 425
Yukon and Northwest Territories and Arctic islands								
New field wildcats	32	32 299	16	54 222	18	57 312	10	32 124
Other exploratory	—	—	2	3 885	—	—	—	—
Development	—	—	9	25 700	8	23 454	7	19 671
Total	32	32 299	27	83 807	26	80 766	17	51 795
Total western Canada								
New field wildcats	553	929 541	419	610 047	414	606 641	410	565 777
Other exploratory	265	406 116	1 406	1 701 300	1 619	2 202 766	2 655	2 963 688
Development	1 718	2 854 036	3 599	3 086 403	3 917	3 410 675	4 391	3 898 944
Total	2 536	4 189 693	5 424	5 397 750	5 950	6 220 082	7 456	7 428 409

Table 7. (cont'd)

	1960		1976		1977		1978	
	(no.)	(m)	(no.)	(m)	(no.)	(m)	(no.)	(m)
Eastern Canada								
Eastcoast offshore								
New field wildcats	—	—	10	22 793	2	7 742	5	19 689
Other exploratory	—	—	—	—	—	—	2	6 553
Total	—	—	10	22 793	2	7 742	7	26 242
Hudson's Bay offshore								
New field wildcats	—	—	—	—	—	—	—	—
Other exploratory	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—
Ontario								
New field wildcats	39	20 846	40	26 459	46	29 357	40	26 741
Other exploratory	55	33 479	15	8 862	8	4 683	26	34 561
Development	213	69 552	89	37 951	111	55 408	77	47 617
Total	307	123 877	144	73 272	165	89 448	143	108 919
Quebec								
New field wildcats	5	1 307	4	8 543	6	13 233	5	14 743
Other exploratory	—	—	—	—	—	—	1	3 350
Development	1	73	—	—	—	—	—	—
Total	6	1 380	4	8 543	6	13 233	6	18 093
Atlantic provinces								
New field wildcats	3	6 969	2	3 271	—	—	—	—
Other exploratory	—	—	—	—	—	—	—	—
Development	—	—	—	—	—	—	—	—
Total	3	6 969	2	3 271	—	—	—	—
Total eastern Canada								
New field wildcats	41	29 122	56	61 066	54	50 332	50	61 173
Other exploratory	55	33 479	15	8 862	8	4 683	29	44 464
Development	214	69 625	89	37 951	111	55 408	77	47 617
Total	316	132 226	160	107 879	173	110 423	156	153 254
Total Canada								
New field wildcats	600	958 662	475	671 113	468	656 973	460	626 950
Other exploratory	320	439 595	1 421	1 710 163	1 627	2 207 449	2 684	3 008 152
Development	1 932	2 923 662	3 688	3 124 355	4 028	3 466 083	4 468	3 946 561
Total	2 852	4 321 919	5 584	5 505 631	6 123	6 330 505	7 612	7 581 663

Source: Canadian Petroleum Association.

Table 8. Wells drilled by province, 1977 and 1978

	Oil		Gas		Dry[1]		Total	
	1977	1978	1977	1978	1977	1978	1977	1978
Western Canada								
Alberta	705	946	2 953	3 090	1 420	1 483	5 078	5 519
Saskatchewan	359	766	83	40	88	168	530	974
British Columbia	38	72	148	186	199	128	305	386
Manitoba	9	10	—	—	2	6	11	16
Yukon and Northwest Territories and Arctic islands	—	1	8	3	18	13	26	17
Westcoast offshore	—	—	—	—	—	—	—	—
Sub-total	1 111	1 795	3 192	3 319	1 647	1 798	5 950	6 912
Eastern Canada								
Ontario	9	11	93	70	63	62	165	143
Quebec	—	—	—	—	6	6	6	6
Atlantic provinces	—	—	—	—	—	—	—	—
Eastcoast offshore	—	—	—	1	2	6	2	7
Hudson's Bay offshore	—	—	—	—	—	—	—	—
Sub-total	9	11	93	71	71	74	173	156
Total Canada	1 120	1 806	3 285	3 390	1 718	1 872	6 123	7 068

Source: Canadian Petroleum Association.
[1] Includes suspended and abandoned wells, but excludes miscellaneous wells and service wells.
— Nil.

Eastern Canada. The number of wells drilled in Ontario in 1978 declined by 15 per cent to 143, but the metreage increased by 20 000 m to a total of 108 919 m. The province recorded 11 oil wells and 70 gas wells, but further evaluations must be done to determine if the wells are economic. Much of the activity was carried out for the exploration and development of natural gas.

In Quebec, the six exploratory wells drilled, for a total depth of 18 093 m, were dry holes. The number of wells drilled equalled that of last year, but total metreage increased to 18 093 m from 13 233 m.

Offshore of Canada's East Coast, a total of seven exploratory wells were completed to an aggregate depth of 26 242 m, an increase in drilling activity of five wells. One of the wells had indications of natural gas. More recently, Petro-Canada made a natural gas discovery of approximately 28 billion m^3 from its Venture D-23 well near Sable Island, bringing the total reserves found in the area close to 84 billion m^3 of natural gas, almost enough to permit commercial development to proceed.

Table 9. Oil wells in western Canada at end of 1977 and 1978

	Producing Wells		Wells Capable of Production	
	1977	1978	1977	1978
Alberta	11 592	12 151	16 224	16 871
Saskatchewan	6 777	7 274	8 063	8 731
Manitoba	701	703	804	808
British Columbia	527	554	733	798
Northwest Territories and Arctic islands	35	35	59	59
Total	19 632	20 717	25 883	27 267

Sources: Provincial and federal government reports.

Transportation

The construction of new crude oil and products lines was small in 1978, except for the completion of gathering lines to tie-in oil and gas wells for production, and the extension of production lines from processing plants.

The Alberta Gas Ethylene Company Ltd. built a line, from Joffre to South Edmonton, late in the year to transport ethylene. The length of the line was 141 km with a diameter of 30 centimetres (cm).

Another line completed late in the year was one by Dome Petroleum Limited of 226 km in length and 15 cm in diameter. The line will be used to transport ethane from the Waterton gas plant to the Cochrane straddle facility.

Gulf Canada Limited completed a 56 km, 8-cm diameter lateral gas liquids transmission line from the

Table 10. Length of pipelines in Canada for transporting crude oil, natural gas liquids and products, 1961-78

Year-end	Kilometres	Year-end	Kilometres[1]
1961	15 376	1970	27 459
1962	16 153	1971	28 706
1963	17 070	1972	29 467
1964	18 900	1973	30 146
1965	19 819	1974	31 262
1966	20 913	1975	31 831
1967	22 780	1976	32 863
1968	23 870	1977	33 463
1969	27 480	1978	34 221

Source: Statistics Canada.
[1] Includes producer gathering lines from 1969 to 1978.

Morrin gas-processing plant to Fenn field station to carry propane, butanes and condensates.

There are currently two pipeline proposals awaiting decisions concerning Alaska oil being transported through Canada. Trans Mountain Pipe Line Company Ltd. proposes to install a crude oil line from Low Point, Washington to Edmonton, Alberta, with a capacity of 79 000 m^3/d, at a cost of $600 million. Foothills Oil Pipeline Ltd. proposes to construct an oil pipeline from a tanker terminal at Skagway, Alaska, to Keg River, Alberta, to transport 84 000 m^3/d of offshore and Alaska crude oil. An alternative all-land route for only Alaska oil from Delta junction to Edmonton is also proposed.

The net increase in length of new pipelines in Canada amounted to 758 km or 2 per cent over 1977, bringing the length of pipelines in 1978 for transporting crude oil, natural gas liquids and products to 34 221 km.

Petroleum refineries

Canadian refinery processing decreased slightly, to 384 271 m^3/d in 1978. Much of this decrease occurred in Quebec and the Maritimes because crude oil supply and maximum-rated capacity have not been maintained. Currently, the only construction projects being undertaken are at those refineries that require modernization. While there were new plants added, for example, Texaco's Nanticoke, Ontario, refinery, others had to be shutdown, including Texaco's Port Credit operation, which has become a storage plant. The refinery at Come-by-Chance, Newfoundland, with a 16 000 m^3/d capacity, remains idle.

As indicated in the accompanying table, there have been a number of changes in the regional crude oil refining capacities. In the Atlantic provinces, the refining capacity has been reduced from 87 267 m^3/d in 1977 to 71 051 m^3/d in 1978, a decrease of 16 216 m^3/d, approximately the capacity of the refinery at Come-by-Chance in Newfoundland. In Quebec, with 25.5 per cent of Canada's refining capacity, a decrease in capacity occurred at Imperial's Montreal refinery as a result of modernization. The provincial total decreased by 4 600 m^3/d to 98 047 m^3/d.

Ontario, which accounts for 34 per cent of Canada's total refining capacity, showed a substantial increase of 16 per cent, from 112 578 m^3/d the previous year to 130 735 m^3/d. This increase was due to the expansions of BP Canada Limited's Oakville plant and Imperial Oil's Sarnia plant. Another major factor was Texaco Canada's Nanticoke plant, with a 7 000 m^3/d net capacity increase over the now inactive Port Credit facility.

In the Prairies, the only major program completed in 1978 was the expansion of the refinery operated by

Table 11. Deliveries of crude oil and propane by company and destination, 1977 and 1978

Company and Destination	1977	1978
	(million m^3)	
Interprovincial Pipe Line Limited		
Western Canada	7.2	7.1
United States	26.1	23.7
Montréal, Quebec	13.5	16.0
Ontario	34.3	35.1
Total	81.1	81.9
Trans Mountain Pipe Line Company Ltd.		
British Columbia	7.2	7.2
State of Washington	1.5	1.0
Westridge terminal	0.5	0.4
Total	9.2	8.6

Sources: Company annual reports

Table 12. Crude oil refining capacity by regions, 1977 and 1978

	1977		1978	
	(m^3/day)	(%)	(m^3/day)	(%)
Atlantic provinces	87 267	22.8	71 051	18.5
Quebec	102 674	26.7	98 047	25.5
Ontario	112 578	29.3	130 735	34.0
Prairies and Northwest Territories	55 645	14.4	57 649	15.0
British Columbia	26 233	6.8	26 789	7.0
Total	384 398	100.0	384 271	100.0

Sources: Provincial and federal government reports.

Table 13. Canada, crude oil received at refineries, 1978 and 1977

Location of Refineries		Country of Origin							
		Canada	Middle East	Trinidad	Venezuela	Africa	Colombia	Other	Total Received
		(m³)							
Atlantic provinces	1978	—	9 935 762	—	5 657 672	—	—	313 550	15 906 984
	1977	—	11 193 376	146 564	5 478 329	—	—	55 486	16 873 755
Quebec	1978	14 604 352	5 622 725	—	6 454 351	—	—	3 717 353	30 398 781
	1977	13 316 974	6 614 149	52 553	9 505 611	263 872	—	2 479 077	32 232 236
Ontario	1978	27 544 186	—	—	—	—	—	3 801 979	31 346 165
	1977	26 201 814	—	—	—	—	—	3 029 704	29 231 518
Prairies	1978	17 067 206	—	—	—	—	—	205 122	17 272 328
	1977	16 981 210	—	—	—	—	—	—	16 981 210
British Columbia	1978	8 727 880	—	—	—	—	—	—	8 727 880
	1977	8 784 380	—	—	—	—	—	—	8 784 380
Northwest Territories and Yukon	1978	144 133	—	—	—	—	—	—	144 133
	1977	135 798	—	—	—	—	—	—	135 798
Total	1978	68 087 757	15 558 487	—	12 112 023	—	—	8 038 004	103 796 271
	1977	65 420 176	17 807 525	199 117	14 983 940	263 872	—	5 564 267	104 238 897

Source: Statistics Canada.
— Nil.

Table 14. Consumption of petroleum products by province, 1978

	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
			(m^3)		
Atlantic provinces	3 140 504	420 893	1 327 720	2 397 394	5 032 924
Quebec	8 679 965	607 790	2 573 245	5 673 157	6 204 846
Ontario	12 945 049	283 454	3 082 215	5 413 902	4 805 457
Manitoba	1 655 037	133 102	733 021	229 367	176 978
Saskatchewan	2 048 787	171 575	998 146	215 274	38 231
Alberta	4 472 365	77 383	2 211 675	124 652	28 286
British Columbia	4 038 992	156 559	2 030 367	901 596	1 171 696
Northwest Territories and Yukon	95 038	53 145	201 108	106 742	21 591
Total	37 075 737	1 903 901	13 157 497	15 062 084	17 480 009

Source: Statistics Canada.

Consumers' Co-operative Refineries Limited in Regina, Saskatchewan. This expansion, after three years and a cost of $31 million, boosted refining capacity to 7 000 m^3/d from 4 600 m^3/d. The refinery has a further potential capacity of 8 000 m^3/d, should demand increase. In Alberta, two expansion programs were completed at Edmonton by Imperial Oil and Texaco Canada.

In British Columbia, there was only a very small increase in refining capacity, up 566 m^3/d for a total of 26 789 m^3/d. There were three expansion projects completed in 1978: Gulf Canada, at Kamloops; Husky Oil, at Prince George; and Imperial Oil, at Ioco.

Imperial Oil, with six refineries, remained Canada's top refiner of crude oil in terms of capacity, with 20 per cent of the total. Gulf Canada, the second-largest with eight refineries, has 15 per cent of the total capacity and Shell Canada, with six refineries and 12 per cent of Canada's capacity, occupies third place.

Marketing and trade

Crude oil deliveries to Canadian refineries during 1978 averaged 284 373 m^3/d, down 1 213 m^3/d from 1977. The deliveries of domestic crude to refineries increased by 7 308 m^3/d to 186 542 m^3/d for a 4 per cent gain. Much of this increase was required by the Montreal refineries, which demanded an additional average of 3 500 m^3/d to serve their markets. The daily delivery of western crude to Quebec averaged 40 000 m^3/d, an increase over the previous year of 10 per cent.

The amount of crude imported into Canada for the year totalled 35 708 514 m^3 or an average of 97 832 m^3/d, a decrease over 1977 of almost 8 500 m^3/d. The Atlantic provinces, which rely completely on imported crude, consumed 43 580 m^3/d, a decrease of 2 600 m^3/d. Quebec, which received an increase in domestic crude, used 43 272 m^3/d of imported oil, a decrease of 8 551 m^3/d over the previous year. In Ontario, the consumption of domestic plus imported crude amounted to 85 880 m^3/d; domestic crude accounted for 88 per cent of consumption. Countries of the Middle East collectively remained the largest source of crude oil for Canada, accounting for 44 per cent of total imports, with Venezuela being the next major supplier. As shown in the accompanying table the "Other" category accounted for 22 022 m^3/d, but this included oil exchanges of 14 225 m^3/d from the United States.

Table 15. Canada, exports and imports of refined petroleum products, 1977 and 1978

	Exports		Imports	
	1977	1978	1977	1978
		$(000\ m^3)$		
Propane and butane	7 312	5 751	17	11
Aviation gasoline	—	—	2	—
Motor gasoline	490	870	—	2
Aviation turbo fuel	7	399	32	52
Kerosene, stove oil and tractor fuel	—	—	—	1
Diesel fuel oil	41	129	53	24
Light fuel oil no. 2 and no. 3	426	1 320	127	13
Heavy fuel oil no. 4, 5 and 6	3 021	4 109	1 243	1 648
Asphalt	20	62	131	15
Petroleum coke	—	—	753	819
Lubricating oils and greases	5	12	212	210
Other products	583	538	63	83
Total, all products	11 905	13 190	2 633	2 878

Source: Statistics Canada.
— Nil.

Table 16. Canada, supply and demand of oils, 1977 and 1978

	1977	1978[p]
	(000 m³)	
Supply		
Production		
Crude oil and condensate[1]	76 447	76 187
Other natural gas liquids	16 869	15 458
Net production	93 316	91 645
Imports		
Crude oil	39 593	36 821
Products	2 633	2 878
Total imports	42 226	39 699
Change in stocks		
Crude oil and natural gas liquids	+808	+781
Refined petroleum products	−2 363	+279
Total change	−1 555	+1 060
Oils not accounted for	−71	−2 300
Total supply	133 916	130 104
Demand		
Exports		
Crude oil	19 783	15 578
Products	11 905	13 190
Total exports	31 688	28 768
Domestic sales		
Motor gasoline	35 774	37 076
Middle distillates	29 302	34 245
Heavy fuel oil	16 514	17 480
Other products	14 949	9 907
Total sales	96 539	98 708
Uses and losses		
Refining	6 487	3 163
Field plant and pipeline	−39	5
Losses and adjustments	−579	−530
Total uses, losses and adjustments	5 869	2 628
Total demand	133 916	130 104

Source: Statistics Canada.
[1] Includes synthetic crude oil.
[p] Preliminary.

By year-end 1978, the demand for Canadian crude oil and natural gas liquids from domestic and export markets had decreased by 3 per cent to 130 million m³ or 356 000 m³/d. The amount of exported crude oil and products declined by 8 000 m³/d to almost 79 000 m³/d.

The price of Canadian crude oil, set by the federal government, is dependent on a number of factors, such as the international price and the fact that oil is a rapidly depleting resource. Canada, being a net importer of oil, is very much affected by the price charged by exporting nations because currently the domestic price of oil is much lower than the imported price. Therefore, refineries receiving imported crude are being compensated for the higher cost in order to provide for a uniform price across Canada, subject only to transportation cost differences.

In January 1978, the average Alberta wellhead price of crude oil was \$73.94/m³ and the price at the U.S. border was \$114.28. In July there was an increase (\$1 per barrel) in the average wellhead price of crude, bringing it to \$80.23/m³. The cost of crude in Toronto became \$87.03/m³, but through export-pricing arrangements involving the levying of an export charge, the U.S. border price was \$115.91/m³.

The national policy of Canada with respect to energy is to make the nation independent of foreign energy supplies. This policy is based on accelerated resource development, more effective conservation measures, replacement of imported oil by more readily available domestic energy sources and the setting of oil and other energy prices in support of these initiatives.

Fluorspar

G.H.K. PEARSE

Fluorspar, or fluorite in mineralogical nomenclature, is calcium fluoride (CaF_2), an industrial mineral with a broad spectrum of uses. The most important of these are: for the manufacture of hydrofluoric acid and other fluorine chemicals; as a fluxing agent in various metallurgical processes, the most important being steel manufacture; for the manufacture of artificial cryolite, an essential cell ingredient in the electrolytic reduction of alumina to aluminum; in the refining of uranium ores; and in the glass and ceramic industries.

During the 1960s, world fluorspar consumption grew rapidly because of increasing demands in the steel, aluminum and chemical industries. Due to a combination of technical, economic and environmental developments, consumption has been stagnant during the present decade. In 1978, world production was an estimated 4.6 million tonnes*. Greater use of the basic oxygen process in steelmaking, which requires about three times more fluorspar, as a slag thinner, than the more traditional basic open-hearth process, will increase the demand for fluorspar in this sector in spite of the partial use of substitutes. However, slack demand in the steel industry over the last three years has arrested growth of metallurgical-grade fluorspar consumption. Recent concern about concentrations of fluorocarbons in the upper atmosphere has led to legislation by the United States government banning nonessential uses of these chemicals by December 1978. Aerosol spray products are alleged to be the main offenders.

Production in Canada

Fluorspar is the principal source of the element fluorine. It occurs in many geological environments from low-temperature fracture fillings to high-temperature emplacements and, as a result, it is not restricted to any particular geological province in Canada. In fact, fluorspar is known to occur in all physiographic provinces, with the exception of the interior plains.

In July 1977 Alcan Smelters and Chemicals Limited announced that it would cease fluorspar operations at St. Lawrence, on Newfoundland's Burin Peninsula, February 1, 1978. Mine production stopped in the fall of 1977. This operation had been Canada's only producer since the last mine closed at Madoc, Ontario in 1961. Reasons stated for the closure were that operations at St. Lawrence were uneconomic, and that higher-quality, lower-cost material was available on world markets. A study of the mines and plant, funded by federal-provincial authorities, was carried out by B.L. Hodge and Associates of London, England. The findings were that operations could be made economic with changes in mining and processing methods and in management and staffing. Estimated capital expenditure to accomplish the changes was $13 million. A new operator will be sought by government authorities to resume fluorspar operations at this single-industry town of 2 100 people.

Concentrates from St. Lawrence were shipped to Alcan's aluminum smelter at Arvida, Quebec, where they were upgraded by flotation and converted to aluminum fluoride for use in the reduction of alumina to aluminum. Small tonnages were sold from time to time to Newfoundland Steel Company Limited for steel slagging. Development of new reserves about 1.5 kilometres (km) northwest of St. Lawrence was halted by a strike in 1975. No ore has been mined from the new reserves. Annual concentrate shipments from St. Lawrence varied between 60 000 and 160 000 tonnes, the lower figure essentially reflecting production lost during strikes. Total production from the district was more than 6 million tonnes of ore. The fluorspar veins on Burin Peninsula are genetically related to two large stocks of alaskite (granitic intrusive). Most of this favourable area is obscured by shallow overburden, but innumerable showings and float blocks containing fluorspar are known.

Allied Chemical Canada, Ltd., imports acid-grade fluorspar for the production of hydrofluoric acid at Valleyfield, Quebec and Amherstburg, Ontario. Some of the acid is utilized in the manufacture of various fluorine chemicals. Allied Chemical operates mines in Mexico and the United States to ensure an uninterrupted supply of fluorspar.

Huntingdon Fluorspar Mines Limited, with a plant near North Brook, Ontario, imports metallurgical-grade fluorspar to make five-pound briquettes for foundry use.

International Mogul Mines Limited's barite-fluorite deposits east of Lake Ainslie, Cape Breton Island, Nova Scotia contain indicated reserves of 2.7 million tonnes, grading 28 per cent barite and 19 per cent fluorite. Pilot plant testing, with the objective of producing an acid-grade

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, fluorspar production, trade and consumption, 1977 and 1978

	1977		1978[p]	
	(tonnes)	($)	(tonnes)	($)
Production (shipments)				
Newfoundland	..	8 685 119	—	—
Imports				
Mexico	60 873	4 982 000	109 236	9 821 000
South Africa	7 072	639 000	29 250	2 594 000
Morocco	8 260	701 000	12 458	975 000
Spain	23 753	1 560 000	9 680	908 000
United States	23 942	2 208 000	9 112	875 000
Other countries	594	76 000	500	104 000
Total	124 494	10 166 000	170 236	15 277 000

	1976	1977[e]
	(tonnes)	
Consumption[1] (available data)		
Metallurgical flux	27 404[r]	38 171
Foundries	5 541	4 603
Other[2]	95 408	77 217
Total	128 353	119 991

Source: Statistics Canada.
[1] As reported by consumers; breakdown by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa. [2] Includes consumption in the production of aluminum, chemicals, petroleum refining and other miscellaneous uses.
[p] Preliminary; .. Not available; — Nil; [e] Estimated.

concentrate at an acceptable rate of recovery, has yet to prove successful. From 1940 to 1949, approximately 1 300 tonnes of fluorspar, along with some barite, were recovered from this deposit.

Prior to The First World War, small tonnages of fluorspar were mined from vein-type deposits in the Madoc district of Ontario. As a strategic material of great importance, it showed a marked increase in production during the war. After the war, production decreased substantially, but was stimulated once again during The Second World War by government assistance for exploratory drilling programs and by loans on capital equipment. From 1943 to 1947 some 23 000 tonnes were mined. Fluorspar was mined continuously in the Madoc area up to 1961, when severe underground flooding, lack of export markets and increased mining costs made the operation uneconomic. Altogether, some 140 000 tonnes of fluorspar were mined in the Madoc area, production being derived from 24 separate properties. Most significant producing properties were along a prominent linear vein structure, the southern extension of which could still contain mineable reserves.

The Rock Candy mine, near Grand Forks, British Columbia, was mined intermittently from 1918 to 1942 and is controlled by Cominco Ltd. Substantial reserves probably remain.

Fluorine is being recovered as fluosilicic acid from the processing of phosphate rock by Erco Industries Limited, at Port Maitland, Ontario, and by Cominco Ltd., at Trail, British Columbia.

Other fluorspar occurrences of interest include the Liard River, British Columbia deposits explored a few years ago by Jorex Limited and Conwest Exploration Company Limited; Eaglet Mines Limited's widespread low-grade mineralization near Quesnel, British Columbia and Consolidated Rexspar Minerals & Chemicals Limited's large uranium-bearing, medium-grade fluorspar deposit adjacent to the Canadian National Railway line at Birch Island, about 95 km north of Kamloops.

Uses, markets and trade

Fluorspar is marketed in three grades according to end-use, although, in time of shortage of metallurgical grade, high-grade material is substituted for this normally lower-grade material. These three grades are: acid grade, containing a minimum of 97 per cent CaF_2; metallurgical grade, containing 60 to 80 per cent CaF_2; and ceramic grade, containing 88 to 97 per cent CaF_2.

Acid grade. Roughly 50 per cent of the world's fluorspar requirement is for acid grade used in the manufacture of

Table 2. Canada, fluorspar production and shipments, 1966-77

	Mine Production	Finished Production	Per cent CaF_2	Shipments	Per cent CaF_2
	(tonnes)			(tonnes)	
1966	112 724	69 400	72.3	76 500	68.6
1967	116 685	66 400	70.9	66 600	68.2
1968	136 418	91 300	66.1	88 100	63.7
1969	181 645	119 400	73.7	92 000	71.6
1970	186 492	124 000	70.1	143 300	69.0
1971	115 491	72 800	67.3	78 700	66.8
1972	217 068	148 900	63.6	143 200	63.9
1973	237 655	157 900	60.9	137 200	61.1
1974	258 502	154 300	62.5	172 700	62.5
1975	90 883	55 100	61.5	—	—
1976	113 061	59 700	64.3	44 400	60.3
1977	95 354	59 500	69.0	122 222	63.5

Source: Compiled by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa, from figures provided by Alcan Smelters and Chemicals Limited. Operations ceased in 1977.
— Nil.

hydrofluoric acid. Most of this material is beneficiated by flotation to achieve the high CaF_2 content required. In general, 2 to 3 tonnes of ore must be mined to produce 1 tonne of acid-grade fluorspar concentrate, and the production of 1 tonne of hydrofluoric acid requires 2 tonnes of acid-grade concentrate and almost 3 tonnes of sulphuric acid. Hydrofluoric acid, produced according to the reaction:

$$CaF_2 + H_2SO_4 \rightarrow CaSO_4 + 2HF$$

has a variety of uses, but by far the most important is in the aluminum and chemical industries, which together account for some 80 per cent.

About one quarter of all hydrofluoric acid produced is used by the aluminum industry. Hydrofluoric acid is reacted with a sodium salt and aluminum fluoride to produce artificial cryolite, an essential cell ingredient for fluxing in the electrolytic reduction of alumina to aluminum. In recent years, fluorspar requirements have declined from 65 kilograms (kg) to 25 kg per tonne of aluminum produced as a result of increased cell efficiencies and recycling. Because fluorite is an essential raw material, many primary aluminum producers operate, or participate in the operation of, fluorspar mines to ensure uninterrupted and adequate supplies.

Almost 40 per cent of hydrofluoric acid is consumed in the manufacture of fluorocarbons. Fluorocarbons, which are used in the manufacture of solvents, resins, plastics, films, refrigerants and aerosol propellants, are produced by reacting hydrofluoric acid with carbon tetrachloride, or with chloroform. Fluorocarbons (more specifically, chlorofluorocarbons) are currently under study as potentially harmful atmospheric pollutants. It is alleged that these substances react with the ozone layer in the upper atmosphere which filters out much of the sun's ultraviolet energy. The resulting increase in ultraviolet radiation could increase the incidence of skin cancer.

Fluorspar is used in uranium refining. Uranium dioxide is reacted with anhydrous hydrofluoric acid to form a green salt (UF_4), which is then reacted with elemental fluorine in the form of fluorine gas to form UF_6, the feedstock for plants requiring enriched uranium. For each tonne of uranium processed into uranium hexafluoride, 1.66 tonnes of fluorspar are required. This presently minor use is expected to develop rapidly as nuclear energy becomes increasingly important.

Metallurgical grade. Normally, about half of the world's fluorspar output is consumed as a metallurgical fluxing agent (metspar), primarily in the manufacture of steel. Metallurgical-grade fluorspar is used in the steel industry to remove impurities during melting and also to improve separation of metal and slag in the furnace by increasing the fluidity of the slag. Consumption of fluorspar in the steel industry has, over the years, increased substantially because of changing technology. Many steelmakers have shifted from the basic open-hearth process to the basic oxygen process. The latter consumes from 5 to 8 kg of metallurgical-grade fluorspar for each tonne of steel produced, compared with 1.5 to 2.5 kg in the open-hearth process. The electric furnace process consumes from 4 to 5 kg of metallurgical grade material for each tonne of steel produced. The basic oxygen process substantially reduces production costs, doubles capacity per unit dollar of capital cost and reaches heat much faster than the open-hearth process. Within the next decade, older basic open-hearth furnaces will probably be replaced by more efficient new basic oxygen or electric furnaces.

Recessionary demand in this industry has resulted in a drop in annual metspar consumption from 2 million to about 1.5 million tonnes in the last four years. Part of the reduction has been due to substitutions of other materials, and economy measures such as using less fluorspar and longer tap-to-tap time in the furnaces. However, a rise in demand will likely result in use of more fluorspar per unit of production as capacity output is approached. No satisfactory total substitute for fluorspar as a fluxing agent in steelmaking has been found, although research in this area is considerable. Indications are that the growth of metallurgical-grade reserves is not keeping pace with requirements. Consequently, steelmakers may have to switch more and more to higher-grade, higher-cost material, produced as flotation concentrates and converted into pellet or briquette form. Metallurgical-grade fluorspar is also used as a flux in foundries and in the reduction of dolomite to magnesium.

Ceramic grade. Ceramic-grade fluorspar is used as an opacifier in enamels and opal glass. It is also used to a limited extent in the manufacture of clear glass as an active flux, as a contributor to the gloss and as a decolourizer. Much of this grade of fluorspar concentrates can be used for the manufacture of hydrofluoric acid, or as pellets and briquettes for steelmaking. This latter requirement has been provided for in this way during shortages of metallurgical-grade fluorspar.

Canadian consumption and trade

About 80 per cent of the fluorspar consumed in Canada is used in the manufacture of aluminum fluoride for the electrolytic reduction of alumina to aluminum.

In 1978, fluorspar imports were 170 236 tonnes, an increase of 37 per cent from the previous year. This reflects curtailment of domestic production in 1977. Mexico provided 64 per cent of total imports: most of the remainder came from South Africa, Morocco, United States and Spain.

Prior to 1957, much of Canadian production was exported to the United States and Europe. In 1958, this trade was displaced by the development of low-cost deposits in Mexico by large consumers in the United States.

World review

Expectation of a serious world shortage of fluorspar by 1970 resulted in intensive exploration efforts during the late 1960s and several new facilities were brought on stream. However, coincident with the surge in production came a slackening in demand due to an economic slowdown, most notably in the United States and Japan. World production, at 4.6 million tonnes, is little changed from that of the previous eight years.

Mexico continued to rank as the world's largest supplier, producing 960 000 tonnes, or 21 per cent of total output, in 1978. Fluorspar mining began in Mexico prior to The First World War. However, the industry received its greatest stimulus during The Second World War, when the United States government, cut off from European sources, encouraged exploration and development in Mexico. Most production is mined in the State of San Luis Potosi in the Zaragoza area, where two major producing mines are located within 1.5 km of each other. The Las Cuevas mine, which is the largest, accounts for over 30 per cent of total Mexican output and is the principal producer of metallurgical-grade fluorspar. This underground operation is an

Table 3. World fluorspar production, 1976-78

	1976	1977	1978[e]
		(tonnes)	
Mexico	896 000	955 000	907 000
U.S.S.R.	490 000	501 000	499 000
Spain	403 000	399 000	180 000
France	350 000	370 000	363 000
People's Republic of China	363 000	349 000	363 000
Republic of South Africa	290 000	351 000	363 000
Mongolia	318 000	320 000	363 000
Thailand	200 000	222 000	227 000
United Kingdom	240 000	200 000	227 000
Italy	210 000	186 000	181 000
Kenya	75 000	124 000	136 000
United States	171 000	153 000	118 000
Canada	60 000	60 000	—
Other countries	537 000	453 000	472 000
Total	4 603 000	4 643 000	4 415 000

Sources: U.S. Bureau of Mines, Mineral Commodity Summaries, 1978, 1979: Alcan Smelters and Chemicals Limited.
[e] Estimated.

affiliate of Noranda Mines Limited. The rapid growth of fluorspar production in Mexico over the years has paralleled consumption increases in the United States, which relies upon Mexico for most of its import requirements. Stagnation of production over the last few years reflects a levelling off in United States demand.

Quimica Fluor S.A.'s hydrofluoric acid plant at Matamoros started up in 1975. It is one of four originally proposed in 1971.

The Mexican Fluorspar Institute, a producer organization, was formed in 1974. This body, backed by the government, formulates policy on sales and prices.

The United States is the world's largest consumer and is heavily reliant on imports to meet demand. In 1978, United States production at 118 000 tonnes, was down 23 per cent from that of 1977. Output of fluosilicic acid from 12 phosphate fertilizer plants was equivalent to 98 000 tonnes of fluorspar. Imports for the year (including CaF_2 equivalent of hydrofluoric acid) totalled 1.03 million tonnes, 67 per cent from Mexico. Most output in the United States comes from the Illinois-Kentucky district and is produced by two companies, Ozark-Mahoning Company (majority interest purchased by Pennwalt Corporation during 1975), and Allied Chemical Corporation, which, through acquisition, took over the former Minerva Oil Company holdings.

Other states producing fluorspar intermittently are: Montana, Colorado, Idaho, Arizona, New Mexico and Utah. Little news of developments at Lost River Mining Corporation Limited's reportedly extensive deposits near Teller, Alaska was forthcoming during the year. Drilling by United States Borax & Chemical Corporation on its new fluorspar-barite deposit in the Sweetwater district, 65 km southeast of Knoxville, Tennessee, has thus far delineated over 50 million tonnes of 15 to 35 per cent CaF_2 amenable to open-pit mining. An exploration shaft is being sunk to complete the evaluation.

In 1978, Spain produced an estimated 180 000 tonnes. Towards year-end, a dispute between the company Fluoruros and its main ore supplier resulted in a major drop in output. Much of the Spanish production is exported, mostly to the United States and West Germany. Estimated French production was 360 000 tonnes. Italy, also a major producer, shipped an estimated 220 000 tonnes in 1978. Production in Britain was about 230 000 tonnes.

The U.S.S.R. is the world's second-largest producer of fluorspar, with an output of about 500 000 tonnes in 1978. Domestic supply has fallen short of requirements for some years, and imports exceed 300 000 tonnes. The People's Republic of China, North Korea and Mongolia, a rapidly growing producer, together produce approximately 700 000 tonnes per year.

Thailand's output was about half of the 1971 peak figure of 420 550 tonnes. Reserves are reportedly much below official figures of about 10 million tonnes. Deposits appear to be controlled by shallow folds and, as such, bottom out much closer to the surface than originally expected.

The Republic of South Africa's output was an estimated 325 000 tonnes in 1978, a fourfold increase over that of ten years ago. This country has about 25 per cent of the world's measured CaF_2 reserves. Although much of the reserves are well below the generally accepted grade of 35 per cent, its production will likely represent an increasing share of world output over the long term. Namibia (formerly South-West Africa) Kenya, Tunisia and Morocco are all significant producers.

After rapid development in the fluorspar industry in Brazil and Argentina during the early 1970s, output has declined in recent years to 70 000 tonnes total.

Outlook

The performance of the fluorspar industry necessarily parallels development in the steel, chemical and aluminum industries, which together account for 95 per cent of fluorspar consumption.

A combination of recessionary demand, economies in fluorspar use and environmental constraints resulted in a seven-year, no-growth period in fluorspar consumption up to 1978. Large producer inventories and declining prices resulted in mine closures – perhaps the most notable being Canada's last producer – and deferred development plans. Signs of the long-awaited turnaround were evident in the closing months of the year.

Consumption of fluorspar in the aluminum industry appears to have reached a plateau as requirements per tonne of metal produced have declined. A new aluminum production technology, which reportedly reduces consumption of electricity by about 30 per cent and uses chlorine instead of fluorine, is in the development stage. Aluminum Company of America postponed doubling of its Palestine, Texas demonstration plant's capacity to 27 200 tonnes, having encountered certain snags in the process. Should these be overcome, the company intends to construct a world-scale plant. Assuming adoption of the new technology, fluorspar in aluminum manufacture could disappear by the turn of the century. In the short run, however, some growth in fluorspar consumption in the aluminum industry is likely as a result of the current healthy growth in demand for this metal.

Many uncertainties surround the outlook for fluorspar consumption in steelmaking. Demand growth for steel products is tied to performance of the world economy about which no clear trends have, as yet, emerged. There seems little doubt, however, that growth over the next few years will be modest. Nevertheless, any significant increase in steel demand will call forth even greater fluorspar usage to facilitate shorter residence time in the furnaces. Also, conversion to basic oxygen technology will continue, further increasing fluorspar demand. In addition to flux needs, about 160 000 tonnes of acid grade equivalent is consumed as acid in pickling stainless steel.

Consumption in fluorocarbon manufacture has been the dominant force in fluorspar usage in the chemical industry in recent years. However, the ban on "nonessential" fluorocarbon products in the United States, principally

Prices

United States fluorspar prices, quoted in "Engineering and Mining Journal" of January 1979

(net ton fob Illinois and Kentucky, CaF_2 content, bulk)

	($)
Ceramic, calcite and silica variable, CaF_2	
88-90%	90-100
95-96%	95-109
97%	100-115
In 100-lb paper bags, extra	9
Metallurgical pellets, 70% effective CaF_2	91
Acid, dry basis, 97% CaF_2	
Carloads	111-116
Bags – carload price plus	9
Pellets, 88% effective	111
Wet filter cake, 8-10% moisture, sold dry content – carload price plus	6
European and South African wet filter cake, 8-10% moisture, sold dry content, duty paid, short ton cif east Coast, Great Lakes and Gulf ports, term contracts	97-105

Mexican

Metallurgical, 70% effective CaF_2	
Mexican border, fob cars	66.70
Tampico, fob vessel	69.45
Acid, 97% + CaF_2 wet filter cake, bulk, fob	
Mexican border	84.14

aerosol sprays, is also under consideration in other countries, and at least a temporary arrest in growth in the chemical sector can be expected. The reduction in fluorspar consumption resulting from such a ban would be about 10 per cent, although growth in other fluorocarbon products is not precluded. Uranium enrichment and oil refining (alkylation) are strong growth segments that will moderate decline in the chemical sector. World consumption of fluorspar (acid grade) for these and other miscellaneous uses presently account for only 2.5 per cent of total fluorspar use, but growth rates in excess of 10 per cent per year over the long term seems likely.

Substitution of fluorspar-based acid by byproduct hydrofluoric acid from phosphate fertilizer production has reached approximately 100 000 tonnes fluorspar equivalent in 1978. Output from this enormous source will continue to expand, although at the present time little is being done outside the United States.

In the longer term, the chemical industry would seem to offer the greatest scope for growth in fluorspar consumption. Fluorine, the most electronegative of elements, reacts with almost all organic and inorganic substances and, in view of this property, only the surface of its potential as a chemical has been scratched.

In balance, world fluorspar consumption is expected to grow only marginally over the next year or two. With the spate of closures during the past few years, however, supplies are expected to tighten and prices should move up accordingly. A significant economic recovery would result in shortages, primarily of metallurgical grade.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
29600-1	Fluorspar	free	free	free	free

United States

Item No.		($ per long ton)
522.21	Fluorspar, containing over 97% calcium fluoride	2.10
522.24	Fluorspar, containing not over 97% calcium fluoride	8.40

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States, Annotated (1978), USITC Publication 843.

Gold

J.J. HOGAN

Gold production in Canada in 1978 was estimated to be 52 875 000 grams (g)* valued at $375 054 000 compared with 53 921 330 g valued at $272 331 217 in 1977. The average yearly afternoon fixing prices of gold on the London Gold Market converted to equivalent Canadian dollars per gram for the years 1977 and 1978 were $5.051 and $7.086 respectively, an increase in price of 40 per cent. Lode gold mines, placer mines and byproduct production from base-metal mines all recorded a small reduction in output in 1978. The value of gold production reached an all time high, increasing by 37.6 per cent over 1977. Record gold production in Canada occurred in 1941, when 166 253 668 g (5 345 179 ounces) were produced.

Canada has been one of the world's leading producers of gold, and since production was first officially recorded in 1858, has produced 6 413 283 kilograms (kg) to the end of 1978, valued at $8 016 million. Although most of the provinces and territories have contributed to Canadian gold output during the period, the largest producers in decreasing order of output were Ontario, Quebec, British Columbia, the Yukon Territory and the Northwest Territories.

In 1978 lode gold mines in Canada accounted for 68.0 per cent of the country's gold output, compared with 66.8 per cent in 1977. At the end of 1978 there were 22 operating lode gold mines in Canada, the ore being treated at 16 mills. One small mine opened in 1978 and two operating mining companies amalgamated. A small amount of gold was recovered from placer deposits in the Yukon Territory and in British Columbia. Ontario continued to be the major gold-producing province in Canada and accounted for 41.7 per cent of the national total, followed by Quebec with 27.4 per cent, British Columbia, 12.1 per cent and the Northwest Territories, 11.9 per cent. The number of workers employed by lode gold mine producers was approximately 5 100 in 1978, compared with 4 840 in 1977.

The much improved gold price enabled all Canadian lode gold mines to operate successfully in 1978. The mines were also able to increase the rate of underground exploration and development, which had fallen behind during the recent period of low gold prices. The mines are still faced with the problem of an increased production cost per ounce of gold produced due to continuing high inflation and the treatment of lower grade ore. Many of the Canadian gold mines have been in operation for a number of years and have limited ore reserves. The gold price in Canadian funds has been increasing at a faster rate than the rate of inflation and has allowed mine operators to treat lower grade ore and to include lower grade material in ore reserves, thereby extending the life of the mines. It is expected that the gold price will remain at a level in 1979 that will enable producers to operate at a profit, but exhaustion of ore reserves could result in the closure of one or two lode gold mines.

Increased exploration activity that would normally follow a relatively high gold price has not developed. Two factors were responsible: the more favourable climate for risk capital investment or speculation in oil, gas and uranium exploration, and the relatively short period that the gold price has been at its present high level. Investors would like some assurance that the gold price will remain reasonably stable before committing funds to extensive exploration and development programs.

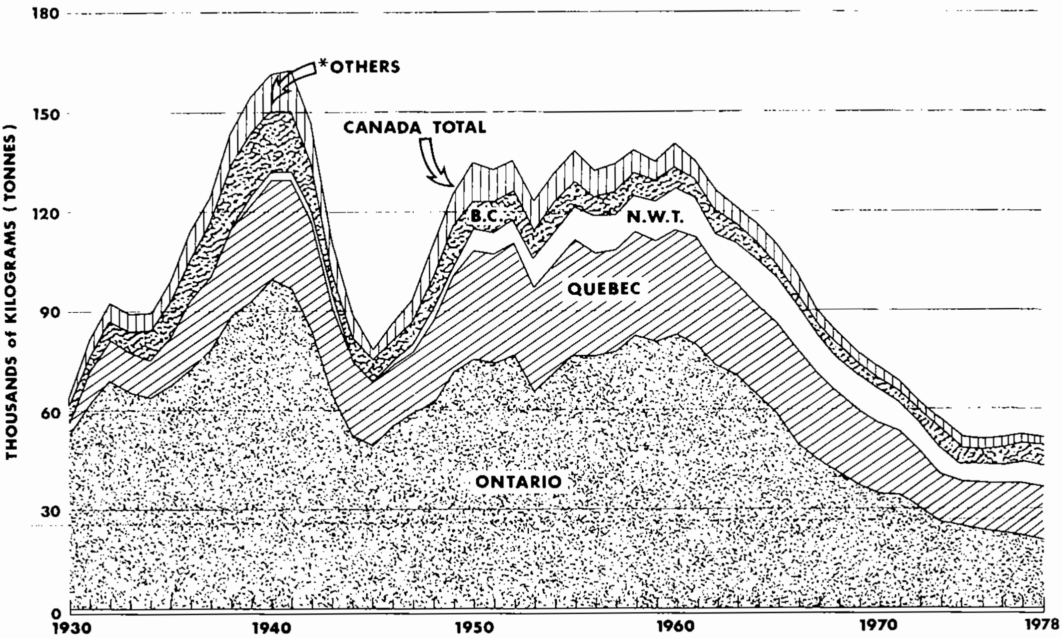
Bill C-39, an Act to amend the Currency and Exchange Act, received Royal Assent on June 30, 1978. This amendment allows the Governor in Council to authorize the Royal Canadian Mint to strike and issue numismatic and bullion gold coins, to determine their face value and to specify the maximum number of gold coins to be struck each year.

The Canadian government minted 200 000 commemorative $100 legal tender gold coins in 1978. The coins contain 91.66 per cent gold (22 karat); weigh 16.965 g, with gold content accounting for 15.511 g; are 27 millimetres in diameter and were sold for $150 each. The reverse design portrays 12 geese flying in formation, representing the ten provinces and the two territories, and bears the inscription "Together into the future – ensemble vers l'avenir". There was a strong demand for this issue.

On the recommendation by the Mining Association of Canada, the minting of a legal tender one ounce bullion coin is under study by the Canadian government. A bullion coin, as distinct from a numismatic gold coin which is valued for its rarity and gold content and trades well above the value of its gold content, is valued according to its gold content alone and trades at current gold prices plus a small premium. A decision to mint the coin should be forthcom-

*31.103 5 grams are equivalent to 1 troy ounce.

GOLD PRODUCTION by PROVINCES



* OTHERS = NFLD., N.S., N.B., MAN., SASK., ALTA., Y.T.
DATA SOURCE: STATISTICS CANADA

ing in early 1979. (On February 23, 1979 authorization was given to proceed with the minting of the one-ounce gold coin.)

Canadian developments

Atlantic provinces. All gold produced in the Atlantic provinces in 1978 was derived as a byproduct of base-metal ores. The Buchans mine of Asarco Incorporated has limited reserves and is expected to close in 1979. Rio Tinto Canadian Exploration Limited is carrying out a major drill program on a gold property in the southwestern part of the province. Exploratory work was carried out on some gold prospects in Nova Scotia.

Quebec. Agnico-Eagle Mines Limited completed the ore and waste pass system in the lower levels of its mine and is preparing these levels for production. An improvement was made in the overall recovery rate of gold. Darius Gold Mines Inc., a private company in which Gold Fields American Corporation, a subsidiary of Consolidated Gold Fields Limited of England, has controlling interest, commenced production in October at its gold property in the Cadillac district of northwestern Quebec. This property is the former O'Brien mine which produced gold from 1933 to 1956. The rated capacity of the plant is 180 tonnes* per day. The mine property of Thompson-Bousquet Gold Mines, Ltd. in the Cadillac district of northwestern Quebec is being prepared for production by Long Lac Mineral Exploration Limited, which holds the controlling interest in Thompson-Bousquet. Development plans call for a shaft to be sunk to a depth of 370 metres (m), at the end of 1978 the shaft had reached a depth of 308 m. Initially four levels will be established and to expedite development a decline, previously driven to test a large nearby low-grade zone, is being extended to the 172 m level. This decline intersected the vein structure in 1978 and a 8 850 tonne bulk sample from the ore zone yielded 76.91 kg of gold. The mine is expected to be in production by mid-1979. The ore will be trucked about 45 kilometres (km) to the custom mill of Malartic Gold Fields (Quebec) Limited for treatment. In September, Noranda Mines Limited announced that a decision was made to develop its Chadbourne mine in Rouyn-Noranda for production to commence in mid-1979, at an approximate rate of 600 tonnes per day. The ore will be treated at the nearby Horne concentrator of Noranda. Ore reserves have been estimated to be 1 030 000 tonnes averaging 5.00 g per tonne, sufficient for a five-year period.

*The term tonne refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, production of gold, 1977 and 1978

	1977	1978^p
	(grams)	
Newfoundland		
Base-metal mines	447 766	498 000
New Brunswick		
Base-metal mines	290 227	218 000
Quebec		
Auriferous quartz mines		
Bourlamaque-Louvicourt	4 239 528	3 894 000
Malartic and Matagami	6 418 327	5 773 000
Total	10 657 855	9 667 000
Base-metal mines	4 322 917	4 796 000
Total Quebec	14 980 772	14 463 000
Ontario		
Auriferous quartz mines		
Larder Lake	5 007 037	4 330 000
Porcupine	6 386 508	8 136 000
Red Lake and Patricia	7 742 340	7 556 000
Total	19 135 885	20 022 000
Base-metal mines	3 883 549	2 030 000
Total Ontario	23 019 434	22 052 000
Manitoba-Saskatchewan		
Base-metal mines	2 055 722	1 959 000
Alberta		
Placer operations	2 053	—
British Columbia		
Base-metal mines	5 906 426	6 330 000
Placer operations	92 439	46 000
Total British Columbia	5 998 865	6 376 000
Yukon		
Base-metal mines	489 413	626 000
Placer operations	432 494	400 000
Total Yukon	921 907	1 026 000
Northwest Territories		
Auriferous quartz mines	6 204 584	6 283 000
Canada		
Auriferous quartz mines	35 998 324	35 972 000
Base-metal mines	17 396 020	16 457 000
Placer operations	526 986	446 000
Total	53 921 330	52 875 000
Total value	$272 331 217	$375 054 000[1]
Average price per oz[2]	$157.09	$220.41

Sources: 1977, Statistics Canada; 1978, Statistics Canada and company reports. Breakdown by type of operation by the Statistics Section, Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Value not necessarily based on average gold price for 1978. [2] Average of London Gold Market afternoon fixings in Canadian funds.
^{p} Preliminary; — Nil.

Table 2. World gold production, 1976 and 1977

	1976	1977^p
	(grams)	
North America		
Canada	52 621 110	53 921 330
United States	32 597 595	34 224 617
Other countries	20 756 625	20 025 414
Total	105 975 330	108 171 361
South America		
Colombia	9 264 513	8 180 214^e
Brazil	4 922 001	5 287 591^e
Chile	4 016 796	3 506 482
Peru	2 510 984	2 992 994
Bolivia	1 291 385	755 597
Other countries	1 822 913	1 624 037
Total	23 828 592	22 346 915
Europe		
U.S.S.R.^{e}	239 496 771	244 162 293
Spain^e	8 397 939	8 397 939
Yugoslavia	4 885 983	4 976 556^e
Romania^e	1 866 209	2 021 726
Other countries	4 735 535	4 627 140
Total	259 382 437	264 185 654

	1976	1977^p
	(grams)	
Asia		
Philippines	15 589 374	17 365 040
North Korea^e	4 976 556	5 598 626
Japan	4 281 984	5 300 997
India	3 131 996	2 853 993
Other countries	5 814 017	5 186 660
Total	33 793 927	36 305 316
Africa		
Republic of South Africa	713 388 971	699 885 987
Southern Rhodesia^e	18 662 086	18 662 086
Ghana	16 561 762	14 957 164
Zaire	3 199 988	2 539 941
Other countries	2 431 452	1 618 127
Total	754 244 259	737 663 305
Oceania		
Papua-New Guinea	38 208 942	40 434 520^e
Australia	15 400 980	14 774 151^e
Fiji	2 045 271	1 526 154
Other countries	120 557	120 433
Total	55 775 750	56 855 258
World Total	1 233 000 295	1 225 527 809

Sources: U.S. Bureau of Mines, Mineral Trade Notes, August 1978; Statistics Canada.
^{p} Preliminary; ^{e} Estimated.

An extensive diamond drill program was completed on the Silverstack joint-venture gold prospect west of Thompson-Bousquet. This property is jointly owned by Silverstack Mines Ltd. (N.P.L.), with 51 per cent interest and Quebec Mining Exploration Company (SOQUEM), a Crown corporation of the Government of Quebec, with 49 per cent interest. Drill results indicated that a study was warranted to determine the feasibility of an open-pit mining operation. Preliminary metallurgical tests indicate that flotation and roasting may be required prior to cyanidation. Two 22 700 tonne bulk test samples are to be treated at two different mills to determine if the contained gold can be recovered economically by straight cyanidation. Belmoral Mines Limited is driving a decline from the surface to develop its gold property to the east of Sigma Mines (Quebec) Limited.

Table 3. Canada, gold production, 1960, 1965, 1970 and 1975-78

	Auriferous Quartz Mines		Placer Operations		Base-Metal Ores		Total	
	(grams)	(%)	(grams)	(%)	(grams)	(%)	(grams)	(%)
1960	122 248 048	84.9	2 513 285	1.7	19 213 893	13.4	143 975 226	100.0
1965	92 031 269	82.1	1 387 153	1.2	18 741 680	16.7	112 160 102	100.0
1970	58 591 610	78.2	228 890	0.3	16 094 525	21.5	74 915 025	100.0
1975	37 529 456	73.0	335 077	0.6	13 568 581	26.4	51 433 114	100.0
1976	38 328 223	72.8	517 375	1.0	13 775 512	26.2	52 621 110	100.0
1977	35 998 324	66.8	526 986	1.0	17 396 020	32.2	53 921 330	100.0
1978^p	35 972 000	68.0	446 000	0.9	16 457 000	31.1	52 875 000	100.0

Source: Statistics Canada. Compiled by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
^{p} Preliminary.

The company is exploring the possibility of having one of the nearby mills treat its ore. Northwestern Quebec was one of the more active areas in Canada in which gold exploration was carried out in 1978.

Ontario. Total gold production in Ontario in 1978 was 22 052 kg, slightly lower than that of 1977. The lode gold mines operating in the province accounted for 90.7 per cent of the 1978 provincial total, with the balance derived from base-metal mining.

Campbell Red Lake Mines Limited, in the Red Lake district, maintained its position as the leading gold producer in Canada. Pamour Porcupine Mines, Limited is carrying out an aggressive exploration program on gold prospects in the Timmins district to ensure a continuing supply of mill feed to its two large mills in the Timmins area. Through an agreement with Falconbridge Nickel Mines Limited Pamour is mining boundary ore on the Falconbridge-Hoyle property adjoining the No. 1 mine. Pamour is recovering some ore from open-pit operations. The shaft at the Ross mine was deepened one level to a depth of 960 m. The company is driving a decline to explore the optioned Porcupine Peninsular prospect of Hydra Explorations Ltd., located to the east of No. 1 mine.

The amalgamation of Dickenson Mines Limited and Robin Red Lake Mines Limited became effective June 30, 1978, following approval by shareholders at the annual and the general meetings of the two companies. The name of the new company is Dickenson Mines Limited. Shares of Dickenson were exchanged on a one-for-one basis and those of Robin at one share of the new company for 2-1/2 shares of Robin. The amalgamation will not affect the physical operations of the two mines. The Robin ore structure is an extension of that occurring in the Dickenson property. Robin Red Lake ore was mined through extensions of the underground workings of Dickenson onto Robin ground and was custom treated at the Dickenson mill. The No. 2 internal shaft is being deepened by 183 m to the 1 658 m level and four new levels will be opened to explore and develop reserves indicated by diamond drilling. The project has been estimated to cost $2.5 million and should be completed in 1979.

Amoco Canada Petroleum Company Ltd. completed a feasibility study on the development of its wholly-owned gold deposit in the Detour Lake district, which is about 230 km northeast of Timmins. The study showed that capital expenditures to bring the mine into production were higher than originally expected and reserves were lower, now estimated at 5 443 000 tonnes averaging 6.86 g of gold per tonne. A limited amount of property evaluation and exploration was carried out on other gold prospects in the province.

Prairie provinces. Virtually all gold produced in the Prairie provinces was recovered as a byproduct of base-metal ores. A small amount of gold was recovered by gravel-washing plants on the North Saskatchewan River, near Edmonton, Alberta. Exploratory work on gold prospects was minimal.

Table 4. Canada, gold production, average value per gram and relationship to total value of all mineral production, 1960, 1965, 1970 and 1975-78

	Total Production	Total Value	Average Value per Gram[1]	Gold as a Percentage of Total Value of Mineral Production
	(grams)	($ Cdn.)	($ Cdn.)	(%)
1960	143 975 226	157 151 527	1.09	6.3
1965	112 160 102	136 051 943	1.21	3.7
1970	74 915 025	88 057 464	1.18	1.5
1975	51 433 114	270 830 389	5.27	2.0
1976	52 621 110	208 273 405	3.96	1.4
1977	53 921 330	272 331 217	5.05	1.5
1978[p]	52 875 000	375 054 000	7.09	1.9

Source: Statistics Canada.
[1] Value not necessarily based on average gold price for 1978.
[p] Preliminary.

British Columbia. With the exception of Northair Mines Ltd. most of the gold produced in British Columbia in 1978 was recovered as a byproduct of base-metal ores. A minor amount of gold was recovered from placer deposits in the north-central district and in the Atlin district in the northwest section of the province. The copper mine-concentrator-smelter complex of Afton Mines Ltd., near Kamloops, which officially opened in 1978, is a substantial producer of byproduct gold. Exploratory work was comparatively active in the potential gold-producing areas of the province. Carolin Mines Ltd. is carrying out a feasibility study on its gold prospect near Hope. The Mosquito Creek Gold Mining Company Limited is considering bringing its gold property in the Cariboo district into production at a rate of 100 tonnes per day.

Yukon Territory. The high gold price ensured continuing strong activity in the older placer districts of the Yukon and the recently discovered placer areas on the Alaska-Yukon boundary about 48 km north of the Alaska highway. A significant quantity of gold was recovered from the copper mine of Whitehorse Copper Mines Ltd.

Northwest Territories. All gold produced in the Northwest Territories in 1978 came from the lode gold mines in the Yellowknife district.

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World developments

In 1978 the Republic of South Africa was, by far, the leading gold producing country, followed by the U.S.S.R., Canada and the United States. Other significant producers listed in decreasing order of importance were Papua-New Guinea, Philippines, Australia, Rhodesia and Ghana.

Consolidated Gold Fields Limited, a company that holds a large interest in the Republic of South Africa's gold mining industry, estimated in its report *"Gold 1979"*, non-communist world total gold production in 1978 to be 969.1 tonnes, compared with 968.3 tonnes in 1977. Consolidated Gold Fields is engaged in a detailed review of U.S.S.R. gold production and has suspended publication of estimates of gold production in communist countries until the study is completed. In the report *"Gold 1978"* the U.S.S.R. output for 1977 was estimated to be 440 tonnes. Gold production for 1978 in the Republic of South Africa was estimated to be 706.4 tonnes, 72.9 per cent of the non-communist world total. Comparable figures for 1977 were 699.9 tonnes and 72.3 per cent. Although Canada is the world's third-largest gold producer, it is a relatively small producer and accounted for only 5.5 per cent of the non-communist world's 1978 gold production. The United States Bureau of Mines (USBM) reported U.S.S.R. gold production for the years 1977 and 1976 to be 244.2 and 239.5 tonnes, respectively. In the past the USBM estimates of gold production have been considerably lower than projections made by Consolidated Gold Fields.

The world's major centres for gold distribution are: London, where gold sales are largely handled through members of the London Gold Market, the group that sets the morning and afternoon London Gold Market fixing prices and Zurich, Switzerland where sales are handled through banks. Hong Kong is becoming an increasingly more active gold-trading centre. The Republic of South Africa is one of the major suppliers of gold to these markets. The U.S.S.R. has also been a substantial supplier of gold to these markets, especially to the Swiss market.

Trading in gold futures was carried out on five commodity exchanges in the United States; the Commodity Exchange Inc. (Comex) of New York and the International Monetary Market (IMM) of Chicago, which are the two most active exchanges; and the Chicago Board of Trade (CBT), the New York Mercantile Board of Trade (NYME) of New York and the MidAmerican Commodity Exchange of Chicago. Gold futures were traded in 400- and 100-ounce contracts on the Winnipeg Commodity Exchange. Gold futures trading began on the Sydney Australia exchange in April. The contracts are for 50 fine troy ounces. Trading is also organized to ensure a spot market. In November,

Table 5. International Monetary Fund – gold auctions, 1978

Date of Sale in 1978	Average Bid Price, or Common Price	Amount of Gold Sales	Amount Bid For	Afternoon Fixing Price on London Gold Market on Day of Auction	Number of Successful Bidders
	($ U.S./troy ounce)	(troy ounces)	(troy ounces)	($ U.S./troy ounce)	
January 4	171.26[1]	524 800	984 800	171.85	19
February 1	175.00[1]	524 800	598 400	176.40	17
March 1	181.95	524 800	1 418 000	182.50	16
April 5	177.92	524 800	1 367 000	178.40	15
May 3	170.40	524 800	3 104 000	170.45	17
June 7	183.09	470 000	1 072 400	183.00	15
July 5	184.14	470 000	797 200	184.20	19
August 2	203.28	470 000	1 467 600	203.25	20
September 6	212.50	470 000	773 200	212.00	10
October 4	223.68	470 000	805 000	223.50	12
November 1	224.02	470 000	689 600	227.50	7
December 6	196.06	470 000	1 965 200	196.25	13

	(troy ounces)	(tonnes)
Total competitive gold sales 1978	5 914 000	183.95
Sales to member countries submitting noncompetitive bids	1 384 000	43.04
Total gold sales in 1978	7 298 000	226.99
Total gold sales in 1976 and 1977	9 926 800	308.76
Total gold sales to end of 1978	17 224 800	535.75
Total gold sales under IMF program	25 000 000	777.59
Gold remaining to be sold under program	7 775 200	241.84

Source: *IMF Survey* (International Monetary Fund Publication).

[1] Common price — all successful bidders receive gold at the lowest acceptable bid price.

Singapore opened a gold futures trading exchange. Trading is in 100-ounce contracts but three one-kilogram bars also constitute a good delivery.

According to *"Gold 1979"* the world market supply of 1 741 tonnes of gold was appreciably above the 1 638 tonnes of the previous year. New mine production from the non-communist world was virtually unchanged from 1977 at 969 tonnes. Sales by the communist countries in 1978 were estimated at 410 tonnes of gold, up slightly from the sale of 401 tonnes in 1977. Gold supplied from official government sources or agencies increased sharply in 1978 to 362 tonnes from 269 tonnes in 1977. Sales by the United States Treasury in 1979 were mainly responsible for the large increase. In order to relieve problems related to balance of payments, Portugal sold about 60 tonnes of gold from its official reserves in 1978, compared with 111 tonnes in 1977.

Purchases of gold by official sources in 1978 was estimated at 22 tonnes.

Republic of South Africa. Gold production in the Republic of South Africa for the year 1978 was estimated by Consolidated Gold Fields to be 706.4 tonnes, compared with 699.9 tonnes in 1976. South African gold production reached a high of 1 000.4 tonnes in 1970, then declined steadily until 1978. Although the grade of ore treated in 1978 was slightly lower than the previous year, an increase in the tonnage treated and recovery of gold from waste dumps were responsible for the increased output.

During the year there was an adequate supply of African labour. An increasing number of workers from the Republic of South Africa are entering the gold mining industry, and reportedly constitute as high as 75 per cent of the work force at some mines. This reduces the dependence on nearby countries for mine workers. A greater percentage of African employees are working for longer periods then returning to the industry after a specific leave period. The return of experienced workers has sharply reduced the costs involved in training programs and the added costs of low productivity

until the required skills are developed. A substantial increase in the workers' wages over the past few years and improved social conditions at the mines are largely responsible for the improved labour situation.

The cost of gold production in South Africa in 1978 increased approximately 15 per cent, an increase that is lower than those of the past several years. Productivity has declined over the past few years and can partly be attributed to the 11-shift fortnight arrangement, to problems related to mining at increasingly greater depths and to pillar recovery. South African mine operators are investigating areas in which increased mechanization can be adopted to increase output, but physical characteristics of the ore deposits make mechanization difficult.

Gold production in the Republic of South Africa will increase over the next few years with new mines coming into production. It is expected to decline after 1985, as older mines treat lower grade ore or exhaust their reserves and close. One large mine came into production in 1978 and is expected to produce about 6 tonnes of gold in 1979. Two other large mines are expected to come into production late in 1979 or early 1980. East Rand Gold and Uranium Company Limited began treating material from old waste dump slimes in 1978 to recover the contained gold, uranium and pyrite, which is used for the production of sulphuric acid. This operation should add 5 to 6 tonnes to South Africa's yearly gold output.

United States. Gold production in the United States in 1978 was estimated to be 30 017 kg by the USBM, compared with 34 225 kg in 1977. About 33 per cent of the United States domestic gold is produced as a byproduct of base-metal mining, mainly from the copper ores in the western states. A small amount of gold is recovered from placer operations and the remainder comes from lode gold mines.

Homestake Mining Company in South Dakota and Carlin Gold Mining Company, an open-pit mine operation in Nevada, were the major lode gold-producing mines in the United States. Kennecott Copper Corporation, a large copper producer was the major contributor to byproduct gold output. A double-oxidation process was developed by Newmont Exploration Limited to treat refractory high-carbon ores. A commercial plant using this process is in operation at the Carlin mine. This is an important technological advance, as it may result in many of the carbon type gold deposits becoming economic. There was increased activity in gold exploration in the western United States, especially in Nevada, in search of the Carlin-type deposits. It has been reported that this activity has been successful and two or three new mines could come into production. Recovery of gold by the heap-leaching process to recover gold from low-grade deposits is becoming increasingly more important in the western United States and several leaching operations were producing gold in 1978.

The United States is one of the major consumers of gold and imported 152 383 kg in 1978, mainly from Canada, the U.S.S.R. and Switzerland. The United States was a major market for the South African krugerrand, a 1-ounce legal tender gold coin. According to USBM 1978 imports of gold coins into the United States contained 3.73 million ounces of gold, more than double the amount imported the previous year. The major proportion of coins was krugerrands.

Dominican Republic. In 1978 Rosario Dominicana S.A., a company in which the Dominican Republic holds 46 per cent interest and Rosario Resources Corporation and J.R. Simplot (both United States companies) each held 27 per cent, maintained its position as the leading lode gold producer in the western hemisphere. The mill capacity was increased from 7 260 to 8 400 tonnes in order to treat a larger proportion of low grade ore. Gold produced in 1978 was 10 805 kg. Exploration and metallurgical research in the large sulphide deposit underlying the oxidize open-pit zone continued in 1978.

Australia. Australian gold output in 1978 was estimated by the Australian Bureau of Mineral Resources to be 20 202 kg, compared with 19 602 kg in 1977. Domestic consump-

Table 6. Gold auctions by the Department of the Treasury of the United States, 1978

Date of Sale in 1978	Average Bid Price	Amount of Gold Sales	Amount Bid For	Afternoon Fixing Price on London Gold Market on Day of Auction	Number of Successful Bidders
	($ U.S./troy ounce)	(troy ounces)	(troy ounces)	($ U.S./troy ounce)	
May 23	180.38	300 000	1 364 000	179.60	12
June 20	186.91	300 000	1 040 000	186.50	21
July 18	185.16	300 000	1 390 000	184.85	9
August 15	215.53	300 000	564 400	213.20	12
September 19	212.76	300 000	771 600	211.45	6
October 17	228.39	300 000	818 000	225.65	9
November 21	199.05	750 000	911 600	200.20	17
December 19	214.17	1 500 000	2 700 000	216.30	16
Total gold sales in 1978		4 050 000 (126 tonnes)			

Source: News release — The Department of the Treasury.

Table 7. Gold reserves of central banks and governments, December 31, 1978

Country	Value in Millions of SDR's; Gold Valued at SDR 35 per Fine Troy Ounce	Tonnes (millions of ounces) of Gold Fine	
		(tonnes)	(million ounces)
United States	9 675	8 597.93	(276.43)
Republic of West Germany	4 152	3 689.81	(118.63)
France	3 570	3 172.56	(102.00)
Switzerland	2 915	2 590.61	(83.29)
Italy	2 909	2 585.01	(83.11)
Netherlands	1 917	1 703.54	(54.77)
Belgium	1 491	1 325.01	(42.60)
Japan	839	745.55	(23.97)
United Kingdom	799	710.09	(22.83)
Canada	775	688.63	(22.14)
Portugal	775	688.63	(22.14)
Austria	737	655.04	(21.06)
Spain	508	451.31	(14.51)
Venezuela	399	354.58	(11.40)
Republic of South Africa	343	304.81	(9.80)
Lebanon	323	287.09	(9.23)
Other countries	3 512	3 120.92	(100.34)
International Monetary Fund	4 137	3 676.43	(118.20)
Other official Agencies	345	306.68	(9.86)
Estimated total world[1]	40 121	35 654.23	(1 146.31)

Sources: Value from International Financial Statistics — International Monetary Fund; tonnes of gold (ounces) calculated by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Excludes holdings of U.S.S.R., other eastern European countries and the Peoples' Republic of China.

tion was 5 000 kg and exports were 15 802 kg. The open-pit Telfer mine located in the northwestern district of Western Australia, in which Newmont Proprietary Limited has a 70 per cent interest and Dampier Mining Company Limited, a subsidiary of Broken Hill Proprietary Company Limited, a 30 per cent interest, recorded its first full year of production. This was responsible for the increase in gold output. Tests on heap leaching of low-grade ore from this deposit are being conducted.

The Kalgoorlie Mining Associates, a partnership consisting of Homestake Mining Company of the United States and Kalgoorlie Lake View Pty. Ltd. operated the Mt. Charlotte mine in the state of Western Australia. The mine was a substantial contributor to the gold output. The Blue Spee mine, a gold and antimony producer in Western Australia, in which Australian Anglo American Limited holds a controlling interest, closed in 1978.

Nicaragua. Noranda Mines Limited holds a 60.5 per cent interest in the Empresa Minera de el Setentrion mine in Nicaragua. In 1978, 120 000 tonnes were treated averaging 11 g of gold per tonne. Shortages of supplies slowed the mine development program.

Papua-New Guinea. Papua-New Guinea is a substantial producer of gold, mainly as a byproduct of the treatment of open-pit copper ore by Bougainville Copper Ltd. Gold production from this property was 23 359 kg in 1978, equivalent to about 44 per cent of total Canadian output. Some gold is recovered by small operators.

Philippines. The Philippines Bureau of Mines reported gold production to be 18 977 kg in 1978, an increase of about 9 per cent over 1977. Production is expected to increase over the next two to three years. The gold-silver refinery of the Central Bank of the Philippines became operational in the latter part of 1977 and the lode gold mines were required to sell all gold produced to the bank, for refining at this plant. This does not apply to byproduct gold producers, who ship copper concentrates containing gold elsewhere for treatment. The Philippine government has delayed indefinitely its plan to establish a gold stabilization fund to replace its subsidy program for lode gold mines experiencing financial problems. The plan would have imposed a tax on profitable mines and the proceeds would have been used to assist mines in financial trouble.

France. Mines et Produits Chimiques de Salsigne, in which Silver Eureka Corporation of Toronto has controlling interest, operates a gold mine in southern France which has been in operation for 55 years. Other metals recovered are silver, copper, arsenic and bismuth. It is planned to increase production by 100 per cent, if suitable financing can be arranged.

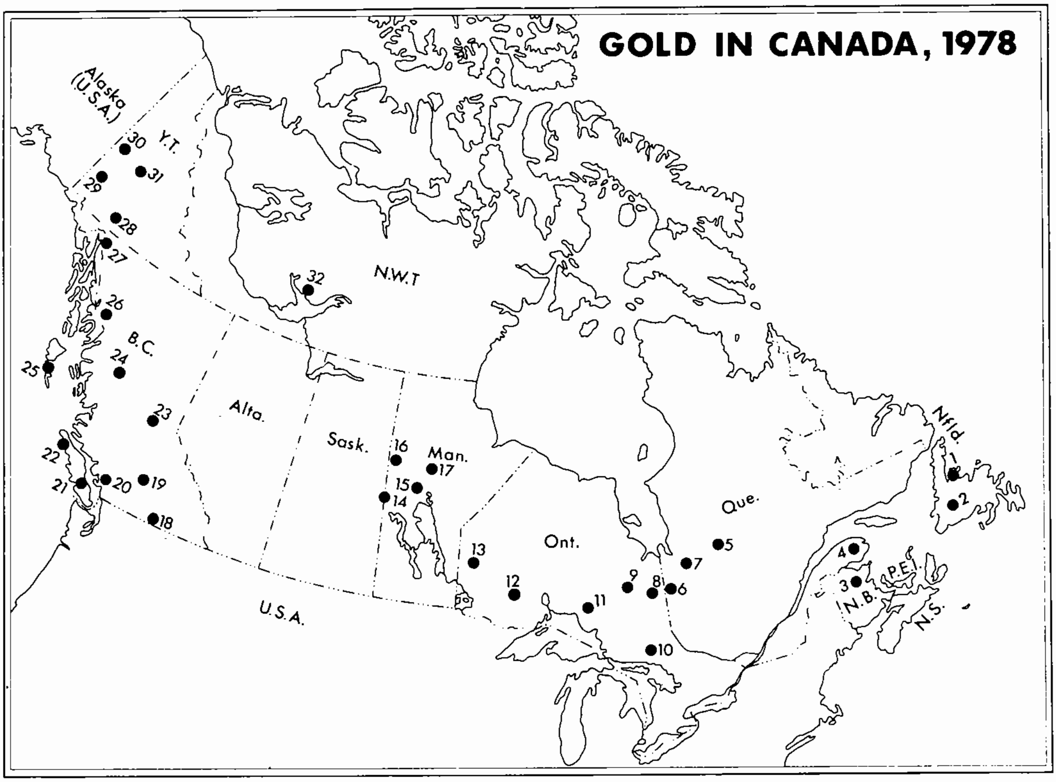
U.S.S.R. Detailed information on the U.S.S.R. gold industry is not available. Gold is recovered in the U.S.S.R. from placer gold deposits, mainly in the northeastern area; from lode mines and from base-metal ores as a byproduct. Placer deposits are the largest single contributor to gold output, although the lode gold mines are becoming increasingly more important. The consensus is that gold production in the U.S.S.R. will continue to increase over the next few years, but reports of a decline in placer reserves could slow this trend.

International Monetary Fund — gold auctions

At the meeting of the 20 finance ministers of the International Monetary Fund (IMF) Interim Committee held in Jamaica on January 7-8, 1976, an agreement was reached on the disposition of part of the IMF's official gold reserves. It was agreed that 777.6 tonnes of gold, one sixth of the IMF's reserves, would be auctioned over a four-year period, and the net proceeds from the sales would go into a trust fund administered by the IMF for the benefit of developing countries. It was also agreed that a further 777.6 tonnes of gold would be restituted over the four-year period to member countries of the IMF in proportion to their quotas in the Fund on August 31, 1975. The restituted gold would be offered at the price of 35 Special Drawing Rights (SDR) an ounce in four equal parts of 194.4 tonnes near the end of each year in which gold is auctioned.

The Second Amendment to the IMF Articles of Agreement became effective on April 1, 1978 following its acceptance by 60 per cent of the 133 IMF member countries that hold 80 per cent of the IMF's voting power. Part of the amendment relates to the reduction in the role of gold in the international monetary system, including the disposition of part of the IMF's gold holdings. Some of the important changes in relation to gold are: the function of gold as unit of value of the SDR has been eliminated; gold could not become a common denominator for par value currencies even if, at some future time, par values were introduced; the official price of gold has been abolished; and member countries are free to buy and sell gold at market related values.

Gold auctioned by the IMF to the end of 1978 amounted to 535.75 tonnes, about 69 per cent of the planned sales program. Details of the sale are shown in the accompanying table. The auctions should end by May 1980.



Gold Producers, 1978

(numbers refer to map on previous page)

Newfoundland

(1) Consolidated Rambler Mines Limited (a)*
(2) ASARCO Incorporated (Buchans Unit) (a)

New Brunswick

(3) Heath Steele Mines Limited (a)

Quebec

(4) Gaspé Copper Mines, Limited (a)
(5) Chibougamau district
Campbell Chibougamau Mines Ltd. (a)
Falconbridge Copper Limited (Opemiska Division) (a)
Lemoine Mines Limited
Patino Mines (Quebec) Limited (Copper Rand Division) (a)
(6) Noranda-Rouyn district
Falconbridge Copper Limited (Lake Dufault Division) (a)
Malartic — Val d'Or district
Camflo Mines Limited (b)
Darius Gold Mines Inc. (b)[1]
East Malartic Mines, Limited (b)
Lamaque Mining Company Limited (b)
Louvem Mining Company Inc. (a)
Sigma Mines (Quebec) Limited (b)
(7) Matagami district
Agnico-Eagle Mines Limited (b)
Mattagami Lake Mines Limited (a)
Orchan Mines Limited (a)[2]

Ontario

(8) Larder Lake Mining Division
Kerr Addison Mines Limited (b)
Pamour Porcupine Mines, Limited (Ross mine) (b)
Willroy Mines Limited (Macassa Division) (b)
(9) Porcupine Mining Division
Dome Mines, Limited (b)
Pamour Porcupine Mines, Limited (Nos. 1 and 3 mines and Timmins property) (b)
Pamour Porcupine Mines, Limited (Schumacher Division, McIntyre mine) (a & b)
(10) Sudbury Mining Division
Falconbridge Nickel Mines Limited (a)
Inco Limited (a)
(11) Thunder Bay Mining Division
Noranda Mines Limited (Geco Mine) (a)
(12) Patricia Mining Division
Falconbridge Copper Limited (Sturgeon Lake) Division (a)
(13) Red Lake Mining Division
Campbell Red Lake Mines Limited (b)
Dickenson Mines Limited (b)[3]
Robin Red Lake Mines Limited (b)[3]

Manitoba

(14) Hudson Bay Mining and Smelting Co., Limited (Flin Flon) (a)
(15) Hudson Bay Mining and Smelting Co., Limited (Snow Lake) (a)
(16) Sherritt Gordon Mines Limited (Fox Lake & Ruttan mines) (a)
(17) Inco Limited (a)

Saskatchewan

(14) Hudson Bay Mining and Smelting Co., Limited (a)

British Columbia

(18) Cominco Ltd. (a)
Granby Mining Corporation (Phoenix Division) (a)
(19) Afton Mines Ltd. (a)
Brenda Mines Ltd. (a)
Similkameen Mining Company Limited (a)
(20) Northair Mines Ltd. (b)
(21) Western Mines Limited (a)
(22) Utah Mines Ltd. (Island Copper Mine) (a)
(23) Small placer operations (c)
(24) Granby Mining Corporation (Granisle Division, (a)
Noranda Mines Limited (Bell Copper mine) (b)
(25) Wesfrob Mines Limited (a)
(26) Newmont Mines Limited (a) (Granduc Mine)[4]
(27) Small placer operations (c)

Yukon Territory

(28) Whitehorse Copper Mines Ltd. (a)
(29) Small placer operations (c)
(30) Small placer operations (c)
(31) Small placer operations (c)

Northwest Territories

(32) Cominco Ltd. (Con mine) (b)
Giant Yellowknife Mines Limited (b)
Lolor Mines Limited (b)
Rycon Mines Limited (b)
Supercrest Mines Limited (b)

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*(a) Base metal; (b) Auriferous quartz; (c) Placer.
[1]Opened in 1978. [2]Merged with Noranda Mines Limited on December 31, 1978. [3]These companies amalgamated to form Dickenson Mines Limited. [4]Closed in 1978.

In May the IMF announed a modification to the format of its gold sales beginning in June. The amount of gold offered at each sale was reduced from 525 000 ounces to 470 000 ounces. The bid price system would be used for awarding gold to successful bidders. The ratification of the Amendments to the Articles of Agreement allows governments and central banks to trade freely at the gold auctions. Arrangements were made for developing nations to submit noncompetitive bids for gold in proportion to each such nation's share in the IMF gold quota, as of August 31, 1975. The IMF reported that 39 developing countries reserved the right to submit noncompetitive bids at the gold auctions. These countries held 14.76 per cent of the IMF

Table 8. Principal gold (mine) producers in Canada, 1978 and (1977)

Company and Location	Mill or Mine Capacity	Gold	Silver	Copper	Combined Lead and Zinc	Ore Treated	Gold Produced	Remarks
		Grade of Ore Treated						
	(Tonnes of (ore/day)	(grams/ tonne)	(grams/ tonne)	(%)	(%)	(tonnes)	(kilograms)	
Newfoundland								
ASARCO Incorporated,	1 150	1.04	104.57	0.79	16.85	183 254	. .	Property expected to close
(Buchans Unit),	(1 150)	(0.75)	(97.04)	(0.99)	(16.88)	(174 180)	(102.8)	in 1979.
Buchans								
Consolidated Rambler Mines	1 100	2.74	26.40	4.70	—	247 878	478.8	
Limited,	(1 100)	(2.43)	(23.07)	(4.25)	(—)	(218 200)	(268.9)	
Baie Verte								
New Brunswick								
Heath Steele Mines Limited,	3 650	0.89	77.48	1.03	5.96	1 137 786	. .	
Newcastle	(3 650)	(0.69)	(68.23)	(1.22)	(5.43)	(1 150 338)	(265.6)	
Quebec								
Agnico-Eagle Mines Limited,	900	6.55	. .	—	—	328 293	1 964.4	Developing lower levels.
Joutel	(900)	(6.13)	(. .)	(—)	(—)	(329 791)	(1 974.5)	
Camflo Mines Limited,	1 130	5.79	. .	—	—	427 090	2 367.0	
Malartic	(1 130)	(6.00)	(. .)	(—)	(—)	(428 015)	(2 715.6)	
Campbell Chibougamau Mines	3 600	2.85	. .	1.40	—	221 357	528.8	Figures for fiscal year
Ltd.,	(3 600)	(2.02)	(7.51)	(1.56)	(—)	(261 274)	(435.4)	ending June 30, 1978.
Cedar Bay, Henderson and								Merrill Pit mine closed.
Merrill Pit Mines,								
Chibougamau								
Darius Gold Mines Inc.,	190	. .	. .	. .	. .	. .	. .	Tune-up operations began
Cadillac								in October, 1978.
East Malartic Mines, Limited,	1 630	2.95	. .	—	—	539 435	1 528.8	Limited ore reserves.
Malartic	(1 630)	(3.19)	(. .)	(—)	(—)	(561 028)	(1 738.1)	

Falconbridge Copper Limited, Lake Dufault Division, Millenbach and Norbec mines, Noranda Rouyn	1 400 (1 400)	0.82 (0.78)	43.5 (38.73)	3.36 (3.27)	3.85 (3.74)	371 952 (389 967)	245.7 (238.6)	Corbet mine expected to commence production in 1979.
Falconbridge Copper Limited, Opemiska Division Perry, Springer and Cooke mines, Chapais	2 700 (2 700)	1.88 (1.06)	14.05 (13.89)	1.99 (2.05)	— (—)	967 982 (927 158)	1 561.4 (849.1)	Cooke mine, substantial gold producer recorded first full year of production
Lamaque Mining Company Limited, Val d'Or	1 900 (1 900)	4.49 (4.59)	. . (. .)	— (—)	— (—)	451 124 (427 636)	2 124.4 (1 851.3)	Developing flats in north end of property.
Lemoine Mines Limited, Chibougamau	350 (350)	5.31 (5.31)	94.63 (100.78)	4.97 (4.67)	11.18 (10.64)	105 235 (110 678)	435.4 (435.4)	
Louvem Mining Company Inc., Val d'Or	900 (900)	1.75 (1.03)	25.60 (41.83)	0.15 (0.12)	6.25 (6.11)	248 077 (277 842)	123.4 (288.6)	Mine operations suspended in 1978.
Mattagami Lake Mines Limited, Matagami	3 500 (3 500)	0.51 (0.48)	32.57 (30.9)	0.52 (0.52)	7.56 (6.6)	878 170 (946 343)	187.0[e] (202.0)	Continuing development for deep exploration project.
Patino Mines (Quebec) Limited, Chibougamau	2 540 (2 540)	3.39 (3.65)	9.60 (10.63)	1.60 (1.74)	— (—)	616 896 (605 102)	1 617.4 (1 634.0)	
Sigma Mines (Quebec) Limited, Val d'Or	1 270 (1 270)	5.25 (5.55)	. . (. .)	— (—)	— (—)	447 532 (450 233)	2 274.1 (2 413.6)	

Table 8. (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Treated: Gold	Silver	Copper	Combined Lead and Zinc	Ore Treated	Gold Produced	Remarks
	(tonnes of ore/day)	(grams/ tonne)	(grams/ tonne)	(%)	(%)	(tonnes)	(kilograms)	
Ontario								
Campbell Red Lake Mines Limited, Red Lake	720 (720)	22.39 (23.60)	. . (. .)	— (—)	— (—)	273 067 (269 663)	5 708.9 (5 941.7)	Negotiations concluded for sale of 726 to 910 tonnes of arsenic trioxide per year over 5-year period.
Dickenson Mines, Limited, Red Lake	430 (430)	18.65 (17.11)	. . (. .)	— (—)	— (—)	100 189 (117 196)	1 794.5 (1 866.8)	Dickenson & Robin amalgamated in 1978. Figures are consolidation of operations.
Dome Mines, Limited, South Porcupine	1 720 (1 720)	4.94 (4.71)	. . (. .)	— (—)	— (—)	616 170 (622 216)	2 928.7 (2 931.8)	
Falconbridge Copper Limited, Sturgeon Lake Division, Sturgeon Lake	1 100 (1 100)	0.72 (0.89)	171.77 (342.86)	2.73 (3.46)	10.31 (11.70)	370 138 (383 927)	171.1 (214.6)	Limited ore reserves.
Falconbridge Nickel Mines Limited, Sudbury district	11 200 (11 200)	. . (. .)	. . (. .)	0.78 (0.74)	— (—)	2 071 138 (2 599 318)	. . (. .)	Cutback in production in 1978.
Inco Limited, Sudbury and Shebandowan districts, Ontario and Thompson, Manitoba	61 200 (61 200)	. . (. .)	. . (. .)	. . (1.15)	— (—)	. . (14 628 655)	. . (. .)	Production cutbacks in 1978, labour strike beginning in in September.
Kerr Addison Mines Limited, Virginiatown	637[1] (594)[1]	11.31 (15.43)	. . (. .)	— (—)	— (—)	232 408 (216 882)	2 588.3 (3 301.3)	Limited ore reserves.
Pamour Porcupine Mines, Limited, No. 1 mine, Pamour	1 945[1] (2 317)[1]	2.85 (2.93)	. . (. .)	— (—)	— (—)	709 928 (767 351)	1 843.4 (2 024.7)	

Pamour Porcupine Mines, Limited, No. 3 mine, Pamour	278[1] (262)[1]	6.48 (7.58)	.. (..)	— (—)	— (—)	101 467 (95 739)	587.6 (657.6)	
Pamour Porcupine Mines, Limited Timmins & Romfield properties, Timmins	728[1] (562)[1]	2.78 (3.39)	.. (..)	— (—)	— (—)	266 079 (205 214)	636.6 (604.4)	Largely open-pit ore.
Pamour Porcupine Mines, Limited, Schumacher Division, Schumacher	1 422[1] (1 612)[1]	2.43 (2.40)	2.67 (..)	— (—)	— (—)	519 230 (588 307)	1 089.8 (1 208.7)	
Pamour Porcupine Mines, Limited, Ross mine, Holtyre	596[1] (425)[1]	4.80 (4.63)	9.70 (..)	— (—)	— (—)	217 638 (155 301)	861.8 (613.9)	Shaft deepened one level.
Willroy Mines Limited, Macassa Division, Kirkland Lake	450 (450)	17.75 (18.55)	.. (..)	— (—)	— (—)	101 077 (92 931)	1 691.7 (1 731.6)	
Manitoba-Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited Flin Flon and Snow Lake districts	7 700 (7 700)	1.37 (1.37)	20.6 (20.6)	2.3 (2.20)	3.3 (3.0)	1 679 403 (1 652 526)	1 289.8 (1 390.5)	Western mine opened in January. Snow Lake concentrator scheduled for completion in March 1979.
Inco Limited Thompson	16 700 (16 700)	included with Ontario figures						

Table 8. (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Treated: Gold	Silver	Copper	Combined Lead and Zinc	Ore Treated	Gold Produced	Remarks
	(tonnes of ore/day)	(grams/ tonne)	(grams/ tonne)	(%)	(%)	(tonnes)	(kilograms)	
Manitoba-Saskatchewan (cont'd)								
Sherritt Gordon Mines Limited Fox mine, Lynn Lake	2 700 (2 700)	. . (. .)	. . (. .)	1.31 (1.46)	1.79 (1.93)	874 541 (807 408)	. . (145.0)	
Sherritt Gordon Mines Limited Ruttan mine Grand Rapids	9 100 (9 100)	. . (. .)	. . (. .)	1.17 (1.13)	1.57 (1.95)	2 307 010 (2 256 206)	. . (453.8)	Underground mining to begin in 1979.
British Columbia								
Afton Mines Limited, Kamloops	6 350	0.62	. .	1.0	—	1 085 918	646.9	Fiscal year ending Sept. 30, 1978 covers only 5-months operation.
Granby Mining Corporation, Granisle mine, Babine Lake	11 800 (11 800)	. . (0.17)	. . (2.06)	0.41 (0.44)	— (—)	4 626 720 (4 538 342)	464.8 (559.6)	Grandby, Granisle Copper Limited and Zapata Canada Limited amalgamated Jan. 1, 1979 to form Zapata Grandby Corporation.
Grandby Mining Corporation, Phoenix mine, Greenwood	2 600 (2 600)	. . (0.5)	. . (5.08)	0.38 (0.39)	— (—)	467 993 (833 829)	. . (265.5)	Milling of stockpiled ore completed, mill closed.
Newmont Mines Limited, Granduc Operating Division, Stewart	7 260 (7 260)	. . (. .)	. . (. .)	1.43 (1.31)	— (—)	740 275 (1 333 584)	. . (167.0)	Closed June 30, 1978.
Newmont Mines Limited, Similkameen Division, Princeton	22 000 (22 000)	0.16 (0.16)	0.59 (0.64)	0.41 (0.37)	— (—)	6 779 506 (7 136 035)	1 153.9 (1 094.8)	Developing Copper Mountain ore bodies.
Noranda Mines Limited, Bell Copper Division, Babine Lake	9 100 (9 100)	0.31 (0.31)	. . (. .)	0.43 (0.43)	— (—)	4 469 774 (4 408 882)	715.4 (714.6)	

Northair Mines Ltd., Brandywine	270 (270)	12.00 (14.40)	67.5 (121.35)	— (—)	3.10 (3.69)	102 414 (93 904)	1 024.1 (1 175.6)	Year ending Feb. 28, 1979. Year ending Feb. 28, 1978.
Utah Mines Ltd., Island Copper mine, Coal Harbour, Vancouver Island	34 500 (34 500)	.. (..)	.. (..)	0.40 (0.42)	— (—)	14 200 517 (13 110 000)	1 380.0 (1 500.0)	
Western Mines Limited, Buttle Lake, Vancouver Island	1 000 (1 000)	2.86 (2.71)	139.9 (147.1)	1.25 (1.14)	9.57 (8.92)	269 039 (269 069)	547.5 (508.3)	
Yukon Territory								
Whitehorse Copper Mines Ltd., Whitehorse	2 300 (2 300)	0.86 (0.93)	7.82 (9.60)	1.40 (1.65)	— (—)	789 083 (817 790)	626.0 (748.3)	
Northwest Territories								
Cominco Ltd., Con and Rycon mines, Yellowknife	700 (700)	18.86 (21.26)	.. (..)	— (—)	— (—)	199 584 (142 430)	3 561.3 (2 889.5)	
Giant Yellowknife Mines Limited, Yellowknife	907[1] (977)[1]	8.98 (8.71)	.. (..)	— (—)	— (—)	331 078 (356 691)	2 645.3 (2 729.5)	27 per cent of mill feed from open-pit workings.
Lolar Mines Limited, Yellowknife	26[1] (19)[1]	11.07 (10.80)	.. (..)	— (—)	— (—)	9 574 (6 952)	94.8 (65.8)	Ore treated at Giant mill.
Supercrest Mines Limited, Yellowknife	53[1] (113)[1]	13.41 (14.02)	.. (..)	— (—)	— (—)	19 195 (41 142)	228.2 (506.1)	Ore treated at Giant mill.

Source: Company reports.
[1] Average daily tonnage milled.
— Nil; .. Not available; [e] Estimated.

quotas and were eligible for 3.7 million ounces of the total 25 million ounces of gold. Eleven countries took advantage of this option in 1978 and were awarded a total of 1 384 000 ounces.

In January 1978, the second of four annual restitutions of 194.4 tonnes of gold to member countries was completed. The restitution was made in proportion to each country's individual quota in the Fund as of August 31, 1975 at a price of SDR 35 an ounce of gold fine.

Beginning in May 1978 the United States Treasury held monthly gold auctions. A total of 4.05 million ounces (126 tonnes) were sold in 1978. At the first six auctions 300 000 ounces of gold were offered for sale. At the seventh auction, sales were increased to 750 000 ounces and at the eighth auction, sales were further increased to 1.5 million ounces. The successful bidders were mainly European and North American banks and bullion dealers. Details of the gold auction are shown in the accompanying table.

The Indian government began a gold auction program in May to curb gold smuggling and bidding was restricted to licensed internal gold dealers. Importation of gold into India has been prohibited and has resulted in a price well above the world market price. Gold for these auctions reportedly came from gold previously confiscated from smugglers. The Indian government suspended the gold auctions in October, having sold about 12.9 tonnes in 1978.

Price

The price of gold on the London Gold Market, in United States dollars, varied considerably in 1978, but the trend was sharply upwards. The price variations were generally the markets reaction to political and economic problems and government announcements of ways and means to solve these problems.

The weakness of the United States dollar in relation to the currencies of other major western trading countries was a leading cause of higher gold prices. It is noted that much smaller gains in the price of gold were recorded against other leading world currencies, although greater advances were recorded towards the end of the year.

The opening gold price on the London market in 1978 was $ U.S. 168.60 a troy ounce, reaching a low for the year of $ U.S. 165.70 an ounce on January 5. An all time high of $ U.S. 243.65 an ounce was recorded on October 31. The closing gold price for 1978 was $ U.S. 226.00.

The gold price increased sharply during the first three months of the year, from a monthly average of $ U.S. 173.18 an ounce in January to $ U.S. 183.66 an ounce in March, owing to the weakness of the United States dollar, uncertainty of the outcome of the French elections to be held in March and a strong demand for gold from the Far East. The average gold price for April dropped to $ U.S. 175.28 an ounce on the announcement by the United States Treasury that it would auction 300 000 ounces of gold a month over a six-month period. In May the gold price resumed its upward trend when it became evident that the market could absorb the extra gold and that there was no improvement in the rate of inflation in the United States. The average gold price for the month of October was $ U.S. 227.41, the high for 1978. On November 1, the United States government announced a package deal designed to defend the dollar. One of the measures was an increase in the amount of gold to be auctioned each month to 1.5 million ounces, beginning at the December sale. The new initiatives adopted strengthened the value of the dollar and as a consequence the gold price dropped to below $ U.S. 200 an ounce by mid-November. The gold price resumed its upward trend again in mid-December because of the announcement by the OPEC countries that oil prices would be raised and because of political problems in Iran.

The average gold price for 1978 based on the afternoon fixing on the London Gold Market was $ U.S. 193.23 an ounce, compared with $ U.S. 147.72 an ounce in 1977. The equivalent Canadian gold price based on the average currency exchange rate differential between the United States and Canadian dollar for 1978 was $ Cdn. 220.41 an ounce, compared with $ Cdn. 157.09 an ounce in 1977.

Uses and consumption

Gold has traditionally been used as a monetary reserve by governments and central banks in the settlement of international balances, but since August 1971, when the President of the United States suspended the convertibility of the U.S. dollar into gold, it has not been used for this purpose. With the ratification of the Second Amendment of the IMF Articles of Agreement, gold ceased to have an official price. It is worth noting that although gold no longer has an official price, most countries, the United States being the main exception, are maintaining the amount of gold held in their reserves.

The major uses of gold are in the jewellery trade, the electronics industry, and for dentistry, coinage and medallions, and decorative applications. In the industrial field research has been directed towards the development of technology leading to a more efficient use of gold, such as a thinner film in gold plating, selective and spot gold-plating, a high carat surface on a low carat base. Other precious metals, chiefly silver, platinum and palladium, can be used in place of gold in many applications.

Consolidated Gold Fields estimated non-communist world consumption of gold for fabrication purposes to be 1 551 tonnes in 1978, a substantial increase from 1 405 tonnes in 1977. A sharp increase in the demand for official coins was largely responsible for the increase. In 1978 all other sectors, with the exception of medals, medallions and illegal numismatic coins had small increases in gold consumed.

In spite of the high price of gold, the jewellery industry in the non-communist world consumed 1 000.8 tonnes of gold in 1978, about 64.5 per cent of the total consumption. In 1977 the jewellery industry used 995.6 tonnes. Normally a sharp rise in the price of gold, such as that experienced in 1978, leads to a drop in the use of gold; this did not occur in 1978 for a number of reasons. Disposable income was used for the purchase of gold jewellery either for its aesthetic qualities or, in the case of high-carat jewellery, for investment purposes. Promotional activity made the public more aware of gold. In some currencies the gold price rise was much less than that of the dollar. Gold consumption by most countries for the fabrication of jewellery in 1978 varied slightly from 1977 but significant drops occurred in Iran and Indonesia, with Japan reporting a sharp increase in consumption. Gold used in the minting of official gold coins in 1978 was 259 tonnes, which was 6.6 per cent of total gold consumed, compared with 137 tonnes in 1977. It is noted that about 84 per cent of the gold consumed by industry in 1978 was used by the jewellery trade, and for minting official gold coinage and in medallions.

There was increased interest in numismatic and bullion gold coins in 1978. The Gold Institute/l'Institut de l'Or prepared a report on the official gold coinage issued in 1978. The report showed that 49 countries issued a total of 128 gold coins of varying gold content. Total gold consumed was 234.1 tonnes (7 281 005 ounces), an increase of about 122 per cent over 1977 consumption. The krugerrand, the 1-ounce gold coin of the Republic of South Africa, accounted for about 84 per cent of the total. The United States became the largest market for the krugerrand in 1978, with purchases of about 3.2 million coins. Other major purchasers were West Germany and Switzerland. The krugerrand gives the small investor an opportunity to invest in gold. Other countries that consumed a significant amount of gold in minting gold coins were Mexico, the U.S.S.R. and Canada.

The U.S.S.R. is issuing six legal tender 100 rouble gold coins to commemorate the 1980 Olympics to be held in Moscow. Two of the coins (130 000 of each) were issued in 1978, with each coin containing 15.55 g (one-half ounce) of gold. The United States Congress passed legislation in October authorizing the United States Treasury to issue a series of commemorative coins. The program is to last five years beginning in 1979 and the medallions will be issued in one ounce and one-half ounce size. The amount of gold to be used in each issue is at least one million ounces and will comes from Treasury reserves. This program should be successful, as the medallions will be sold at the cost of the contained bullion plus manufacturing and distribution costs. Sales structure of the medallions will be similar to that of legal tender bullion coins. At year-end, Congress had not approved the funds necessary to finance the program.

Outlook

The normal demand-supply situation that exists for other metals does not apply to gold because of the enormous stocks in the hands of governments, investors, speculators and hoarders. The overhanging uncertainty of possible gold sales to the world market by the communist countries, chiefly the U.S.S.R., also affects the demand-supply equation. Sales from stocks and by the U.S.S.R. are difficult to predict and this complicates efforts to determine future gold price patterns. Another major problem encountered in forecasting the price of gold is that investment in gold has been used as a hedge against rapidly increasing inflation and weakening currencies, especially the U.S. dollar. The gold price is expected to continue its upward trend, at or slightly above, the rate of inflation.

Table 9. Average annual price of gold, 1965, 1970 and 1975-78

	London Gold Market[1]		Royal Canadian Mint[2]
	($ U.S.)	(Equiv. $ Cdn. per troy ounce)	($ Cdn.)
1965	37.76	40.82	37.73
1970	35.97	37.55	36.56
1975	161.018	163.781	43.22
1976	124.836	123.107	39.85
1977	147.718	157.089	43.49
1978[p]	193.228	220.407	. .

Sources: Sharpes Pixley; Royal Canadian Mint.
[1] Annual average of London Gold Market afternoon fixing price, as reported by Sharpes Pixley Ltd.. [2] Annual average of the Royal Canadian Mint weekly published buying price.
[p] Preliminary; . . Not available.

In the first half of 1979 the gold price has increased to over $ U.S. 280 an ounce, largely because of problems relating to oil shortages and pending increases in oil prices. The gold price increased in spite of an improvement in exchange rates for the United States dollar and the large official gold sales by the United States Treasury. The consumption of gold in all sectors in the non-communist world in 1979 is expected to closely parallel the performance of 1978, which is a bullish factor, as new mine production is well below world consumption. The gold price is expected to remain strong with the price advancing to near $ U.S. 300 in 1979. Prices could ease as a result of profit taking or larger official sales but the price is not expected to decline drastically because of counterbalancing economic factors. The U.S.S.R. sells gold to finance purchases of capital goods and wheat and it is expected that any future U.S.S.R. sales will be carried out in a manner least disruptive to the world gold price. In 1978 sales amounted to 410 tonnes.

In the short term gold production in Canada is expected to decline. New properties scheduled for production in late 1979 or early 1980 will at best offset losses in production by pending mine closures or by present producers taking advantage of the high gold price to mine lower grade ore, thereby extending the life of their operations. There are no major developments on the horizon that could significantly add to Canada's gold output. The high gold price has generated only a moderate amount of activity in gold exploration.

In the short term, gold production in the non-communist world is expected to increase because of three large mines in the Republic of South Africa coming into production. One of these mines came into production late in 1978 and the other two will come into production in late 1979 or early 1980. South African gold production should increase to the mid-1980s when it is expected to decline as older mines deplete reserves or mine lower grade ore. No major exploratory programs are being carried out in other parts of the world.

The shortfall between world primary gold production and consumption began in 1970 and has increased steadily. The difference has been made up by U.S.S.R. sales and lately by sales from official sources. This shortfall will continue. It is estimated that overall supply of gold to the world market in 1979 will be about 1 900 tonnes provided that the United States Treasury continues its sales at the revised rate of 750 000 ounces a month and provided that 1979 sales of gold by the U.S.S.R. are between 350 and 400 tonnes.

Gypsum and Anhydrite

D.H. STONEHOUSE

Canadian production and developments

Production of gypsum in Canada, being closely related to activity in the building construction industry in both Canada and the United States, particularly the eastern United States, reached a record 7.9 million tonnes* in 1978. Exports, traditionally about 70 per cent of shipments, were at a record 5.2 million tonnes while domestic consumption increased by 23 per cent to an apparent 2.8 million tonnes.

Wallboard, lath and sheathing are the principal gypsum products. Minor tonnages of plaster of paris and joint-filling compounds are also produced. Wallboard production was nearly 200 million square metres (m^2) in 1978, up some 16 per cent over 1977. Western plants were hard pressed to meet demand as imports were significantly reduced during the year because of the strong demand for wallboard in the United States. In fact some exports of wallboard from Ontario to the United States were reported.

During 1978 plant construction and mine expansion continued at the Ontario operations of both Domtar Inc. and Canadian Gypsum Company, Limited. A new shaft at Westroc Industries Limited's Drumbo, Ontario mine was scheduled to be producing by January 1979. Westroc began shipments from a new quarry at Amaranth, Manitoba in mid-October 1978.

Domtar Inc. purchased the integrated gypsum wallboard and covering paper plants of Kaiser Cement & Gypsum Co. in Long Beach and San Leandro, California. Also included in the sale were two ships currently used to haul gypsum from Mexico to the California plants. This acquisition represents Domtar's first major move into the United States gypsum industry. The company already operates two lime-producing plants in the United States — one at Tacoma, Washington, and one at Bellefonte, Pennsylvania. Early in 1979 Domtar announced a "multi million dollar" expansion program for its newly acquired U.S. wallboard plants.

Domtar Inc., Genstar Limited and Westroc Industries Limited pleaded guilty in May 1978 to conspiring together, and with Canadian Gypsum Company, Limited, to prevent competition in the sale of gypsum wallboard. They were fined a total of $275 000 under the Combines Investigation Act. The three companies, controlling 90 per cent of the Western Canadian wallboard market, sold about $127 million worth of wallboard during 1967-72, but offered the defense that the agreement to lower prices was necessary to protect themselves against wallboard dumped in the southern prairies by United States manufacturers.

Markets, trends and outlook

Because gypsum is a relatively low-cost, high-bulk mineral commodity it is generally produced from those deposits situated as conveniently as possible to areas in which markets for gypsum products exist. Exceptions occur if deposits of unusually high quality are available, even at a somewhat greater distance from markets, if comparatively easy and inexpensive mining methods are applicable, or if low-cost, high-bulk shipping facilities are accessible. Nova Scotia and Newfoundland deposits meet all three of these criteria and have been operated for many years by, and for, United States companies in preference to United States deposits. Crude gypsum, mainly from the Newfoundland port of St. George's and from Halifax and Little Narrows in Nova Scotia, is also shipped to the Montreal and Toronto areas for use in gypsum products manufacture and portland cement production.

Since the closure of the Westroc Industries Limited mine at Silver Plains, Manitoba, gypsum from Windermere, British Columbia has been rail-hauled abnormally long distances to supply the needs of cement producers and the gypsum products industry in the prairie provinces. Start up of an open-pit mine at Amaranth, Manitoba by Westroc should benefit all consumers in the Prairie region. Raw gypsum is imported on the west coast from Mexico, mainly for cement manufacture. Minor amounts of crude gypsum have been shipped to the mid-United States for agricultural use, and quantities have been exported to the northwestern

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, gypsum production and trade, 1977 and 1978

	1977		1978ᵖ	
	(tonnes)	($)	(tonnes)	($)
Production (shipments)				
Crude gypsum				
Nova Scotia	5 079 297	20 817 065	5 375 000	23 653 000
Newfoundland	603 340	3 213 601	831 000	4 580 000
Ontario	699 390	3 991 126	724 000	4 209 000
British Columbia	669 143	2 366 952	741 000	3 172 000
Manitoba	135 770	611 314	161 000	767 000
New Brunswick	46 991	375 547	57 000	379 000
Total	7 233 931	31 375 605	7 889 000	36 760 000
Imports				
Crude gypsum				
Mexico	14 248	252 000	58 358	1 313 000
United States	9 760	312 000	12 436	344 000
United Kingdom	16	1 000	201	4 000
Belgium and Luxembourg	18	10 000	–	–
Total	24 042	575 000	70 995	1 661 000
Plaster of paris and wall plaster				
United States	20 811	2 044 000	20 847	2 668 000
United Kingdom	291	35 000	385	59 000
Italy	5	4 000	35	24 000
West Germany	153	11 000	18	3 000
Other countries	29	8 000	92	8 000
Total	21 289	2 102 000	21 377	2 762 000
	(square metres)		(square metres)	
Gypsum lath, wallboard and basic products				
United States	13 438 769	7 282 000	4 174 539	3 308 000
Total	13 438 769	7 282 000	4 174 539	3 308 000
Total imports gypsum and gypsum products		9 959 000		7 731 000
	(tonnes)		(tonnes)	
Exports				
Crude gypsum				
United States	4 977 822	19 072 000	5 142 424	22 837 000
Bahamas	–	–	36 180	193 000
Taiwan	16 501	72 000	–	–
Total	4 994 323	19 144 000	5 178 604	23 030 000

Source: Statistics Canada.
ᵖPreliminary; — Nil.

United States from British Columbia, mainly for use by cement manufacturers.

Gypsum products are not shipped great distances because freight and handling costs represent a major part of the price to the consumer for items that are relatively low-priced and readily available at many locations. However, substantial quantities of wallboard are imported from the United States each year. During 1978 a total of 4.2 million m² valued at $3.3 million was imported, down from 1977 imports of 13.1 million m² at $7.3 million. Ontario, Alberta and Quebec are the leading importing provinces. With modern containerized shipments becoming more popular and with the trend to trade off economic and environmental factors, the establishment of wallboard plants at the raw material source could become attractive. Greater use of gypsum products in nonresidential construction has been of major importance to the industry. Its fire-retardant and sound-insulating properties have made it a preferred material for elevator shaft lining, mobile home manufacture and housing rehabilitation.

Table 2. Canada, summary of gypsum mining operations, 1978

Company	Location	Remarks
Newfoundland		
Flintkote Holdings Limited	Flat Bay	Open-pit mining of gypsum
Nova Scotia		
Little Narrows Gypsum Company Limited	Little Narrows	Open-pit mining of gypsum and anhydrite
Georgia-Pacific Corp. Bestwall Gypsum Division	River Denys	Open-pit mining of gypsum
Fundy Gypsum Company Ltd.	Wentworth and Miller Creek	Open-pit mining of gypsum and anhydrite
National Gypsum (Canada) Ltd.	Milford	Open-pit mining of gypsum
Domtar Inc.	MacKay Settlement	Open-pit mining of gypsum
New Brunswick		
Canadian Gypsum Company, Limited	Hillsborough	Open-pit mining of gypsum
Canada Cement Lafarge Ltd.	Havelock	Open-pit mining of gypsum used in cement manufacture
Ontario		
Canadian Gypsum Company, Limited	Hagersville	Underground mining of gypsum
Domtar Inc.	Caledonia	Underground mining of gypsum
Westroc Industries Ltd.	Drumbo	Underground mine development
Manitoba		
Domtar Inc.	Gypsumville	Open-pit mining of gypsum
Westroc Industries Ltd.	Amaranth	Open-pit mining of gypsum
British Columbia		
Western Gypsum Ltd.	Windermere	Open-pit mining of gypsum

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.

Construction expenditures in both Canada and the United States are expected to increase in 1979. Construction of homes, apartments, schools and offices will continue and the need for gypsum-based building products will rise steadily. Although new construction materials are being introduced, gypsum wallboard will remain popular because of its low price, ease of installation and well-recognized insulating and fire-retarding properties. The present structure of the gypsum industry in Canada is unlikely to change greatly in the near future. Building materials plants either have sufficient capacities to meet the short-term, regional demand for products, or are implementing expansion programs to provide greater capacity.

Technology

Gypsum is a hydrous calcium sulphate ($CaSO_4 \cdot 2H_2O$) which, when calcined at temperatures ranging from 120° to 205°C, releases three-quarters of its chemically combined water. The resulting hemihydrate of calcium sulphate, commonly referred to as plaster of paris, when mixed with water, can be moulded, shaped or spread and subsequently dried, or set, to form a hard plaster product. Gypsum is the main mineral constituent in gypsum wallboard, lath and tile. Anhydrite, an anhydrous calcium sulphate ($CaSO_4$), is commonly associated geologically with gypsum.

Crude gypsum is crushed, pulverized and calcined to form stucco, which is mixed with water and aggregate (sand, vermiculite or expanded perlite) and applied over wood, metal or gypsum lath to form interior wall finishes. Gypsum board, lath and sheathing are formed by introducing a slurry of stucco, water, foam, pulp and starch between two unwinding rolls of absorbent paper, the result is a continuous "sandwich" of wet board. As the stucco hardens, the board is cut to predetermined lengths, dried, bundled and stacked for shipment.

Table 3. Canada, summary of gypsum products operations, 1978

Company	Location	Remarks
Newfoundland		
Atlantic Gypsum Ltd.	Corner Brook	Gypsum products manufacture
Nova Scotia		
Domtar Inc.	Windsor	Gypsum plaster manufacture
New Brunswick		
Canadian Gypsum Co., Ltd.	Hillsborough	Gypsum products manufacture
Quebec		
Canadian Gypsum Co. Ltd.	Montreal	Gypsum products manufacture
Canadian Gypsum Co. Ltd.	St-Jerome	Gypsum products manufacture
Domtar Inc.	Montreal	Gypsum products manufacture
Westroc Industries Ltd.	Ste-Catherine d'Alexandrie	Gypsum products manufacture
Ontario		
Canadian Gypsum Co. Ltd	Hagersville	Gypsum products manufacture
Domtar Inc.	Caledonia	Gypsum products manufacture
Westroc Industries Ltd.	Clarkson	Gypsum products manufacture
Manitoba		
Domtar Inc.	Winnipeg	Gypsum products manufacture
Westroc Industries Ltd.	Winnipeg	Gypsum products manufacture
Saskatchewan		
Genstar Limited	Saskatoon	Gypsum products manufacture
Alberta		
Domtar Inc.	Calgary	Gypsum products manufacture
Westroc Industries Ltd.	Calgary	Gypsum products manufacture
Genstar Limited	Edmonton	Gypsum products manufacture
British Columbia		
Westroc Industries Ltd.	Vancouver	Gypsum products manufacture
Domtar Inc.	Vancouver	Gypsum products manufacture
Genstar Limited	Vancouver	Gypsum products manufacture

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.

Keene's cement is made by converting crushed gypsum to insoluble anhydrite by calcining at temperatures as high as 700°C, usually in rotary kilns. The ground calcine, mixed with a set accelerator, produces a harder and stronger plaster product than ordinary gypsum plaster.

Crude gypsum is also used in the manufacture of portland cement where it acts as a retarder to control set. It is used as a filler in paint and paper manufacture, as a substitute for salt cake in glass manufacture and as a soil conditioner.

Byproduct gypsum, produced from the acidulation of phosphate rock in phosphate fertilizer manufacture, has not been utilized in Canada despite available technology from European countries and from Japan. In these countries, byproduct gypsum is used in the manufacture of gypsum products, by cement manufacturing plants, and also for soil stabilization. Recent studies have indicated that a potential radiation hazard exists in the use of phosphogypsum produced from sedimentary phosphate rock which can contain significant quantities of uranium and radium. Methods of extracting U_3O_8 from the phosphoric acid product have been devised, but removal of radium from the byproduct phosphogypsum is yet to be accomplished.

The use of lime or limestone to desulphurize stack gases from utility or industrial plants burning high-sulphur fuel will also result in production of large amounts of waste gypsum sludge, which in itself will present disposal problems if profitable uses are not developed.

Canadian Standards Association standards A 82.20 and A 82.35 relate to gypsum and gypsum products.

Occurrences

Gypsum occurs in abundance throughout the world but,

Table 4. World production of gypsum, 1977 and 1978

	1977	1978[e]
	(000 tonnes)	
United States	12 147	13 335
Canada	7 234	7 889
Iran	6 713	6 713
France	5 806	5 806
Spain	4 300	4 536
Italy	4 180	4 173
United Kingdom	3 266	3 538
West Germany	2 100	2 177
Mexico	1 496	1 633
Other Free World	10 327	10 433
Communist countries	8 092	8 165
World total	65 661	68 398

Sources: United States Bureau of Mines, Commodity Data Summaries, January 1979; Statistics Canada.
[e]Estimated.

because its use is dependent on the building construction industry, developments are generally limited to the industrialized countries. Reserves are extremely large and are conservatively estimated at over 2 billion tonnes. In Canada many occurrences besides those currently being exploited are known – in the southwest lowlands, west of the Long Range Mountains in Newfoundland; throughout the central and northern mainland of Nova Scotia as well as on Cape Breton Island; in the southeastern counties of New Brunswick; on the Magdalen Islands of Quebec; in the Moose River, James Bay and southwestern regions of Ontario; in Wood Buffalo National Park, in Jasper National Park, along the Peace River between Peace Point and Little Rapids, and north of Fort Fitzgerald in Alberta; on Featherstonhaugh Creek, near Mayook, at Canal Flats, Loos, and Falkland in British Columbia; on the shores of Great Slave Lake, the Mackenzie, Great Bear and Slave rivers in the Northwest Territories; and on several Arctic islands.

The United States is the world's largest single producer of natural-gypsum and, together with Canada, brings North American production to about 30 per cent of world output.

Table 5. Canada, gypsum production, trade and consumption, 1965, 1970 and 1975-78

	Production[1]	Imports[2]	Exports[2]	Apparent Consumption[3]
	(tonnes)			
1965	5 720 370	68 432	4 306 068	1 482 734
1970	5 732 068	35 271	4 402 843	1 364 496
1975	5 719 451	55 338	3 691 676	2 083 113
1976	6 002 154	54 770	3 798 243	2 258 681
1977	7 233 931	24 042	4 994 323	2 263 650
1978[p]	7 889 000	70 995	5 178 604	2 781 391

Source: Statistics Canada.
[1]Producers' shipments, crude gypsum. [2]Includes crude and ground, but not calcined. [3]Production, plus imports, minus exports.
[p]Preliminary.

Anhydrite

Production and trade statistics for anhydrite are included with gypsum statistics. Anhydrite is produced by Fundy Gypsum Company Limited at Wentworth, Nova Scotia, and by Little Narrows Gypsum Company Limited at Little Narrows, Nova Scotia. According to the *Nova Scotia Annual Report on Mines*, production of anhydrite in 1978 was 260 633 tonnes. Most of this was shipped to the United States for use in portland cement manufacture and as a peanut crop fertilizer. Cement plants in Quebec and Ontario also used some Nova Scotia anhydrite.

Table 6. Canada, house construction, by province, 1977 and 1978

	Starts			Completions			Under Construction		
	1977	1978	% Diff.	1977	1978	% Diff.	1977	1978	% Diff.
Newfoundland	3 719	2 865	−23	4 292	3 561	−17	2 878	3 483	+21
Prince Edward Island	824	1 210	+47	652	1 036	+59	347	528	+52
Nova Scotia	7 495	4 853	−35	7 521	5 745	−24	6 479	5 463	−16
New Brunswick	4 308	5 167	+20	5 313	5 896	+11	2 709	1 888	−30
Total (Atlantic Provinces)	16 346	14 095	−14	17 778	16 238	−9	12 413	11 362	−8
Quebec	57 580	43 671	−24	61 979	54 129	−13	35 366	24 053	−32
Ontario	79 130	71 710	−9	80 717	80 429	−1	75 518	66 106	−12
Manitoba	9 410	12 121	+29	8 720	10 550	+21	6 479	8 048	+24
Saskatchewan	12 825	9 527	−26	11 485	11 383	−1	10 097	8 138	−19
Alberta	38 075	47 925	+26	37 879	43 025	+13	27 305	31 323	+15
Total (Prairie Provinces)	60 310	69 573	+15	58 084	64 958	+12	43 881	47 509	+8
British Columbia	32 358	28 618	−12	33 231	30 779	−7	18 421	15 672	−15
Total Canada	245 724	227 667	−7	251 789	246 533	−2	185 599	164 702	−11

Source: Statistics Canada.

Tariffs

Canada

Item No.		British Preferential Tariff	Most Favoured Nation	General	General Preferential
29200-1	Gypsum, crude	free	free	free	free
29300-1	Plaster of Paris, or gypsum, calcined, and prepared wall plaster, weight of package to be included in weight for duty; per hundred pounds	free	6¢	12½¢	free
29400-1	Gypsum, ground, not calcined	free	free	15%	free
28410-1	Gypsum tile	15%	15%	25%	10%

United States

Item No.		
512.21	Gypsum, crude	free
512.24	Gypsum, ground calcined	59¢ per long ton
245.70	Gypsum or plastic building boards and lath	6% ad valorem

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978), USITC Publication 843.

Iron Ore

MICHEL A. BOUCHER

World demand for steel was generally weak in 1978. This was particularly so for Western Europe and Japanese producers, and notwithstanding a comparatively strong performance by North American steel producers. Consequently, iron ore consumption softened and offshore prices experienced downward pressure. Within this economic environment, Canadian iron ore production was further affected by downward pressure on pellet sales in Western Europe. These factors along with a four-month strike in the Labrador-Quebec district were the main cause of a 26 per cent reduction in Canadian iron ore shipments.

Summary of international developments

Within this article, reference is made to a variety of international iron ore developments related to Canadian iron ore interests including: the signing of several iron ore contracts by China; the startup of construction of a railroad in Brazil that will link the huge deposits of Carajas to the port of Itaqui; the announcement by the Australian Government of new guidelines for exports of iron ore and other commodities such as coal, bauxite and alumina; three UNCTAD meetings on iron ore; and finally, a list of countries where new iron ore mines might be developed or existing mines expanded during the next five years.

Summary of Canadian developments

Major iron ore-related events in Canada during 1978 included: a drastic reduction in iron ore production and shipments as a result of a strike at Quebec-Labrador mines; two iron ore price increases for captive mines; the closure of Marmoraton Mining Company in Ontario; announcement of the closure in 1979 of Steep Rock Iron Mines Limited, Caland Ore Company Limited and National Steel Corporation of Canada, Limited all in Ontario, and the closure of Craigmont Mines Limited in British Columbia; the formation of an international iron ore division at Sidbec; the application of the first phase of a three-phase toll increase on the St. Lawrence Seaway; the purchase of iron ore deposits in Montana by Steel Alberta Ltd.; a study undertaken by the three major steel producers of Ontario, namely The Steel Company of Canada, Limited (Stelco), Dominion Foundries and Steel, Limited, and The Algoma Steel Corporation, Limited, of future developments of iron ore in Ontario; an iron ore mission from Canada to China, followed by an iron ore mission from China to Canada; and finally a U.S.S.R. – Canada iron ore exchange visit.

Canadian developments

Iron ore shipments in Canada in 1978 were an estimated 39 622 000 tonnes* valued at $1 149 890 000. This compares with 53 621 096 tonnes valued at $1 375 566 426 the previous year.

The lower level of shipments was due primarily to a strike that paralyzed all iron ore operations in the Quebec-Labrador region from March 9 to July 14 and affected directly 10 000 to 11 000 iron ore workers. The strike came at a time when demand for iron ore was weak and inventories were high.

As a result of the settlement, labour wages, which are already high in Canada with respect to competing countries such as Brazil, India and West Africa, and fringe benefits will together increase by some 10 per cent a year over the next three years. About 50 per cent of Canada's iron ore production is in the form of pellets which require substantial amounts of imported oil for their processing, and oil prices have been rising rapidly.

Higher labour and energy costs mean that it is becoming relatively more difficult for companies such as the Iron Ore Company of Canada and Quebec Cartier Mining Company to sell the noncaptive portion of their pellet output to overseas markets, especially in Western Europe and Japan.

These trends, along with the fact that Canada's iron ore deposits are lower in grade relative to new deposits developed elsewhere, are making it difficult to attract new investment at this time. In fact, a survey carried out by the United Nations in 1977 indicated that between 1979 and 1985 additional iron ore capacity might be added and new mines developed in some 14 countries other than Canada.

As a result of increased cost of labour, fuel, supplies and equipment, the price of iron ore to North American consumers was increased in March and September 1978. At

*The term "tonne" refers to the metric ton of 2 204.61 pounds avoirdupois.

Table 1. Canada, iron ore production and trade, 1977 and 1978

	1977		1978[p]	
	(tonnes)[1]	($)	(tonnes)[1]	($)
Production (mine shipments)				
Newfoundland	26 658 063	742 132 236	15 831 000	504 973 000
Quebec	16 198 058	338 261 090	13 798 000	338 900 000
Ontario	10 319 657	287 810 755	9 425 000	295 437 000
British Columbia	445 319	7 362 345	568 000	10 580 000
Total[2]	53 621 097	1 375 566 426	39 622 000	1 149 890 000
Imports				
Iron ore				
United States	2 091 607	64 596 000	3 860 929	142 761 000
Sweden	36 599	1 191 000	418 735	12 915 000
Brazil	376 070	10 412 000	365 020	10 654 000
Norway	—	—	41 159	1 320 000
Belgium-Luxembourg	786	59 000	—	—
Peru	141	16 000	—	—
Total	2 505 203	76 274 000	4 685 843	167 650 000
Exports				
Iron ore, direct shipping				
United States	2 665 028	39 745 000	2 517 399	27 711 000
Italy	344 141	4 902 000	283 511	3 069 000
Belgium-Luxembourg	—	—	117 303	1 270 000
United Kingdom	97 046	1 431 000	—	—
Total	3 106 215	46 078 000	2 918 213	32 050 000
Iron ore concentrates				
United States	5 326 347	113 858 000	3 631 230	89 627 000
Netherlands	4 137 583	58 482 000	2 704 193	40 010 000
United Kingdom	3 095 768	48 104 000	2 232 056	34 915 000
Japan	4 193 208	51 822 000	2 247 453	26 375 000
Italy	1 112 358	17 436 000	919 143	14 032 000
France	1 125 902	16 213 000	751 926	11 508 000
Belgium-Luxembourg	303 705	4 449 000	501 883	10 158 000
West Germany	1 066 091	17 484 000	544 381	9 039 000
Yugoslavia	252 628	4 227 000	224 014	3 855 000
Philippines	426 069	4 361 000	121 661	1 245 000
Portugal	97 385	1 893 000	48 278	1 148 000
Spain	125 246	2 287 000	42 742	844 000
Other countries	27 052	684 000	33 012	918 000
Total	21 289 342	341 300 000	14 001 972	243 674 000

Table 1 (cont'd)

	1977		1978[p]	
	(tonnes)[1]	($)	(tonnes)[1]	($)
Iron ore agglomerated				
United States	18 193 236	596 179 000	12 439 635	419 024 000
Netherlands	999 853	32 149 000	883 090	29 996 000
United Kingdom	173 012	5 704 000	616 800	22 310 000
Italy	471 605	15 122 000	315 957	10 862 000
West Germany	208 960	6 624 000	152 498	4 767 000
Spain	310 514	10 217 000	128 498	4 652 000
Other countries	129 921	4 022 000	183 020	5 251 000
Total	20 487 101	670 017 000	14 719 498	496 862 000
Iron ore, nes				
United States	177 733	6 528 000	289 244	10 207 000
Total exports, all classes				
United States	26 362 344	756 310 000	18 877 508	546 569 000
Netherlands	5 137 436	90 631 000	3 587 283	70 006 000
United Kingdom	3 365 826	55 239 000	2 848 856	57 225 000
Italy	1 928 104	37 460 000	1 518 611	27 963 000
Japan	4 269 513	54 075 000	2 295 341	27 380 000
West Germany	1 275 051	24 108 000	696 879	13 806 000
Belgium-Luxembourg	357 321	6 217 000	702 536	13 779 000
France	1 125 902	16 213 000	751 926	11 508 000
Spain	435 760	12 504 000	171 240	5 496 000
Yugoslavia	252 628	4 227 000	224 014	3 855 000
Other countries	550 506	6 939 000	254 733	5 206 000
Total	45 060 391	1 063 923 000	31 928 927	782 793 000
Consumption of iron ore at Canadian iron and steel plants	14 170 500	..	15 282 779	..

Source: Statistics Canada.
[1] Dry tonnes for production (shipments) by province; wet tonnes for imports and exports. [2] Total iron ore shipments include shipments of byproduct iron ore.
[p] Preliminary; — Nil; .. Not available; nes Not elsewhere specified.

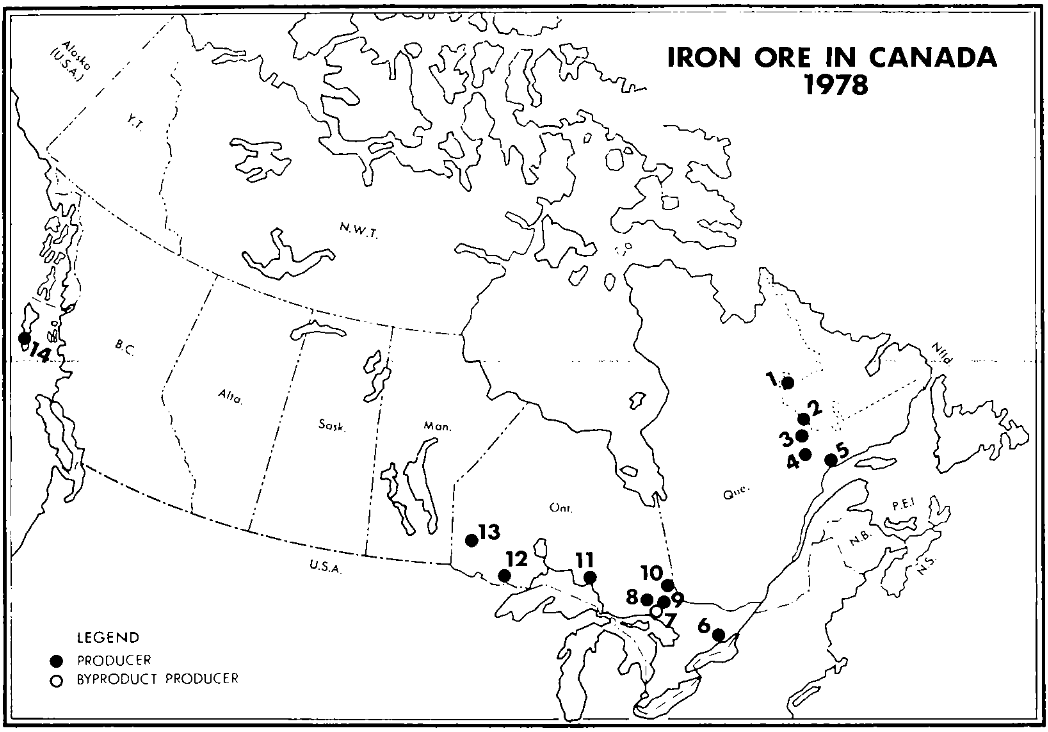
the end of 1977 pellets were selling for 54.6 cents a unit cif Lake Erie, and at the end of 1978 they were selling for 59.4 cents per unit, an increase of 10 per cent. During the same period Mesabi Non-Bessemer increased from $ U.S. 20.84 per tonne to $ U.S. 21.95 per tonne, an increase of 5 per cent.

Mine developments

In March 1978 Bethlehem Steel Corporation of the United States closed its Marmoraton Mining Company mine, concentrator and pellet plant near Marmora, Ontario, approximately 290 people were affected. About 1.5 to 2.0 million tonnes of ore were left in the ground when the operation closed. The mine was originally scheduled to close in July 1980 when ore reserves would be exhausted but the closure date was advanced because demand for iron ore by Bethlehem had been considerably reduced and financial losses had been very heavy in 1977.

The Marmora mine began operation in 1955 and produced pellets at an annual rate of 500 000 tonnes. Markets other than steel are being sought by government and industry entrepreneurs for the remaining ore reserves. Potential markets for the ore include its possible use as heavy aggregate for railroad ballast, high density concrete for shielding in nuclear power stations, and for heavy media in separation plants. Markets for crushed waste rock include railroad ballast, asphalt aggregate and road fill. In order to minimize the impact of the mine closure on local employment, a feasibility study is underway for the production of magnetite powder for use as heavy media and for use in the ferrite and pigment industries. The ore would be supplied from small deposits near Havelock and Bancroft in Ontario.

It was announced by Steep Rock Iron Mines Limited of Atikokan, Ontario that the company may be forced to cease operations by the end of 1979 because of low reserves and because Caland Ore Company Limited has decided to terminate its lease on the "C" orebody owned by Steep Rock. Mining at Steep Rock and at Caland is scheduled to end in February and in November 1979, respectively. Pelletizing will terminate in August at Steep Rock and in mid-1980 at Caland. Average employment in 1978 at Steep Rock was about 530 people, and about 470 were employed at Caland. Steep Rock also reported that it has decided to postpone the development of the Bending Lake iron ore



Producers

(numbers refer to numbers on map above)

1. Iron Ore Company of Canada, Knob Lake Division (Schefferville)
2. Iron Ore Company of Canada, Carol Division, (Labrador City)
2. Scully Mine of Wabush Mines (Wabush)
3. Quebec Cartier Mining Company (Mount Wright)
4. Sidbec Normines Inc. (Gagnon, Fire Lake)
5. Iron Ore Company of Canada, Sept-Iles Division (Sept-Iles)
5. Pointe Noire Division of Wabush Mines (Pointe Noire)
6. Marmoraton Mining Company, Division of Bethlehem Chile Iron Mines Company (Marmora)
8. National Steel Corporation of Canada, Limited (Capreol)
9. Sherman Mine of Dominion Foundries and Steel, Limited (Temagami)
10. Adams Mine of Dominion Foundries and Steel, Limited (Kirkland Lake)
11. Algoma Ore Division of the Algoma Steel Corporation, Limited (Wawa)
12. Caland Ore Company Limited (Atikokan) Steep Rock Iron Mines Limited (Atikokan)
13. The Griffith Mine (Bruce Lake)
14. Wesfrob Mines Limited (Moresby Is.)

Byproduct producers

7. Inco Limited (Copper Cliff)

deposit located some 60 kilometres (km) northwest of Atikokan, mainly because of the iron ore surplus both at Algoma Steel and in the Great Lakes region. The Bending Lake deposit contains some 200 million tonnes of iron ore (measured and indicated) grading 25 per cent soluble iron, containing some 20 per cent magnetic iron which could be concentrated to 69 per cent iron. The deposit is low in terms of an average grade of 36 per cent for iron ore mined in Canada. The Bending Lake assessment proved the deposit to be uneconomic, at least for the next couple of years.

In response to the impending Steep Rock shutdown, the Ministry of Natural Resources of Ontario has been asked to coordinate a study for the establishment of a brick-clay plant at Atikokan that would use the residual red-coloured bottom mud found in the Steep Rock pit. As a result of a surplus of iron ore in the United States and in Canada, National Steel announced that its Capreol mine will be closed in May 1979. Some 250 people will be affected.

Craigmont Mines Limited, a byproduct producer of magnetite in British Columbia, will close its operations in July 1979. The company produces 40 000 to 50 000 tonnes per year of magnetite for use by coal preparation plants, the potash industry, base-metal smelters and the cement industry. Stockpiled material will be sufficient to supply these markets for at least another ten years after the mine closes.

A fourth division of Sidbec was formed at year-end. The new division, called Sidbec International Inc. will be responsible for export sales of iron ore pellets, sponge iron and raw steel. Sidbec-Feruni Inc. was previously responsible for the sale of these products in the export markets.

Steel Alberta Ltd. owned equally by The Alberta Gas Trunk Line Company Limited and the provincial-government-controlled Alberta Energy Company Ltd., paid $1.7 million for two adjacent iron ore properties located some 100 km south of Butte, Montana and 650 km south of Calgary. The properties were previously owned by Carter Creek Holdings Corp. and Mineral Services Inc., private companies from Colorado. The iron ore deposit contains about 80 million tonnes of proven ore (magnetite) grading 25 to 28 per cent iron and a further 80 million tonnes of probable ore. Initial plans call for a market survey in the United States and Canada for the sale of pellets and sponge iron.

A study is being prepared by the three major steel companies of Ontario for future developments (mid to late 1980s) of iron ore deposits in northwestern Ontario. The study will determine the feasibility of building a pellet plant, possibly on Lake Superior, that would draw feed from their pooled deposits.

Seaway tolls

The tolls were increased on the St. Lawrence Seaway in 1978. Tolls on the Montreal-Lake Ontario section were increased from 44.1 cents per tonne to 50.0 cents per tonne; the rate applied to Gross Registered Tonnage* (GRT) increased from 4 cents to 7 cents per tonne. On the Welland Canal section the toll structure has been changed from $100 per lock for each of its eight locks to 20 cents per tonne and from nil GRT to a 7 cents GRT. The tolls were increased principally to lower the annual and rapidly increasing deficits on the Welland canal, an all-Canadian portion of the Seaway. The Montreal–Lake Ontario section, which is owned by Canada and the United States, has barely covered its costs of operation in the past. The toll increases indicate that iron ore imported through the Welland canal from the United States will be more costly. Also, royalty incomes for some exploration companies such as Hollinger North Shore Exploration Company Limited and Labrador Mining and Exploration Company Limited will be reduced by the toll increases because royalties are based on fob prices of concentrates and pellets at Sept Iles. Tolls will be increased again in 1979 and 1980.

Relations with China

A Canadian scientific mission went to China in May and June 1978. The purpose of the mission was to identify the iron resources which are significant for the development of a modern iron ore industry in China and to discuss iron ore exploration and resource evaluation methods. The deposits in China are usually low grade and show many similarities with the deposits being mined in Canada. For this reason, geophysical methods used to find such deposits in Canada can also be used in China. Geophysical equipment manufactured in Canada has been sold to China in the past.

In August, a group of Chinese engineers visited several mines and iron ore processing plants in the Quebec–Labrador region, mining machinery manufacturers in Ontario, and consulting firms in Quebec. The purpose of the mission was threefold: to become acquainted with the mining machinery and equipment used by large modern mines in the western world, to meet consulting engineering firms in order to determine whether they have the capability to undertake major projects in China and to investigate the possibility of exchanging engineering workers and students with Canada. Following their visit to Canada the Chinese placed orders for mining machinery valued over $100 million with manufacturing firms in Ontario.

At the end of the year Canadian Met-Chem a subsidiary of United States Steel Corporation, a consulting firm in Quebec, had sent personnel to China to negotiate the development of a large mine and beneficiation plant. Also, Surveyor, Nenniger and Chenevert, a consulting firm in Quebec, will send a technical and commercial mission to China in early 1979 to negotiate the development of a medium-sized iron ore mine.

During their visit to Canada the Chinese expressed interest in drilling equipment, transportation machinery and manufacturing equipment for use by their mining industry in general.

The Chinese government intends to increase annual steel production capacity from an estimated 30 million tonnes in 1978 to 60 million tonnes in 1985. This means that iron ore mine production will have to increase from 125 million tonnes per year to about 250 million tonnes in China.

*This is a rating for ships based on the volume of enclosed space and not related to cargo tonnage.

Table 2. Canada, iron ore production, 1976-78

Company and Location	Ore Mined	Product Shipped	1976	1977	1978
				(000 tonnes)	
Adams Mine, Kirkland Lake, Ont.	Magnetite	Pellets	1 197	1 218	1 250
Algoma Ore Division of The Algoma Steel Corp. Ltd., Wawa, Ont.	Siderite	Sinter	1 865	1 771	1 732
Caland Ore Co. Ltd., Atikokan, Ont.	Hematite and Goethite	Pellets	860	1 027	957
		Concentrate	729	477	546
Griffith Mine, Bruce Lake, Ont.	Magnetite	Pellets	1 579	1 565	1 553
Hilton Mines, Ltd., Shawville, Que.	Magnetite	Pellets	657	177	
Iron Ore Company of Canada Schefferville, Que.	Hematite, goethite and limonite	Direct shipping	4 125	3 069	3 007
Carol Lake, Lab.	Specular hematite and magnetite	Concentrate	7 301	6 435	3 898
		Pellets	10 085	11 158	6 755
Sept Iles, Que.	Schefferville "treat ore"	Pellets	3 585	4 552	3 597
Marmoraton Mining Co., Marmora, Ont.	Magnetite	Pellets	462	611	137
National Steel Corporation, Capreol, Ont.	Magnetite	Pellets	627	582	655
Quebec Cartier Mining Company, Mount Wright, Que.	Specular hematite	Concentrate	14 137[1]	13 169	9 911
Sidbec-Normines Inc., Fire Lake and Lac Jeannine, and Port Cartier, Que.	Specular hematite	Concentrate	—	297	248
		Pellets (standard)	—	—	1 164
		Pellets (low silica)	—	—	344
Sherman Mine, Temagami, Ont.	Magnetite	Pellets	1 093	1 109	1 155
Steep Rock Iron Mines Ltd., Atikokan, Ont.	Hematite	Pellets	1 363	1 433	1 302
Texada Mines Ltd., Texada Island, B.C.	Magnetite	Concentrate	388	100	—

Wabush Mines, Wabush, Lab. and Pointe Noire, Que.	Specular hematite and magnetite	Pellets	5 487	5 640	4 419
Wesfrob Mines Limited, Queen Charlotte Islands, B.C.	Magnetite	Sinter concentrate	344	—	—
		Pellet concentrate	564	366	610
Byproduct producer					
Inco Limited, Sudbury, Ont.	Pyrrhotite	Pellets	485	649	361
Total			56 933	55 397	43 601

Sources: Statistics Canada; Personal communication.
[1] Includes preliminary shipments of Fire Lake mine.
— Nil.

Table 3. Production and capacity of pig iron and crude steel for Canadian iron and steel plants, 1977 and 1978

	1977	1978[p]
	(tonnes)	
Pig iron		
Production	9 660 927	10 338 264
Capacity at December 31[1]	10 871 000	11 807 009
Steel ingots and castings		
Production	13 631 243	14 898 449
Capacity at December 31	17 983 487	18 607 629

Source: Statistics Canada.
[1] In blast or in use.
[p] Preliminary.

Table 4. Receipts, consumption and stocks of iron ore at Canadian iron and steel plants, 1977 and 1978

	1977	1978[p]
	(tonnes)	
Receipts imported	2 604 502[1]	5 236 968[2]
Receipts from domestic sources	11 198 509[3]	10 690 677[4]
Total receipts at iron and steel plants	13 803 011	15 927 645
Consumption of iron ore	14 170 500[5]	15 282 779[6]
Stocks of ore at iron and steel plants, December 31	3 940 556	4 597 982
Change from previous year	+ 65 632	+ 657 426

Source: American Iron Ore Association.
[1] Compared with 2 505 203 tonnes in Table 1. [2] Compared with 4 685 843 tonnes in Table 1. [3] Compared with domestic shipments of 11 434 523 tonnes compiled by Statistics Canada. [4] Compared with 11 058 882 tonnes compiled by Statistics Canada. [5] Compared with 13 618 732 tonnes compiled by Statistics Canada for blast furnace consumption. [6] Compared with 14 847 867 tonnes compiled by Statistics Canada for blast furnace consumption.
[p] Preliminary.

A scientific Russian delegation came to Canada in late 1978 and visited several iron ore mines in Ontario and Quebec. The purpose of the visit was to study open-pit mining operations and associated waste disposal techniques in operation under severe climatic conditions. A reciprocal visit to the U.S.S.R. by Canadian government and industry officials is scheduled for early 1979.

International developments

In an attempt to keep exports at reasonable levels, several producing countries reduced the price of iron ore in 1978. The international price for pellets was particularly affected. Lumpy ore and direct-shipping ore prices were also reduced because of a low demand for iron ore in general and as a result of a change in blast furnace technology. It was reported that Brazilian pellets were selling for 36 cents a unit cif Rotterdam in 1978, a decrease of 15 per cent from the previous year. Fines and lumpy ore from Brazil were also down by 7 and 9 per cent respectively from the previous year.

In Japan, the price of fines from India was reduced by a hefty 11 per cent to 15 to 16 cents per unit. Fines and lumpy ores from Brazil and South Africa however, were reduced by only a few percentage points to about 20 cents per unit and to 22 cents per unit, respectively.

World steel market problems adversely affected many iron ore industries and their ability to offer substantial increased benefits to workers. As a result, there were strikes by iron ore workers in Canada, Australia and India. Employees were laid off in France, Sweden, Canada and India.

Besides labour disruptions, the iron ore industry is being reorganized in several countries including India, Sweden and France. In the European Economic Community, for example, small mines are being closed, and government assistance is expected for loans to modernize mines, for research on ore processing, for labour retraining and for worker relocation. In France over 1 500 workers were reported to have lost their jobs permanently and another 1 500 are expected to be laid off in the next two years.

Several iron ore contracts were signed with the Chinese in 1978 and more are expected to be signed in the next five to ten years. Imports of iron ore in China should be in the order of 30 million tonnes per year for the next ten years until new iron ore mines are developed and expansions at existing mines are completed.

The major suppliers of iron ore to China are Australia, Brazil and India. China uses hard currency for its imports but also tends to use barter agreements, exchanging oil and coal (which it has in large quantities) for iron ore.

Contracts for the development of iron ore mines in China were signed in 1978 by Kaiser Engineers Inc. and by Bethlehem Steel Corporation, both of the United States. It is also very likely that U.S. Steel will sign a major contract with China in 1979 for the development of a large iron ore mine.

Construction in Brazil of a railroad that will link the Carajas iron ore deposits to the port of Itaqui began in May 1978; construction should be completed in mid-1979. Mining of the Carajas deposits is scheduled to start in 1982-83 with an initial annual production of 8 million tonnes of iron ore products, eventually increasing to 20 million tonnes per year as demand increases.

The Government of Australia announced new guidelines for exports of iron ore; the government felt that export prices were not high enough to generate the cash flows necessary for new iron ore mine development. Western Australia's iron ore producers were unanimous in their opposition to the Government action and indicated their concern of losing Japanese contracts to the Brazilians.

Three United Nations Conference on Trade and Development (UNCTAD) meetings on iron ore were held in Geneva during the year. Experts from some 40 countries

Table 5. Canadian consumption of iron-bearing materials at integrated[1] iron and steel plants, 1978

	In Sinter Plants	In Direct Reduction Plants	In Iron and Steel Furnaces: In the Production of Pig Iron	In Steel Furnaces	Total in Furnaces
			(tonnes)		
Iron Ore					
Crude and concentrate	217 163	—	214 860	9 880	441 903
Pellets	75 364	905 400	11 878 153	53 372	12 912 289
Sinter	103 863	—	1 626 648	—	1 626 648
Sinter produced at steel plant	—	—	1 104 317	—	1 104 317
Direct-reduced iron	—	—	—	576 000	576 000
Other iron-bearing materials					
Flue dust	90 278	—	—	—	90 278
Mill scale, cinder, slag	531 136	—	414 674	256	946 066

Source: Company data.
[1]Dominion Foundries and Steel, Limited, Hamilton, Ont.; Sidbec-Dosco Limited, Contrecoeur, Que.; Sydney Steel Corporation, Sydney, N.S.; The Algoma Steel Corporation, Limited, Sault Ste. Marie, Ont.; The Steel Company of Canada, Limited, Hamilton, Ont.
— Nil.

discussed problems facing the iron ore industry. Although solutions for stabilizing the industry were not found, most governments agreed to provide more statistics on production, imports, exports, consumption and prices in order to help work out solutions.

A study prepared by the United Nations indicates that from 1979 to 1985 new iron ore mines might be developed or existing mines expanded in the following countries: Algeria, Argentina, Australia, Brazil, China, Chile, Gabon, India, Ivory Coast, Mexico, South Africa, Sweden, United States and the U.S.S.R. Most new production would come from Brazil, Australia and the United States. The timing of these projects however depends very much on the future demand for steel which is very difficult to predict and on the price of iron ore. During the past two to three years iron ore prices have been too low to justify the development of new mines oriented for the export markets.

Outlook

Production in Canada in 1979 is expected to return to normal and should be in the order of 57 million tonnes. In 1980 production is forecast at 60 million tonnes. Production thereafter will only increase marginally until capacity is fully utilized. Exports will also increase only marginally due to strong competition overseas.

Worldwide, the surplus capacity in the iron ore industry is expected to last until 1983-85.

Table 6. World iron ore production, 1976-78

	1976	1977[p]	1978[e]
	(000 tonnes)		
U.S.S.R.	239 109	237 700	244 000
Australia	93 200	97 500	93 000
Brazil	67 092	67 000	89 000
United States	80 546	56 275	82 000
People's Republic of China	48 000	50 000	65 000
India	42 647	41 220	43 000
Canada (mine shipments)	55 416	53 621	40 000
France	45 543	36 984	35 000
Sweden	29 862	25 416	23 000
Liberia	27 000	26 500	18 000
Venezuela	23 000	22 000	14 000
South Africa	15 685	15 500	. .
Chile	10 383	10 200	. .
Mauritania	8 500	8 300	. .
North Korea	8 200	8 100	. .
Spain	7 908	7 700	. .
Peru	7 000	7 000	. .
Angola	5 500	5 500	. .
Other countries	53 312	50 205	122 000
Total	867 903	826 721	868 000

Sources: Statistics Canada; *Metal Bulletin Handbook, 1978*; U.S. Bureau of Mines, Mineral Commodity Summaries, 1979.
[p] Preliminary; [e] Estimated; . . Not available.

Due to the proximity of Japan to the Chinese market, Japanese exports of steel products to China should increase substantially during the next decade. This will result in an increased demand for iron ore. Brazil and Australia are likely to benefit the most from this increased demand.

During the next three to five years demand for iron ore in the communist countries, in Latin America, especially Brazil, Mexico, Argentina, Venezuela, and in the Middle East countries is expected to remain strong because of rapid increases in consumption. In Western Europe demand for iron ore will remain weak and will improve only marginally in the United States.

(text continued on page 15)

Table 7. Canada, imports of steel scrap by province, 1976-78

		1976		1977		1978[p]	
		World	U.S.A.	World	U.S.A.	World	U.S.A.
Nova Scotia	tonne	—	—	—	—	152	152
	$000	—	—	—	—	9	9
New Brunswick	tonne	435	435	331	331	434	434
	$000	20	20	15	15	43	43
Quebec	tonne	49 076	234	44 866	44 866	64 267	64 263
	$000	2 583	32	2 538	2 538	3 336	3 296
Ontario	tonne	320 145	320 136	180 064	179 876	277 606	277 399
	$000	19 047	19 040	8 762	8 729	17 857	17 792
Manitoba	tonne	23 494	23 494	7 287	7 287	85 981	85 981
	$000	1 220	1 220	174	174	4 730	4 730
Saskatchewan	tonne	184 335	184 335	112 734	112 734	155 407	155 407
	$000	10 914	10 914	6 717	6 717	9 690	9 690
Alberta	tonne	1 570	1 570	1 433	1 433	81 864	81 864
	$000	60	60	47	47	3 722	3 722
British Columbia	tonne	1 333	1 333	868	830	2 272	2 249
	$000	110	110	98	98	158	156
Canada total	tonne	580 388	531 537	347 583	347 357	667 983	667 749
	$000	33 954	31 396	18 351	18 318	39 545	39 438

Source: Statistics Canada.
[p] Preliminary; — Nil.

Table 8. Canada, exports of steel scrap, by province of lading, 1976-78

		1976		1977		1978p	
		World	U.S.A.	World	U.S.A.	World	U.S.A.
Newfoundland	tonnes	—	—	3 802	—	168	168
	$000	—	—	168	—	16	16
Nova Scotia	tonnes	8 418	—	388	388	940	486
	$000	455	—	46	46	196	107
New Brunswick	tonnes	—	—	56	56	118	118
	$000	—	—	6	6	13	13
Quebec	tonnes	299 814	37 549	135 019	18 370	225 949	18 195
	$000	24 422	2 188	10 151	1 769	16 479	1 480
Ontario	tonnes	536 060	508 673	347 195	325 975	381 756	349 908
	$000	23 097	20 486	19 075	17 040	28 334	23 874
Manitoba	tonnes	3 814	3 815	3 310	3 310	2 761	2 761
	$000	350	350	350	350	346	346
Saskatchewan	tonnes	6 376	6 376	377	377	18	18
	$000	144	144	45	45	8	8
Alberta	tonnes	1 453	1 453	1 094	880	1 524	1 504
	$000	77	77	59	40	121	118
British Columbia	tonnes	35 451	35 238	79 696	79 381	94 930	92 282
	$000	2 060	2 027	4 429	4 321	6 889	6 487
Yukon Territory	tonnes	—	—	204	204	—	—
	$000	—	—	18	18	—	—
Canada total	tonnes	891 386	593 104	571 141	428 941	708 164	465 440
	$000	50 605	25 272	34 347	23 635	52 402	32 449

Source: Statistics Canada.
p Preliminary; — Nil.

Table 9. Lake Erie base price of selected ores[1] at year-end, 1970-78

	1970	1971	1972	1973	1974	1975	1976	1977	1978
					($U.S. per tonne)				
Mesabi Non-Bessemer	10.63	10.99	10.99	11.72	15.50	18.21	19.94	20.84	21.95
Mesabi Bessemer (+ phos. premium	10.78	11.14	11.14	11.87	15.65	18.35	20.09	20.09	22.10
Old-Range Non-Bessemer	10.87	11.24	11.24	11.97	15.75	18.45	20.18	21.09	22.19
Pellets (per tonne natural iron unit)[2]	0.262	0.275	0.275	0.289	0.399	0.464	0.522	0.546	0.594

Source: *Skillings Mining Review*; *Iron Age*.
[1] 51.5 per cent of iron natural, at rail of vessel, lower-lake ports. [2] Equals 1 per cent of a tonne, a 60 per cent iron ore, therefore, has 60 units.

Table 10. Products, uses, price and major Canadian producers

Raw Materials "Simplified" Process	Commercial Name	Uses	Prices/tonne	Major Canadian Producers
Iron oxide concentrates	Fines	Blast furnaces	$U.S. 21.94 cif Lake Erie	See Table 2
Iron oxide concentrates + coke-breeze + limestone (Ls)	Sinter	Blast furnaces	Not traded commercially	Algoma Ore Division of the Algoma Steel Corp. Ltd.
Iron oxide concentrates + bentonite + water + energy (oil or gas) for induration	Pellets		$U.S. 38.40 cif Lake Erie for pellets grading 64 per cent	See Table 2
Iron oxide concentrates + limestone + bentonite + water + energy (oil or gas) for induration	Self-fluxing pellets	Blast furnaces and direct reduction plants	. .	—
Iron oxide fines + coal fines or coke-breeze + lime + water + energy (oil or gas) for drying and hardening	Self-reducing pellets	Blast furnaces	. .	—
Iron oxide pellets + reductant (gas, oil or coal)	Sponge iron	Electric furnaces	$Cdn 115 fob plant	Sidbec-Dosco; Stelco
Finely ground magnetite	—	Heavy media for the treatment of coal, potash and iron ore. Sewage treatment plants	$Cdn 70 cif Sydney, N.S.	Craigmont Mines Ltd., Falconbridge (Wesfrob Mines)
Limonite or clayish hematite	—	Bricks	$130-200 per 1 000 bricks fob producers	—
Magnetite and hematite	—	Fluxing agents in base-metal smelters	. .	Craigmont Mines Ltd.
Natural pure hematite or magnetite + grinding	Natural iron oxide	Pigments for the production of paints	$80-120 fob producers in U.S.	—
Ferrous scrap + sulphuric acid (for solution), precipitation and crystallization of iron oxide	Synthetic iron oxide	Pigments for the production of paints	$700-$800 fob plant	Northern Pigment
Finely ground and pure iron oxide (natural or synthetic) + carbonate + calcining + pulverizing	Ferrite powder	Magnets for the electrical and electronic industries	$180 cif plant	—
Ferrous scrap + pig iron + mill scale + electricity + decarburization, pulverization	Iron powder	Intricate parts for the automotive and appliance industries and in the making of welding electrodes	$440	Quebec Metal Powders Limited; Domfer Metal Powders Limited

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
— Nil; . . Not available.

Table 11. Direct reduction plants, 1979, in operation, under construction or planned

Customer	Location	Capacity [1]	Start-up Date
North America			
Gilmore Steel Corp.	Portland, Oregon	300 000	1969
Georgetown Ferreduction	Georgetown, S.C.	400 000	1971
Sidbec-Dosco I	Contrecoeur, Quebec	400 000	1973
Sidbec-Dosco II	Contrecoeur, Quebec	650 000	1977
Texas Ferreduction	Beaumont, Texas	400 000	1981
Hecla	Casa Grande, Ariz.	65 000	1975
Stelco	Red Lake, Canada	360 000	1975
Armco Inc.	Houston, Texas	330 000	1972
Allis-Chalmers	Niagara Falls, N.Y.	50 000	1973
Sudbury Metals	Sudbury, Ontario	240 000	1976
Azcon	Rockwood, Tenn.	100 000	1979
Hoegenaes Corp.	Hoegenaes, N.J.	70 000	1954
Latin America			
Dalmine Siderca	Campana, Argentina	400 000	1976
Sidor I	Matanzas, Venezuela	400 000	1977
Sidor II	Matanzas, Venezuela	1 200 000	1979
Acindar	Villa Constitucion, Argentina	400 000	1978
Iscott I	Point Lisas, Trinidad	400 000	1978
Iscott II	Point Lisas, Trinidad	400 000	1982
Ecuasider	Puerto Bolivar Ecuador	400 000	1983
Europe			
Hamburger Stahlwerke	Hamburg, W. Germany	400 000	1972
British Steel Corp.	Hunterston, Scotland	800 000	1979
Norddeutsche Ferrowerke	Emden, W. Germany	800 000	1981
Government of U.S.S.R. I	Kursk, U.S.S.R.	1 600 000	1981
Government of U.S.S.R. II	Kursk, U.S.S.R.	3 400 000	1984
Kingleor Metor	Buttrio, Italy	11 000	1973
Thyssen Purofer	Oberhausen, W. Germany	150 000	1970
Arvedi	Cremona, Italy	40 000	1976
Sandvik	Sandviken, Sweden	25 000	1952
Uddeholms	Sweden	30 000	1954
SKF	Stal Hotors Sweden	25 000	1960
SSAR	Oxelosund Sweden	30 000	1954
Africa			
Industries Ministry	Port of Warri Nigeria	1 200 000	1981
Highveld I	Witbank S. Africa	1 000 000	1968
Highveld II	Witbank S. Africa	300 000	1977
Dunswart	Benoni, S. Africa	150 000	1973
Tike	Solwezi, Zambia	250 000	. .
Middle East			
Qatar Steel Co.	Umm Said Qatar	400 000	1978
Nisic I	Ahwaz, Iran	1 200 000	. .
Nisic II	Ahwaz, Iran	1 000 000	. .
Nisic III	Ahwaz, Iran	330 000	. .
Sabic	Al-Jubail, Saudi Arabia	800 000	1982
Iraq Iron & Steel	Khor Alzubar, Iraq	1 485 000	1979
Oceania			
NZ Steel	Glenbrook, New Zealand	125 000	1969
Asia			
Krakatau Steel I	Kota Baja, Indonesia	575 000	1978
Krakatau Steel II	Kota Baja, Indonesia	1 725 000	1978
KKK	Fukuyama, Japan	350 000	1974
Sponge Iron India	Kothaguden, India	30 000	1980
Kawasaki Steel I	Chiba, Japan	72 000	1969
Kawasaki Steel II	Chiba, Japan	250 000	1977

Table 11. (cont'd)

Customer	Location	Capacity [1]	Start-up Date	Customer	Location	Capacity [1]	Start-up Date
Kawasaki Steel III	Misushima, Japan	240 000	1972	Sumitomo Metals I	Wakayama, Japan	240 000	1975
Nippon Steel I	Hirohata, Japan	150 000	1976	Sumitomo Metals II	Kashima, Japan	210 000	1975
Nippon Steel II	Hirohata, Japan	240 000	1977	Tohoku Satetsu	Sendai, Japan	24 000	1957
Nippon Steel III	Muroran, Japan	48 000	1971	Hitachi Metals	Yasugi, Japan	10 000	1964
India-Tor Steel	Orrissa, India	150 000	1978				

Source: Midrex Corporation.
[1] Capacity in tonnes per year.
. . Not available.

Direct reduction

Direct-reduced sponge produced from the reduction of iron ore pellets, lumps or fines is used mainly in electric furnaces as a source of iron and as a substitute for ferrous scrap.

In Canada, direct-reduced sponge iron can be produced by three companies: Sidbec-Dosco Limited, Stelco, and Sudbury Metals Company. These companies have respective sponge iron production capacity of 1 050 000 tonnes, 360 000 tonnes and 240 000 tonnes.

In 1978 Sidbec-Dosco was the only company that produced sponge iron, and produced close to 701 000 tonnes. In 1979 production is planned at 1 million tonnes, which means that the two direct-reduction modules should be operating close to capacity.

In 1978 the composite price for No. 1 heavy melting steel scrap in the United States ranged between $U.S. 70 and $ U.S. 90 per tonne. Unless the price of scrap increases in 1979 Stelco and Sudbury Metals will not operate during the year.

The value of direct-reduced iron, relative to No. 1 heavy-melting scrap (HMS), can be estimated on the basis of two factors, "per cent of tramp element" such as copper and "metallic yield factor". Heavy-melting scrap containing a high percentage of copper sells at a lower price and has a lower metallic yield in an electric furnace than a HMS with a low copper content.

The following table shows the estimated value of direct-reduced iron and different grades of scrap when No. 1 HMS sells for $100.00 per tonne.

Grade	Tramp Element	Metallic Yield	Estimated "selling price" per tonne
No. 1 HMS	0.2	92	$100
Direct reduced iron	—	90	$120
No. 2 HMS	0.33-0.36	89	$81-$85
No. 1 Dealer Bundles	0.06-0.07	92	$112-$115
No. 1 Factory Bundles	0.04-0.05	94	$120
No. 2 Bundles	0.55-0.60	89	$54-$62

Source: Steel/Seminar 2/R.43 A Concept for Predicting Steel Scrap and Direct Reduced Material Prices. Economic Commission for Europe, Steel Committee Seminar on the Utilization of Pre-Reduced Materials on Iron and Steelmaking, Bucharest, Romania May 1976.
— Nil.

The trend towards using more additives and ferroalloys in order to make stronger and better quality steels will result over time in an increase in the percentage of tramp elements contained in steel scrap. Consequently the relative value of direct-reduced, high-purity sponge iron should also increase.

At the end of the year North American direct-reduced iron pellets were selling for about $115.00 per tonne fob plant Contrecoeur, Quebec and Georgetown, South Carolina.

Contrary to eastern Canadian steelmakers, who use scrap mainly from Canadian sources, the western Canadian mills are dependent upon imports of U.S. scrap. Also, in the western provinces ferrous scrap is used exclusively to produce steel. Currently raw steel furnace capacity in the western provinces is about 1.4 million tonnes. In 1978, imports of ferrous scrap into the western provinces from the United States totalled 325 000 tonnes; exports were 98 000 tonnes, thus making these provinces net importers of ferrous scrap.

Based on projected expansion plans it is very likely that scrap shortages will develop in the early 1980s. For this reason the government of Saskatchewan is studying the possibility of building a direct-reduction plant in the province. Iron ore would be imported from the United States, or supplied from deposits in Ontario or Quebec.

Another potential for building a direct-reduction plant is in the province of Alberta. The province has all it needs to develop a steel industry: the finances, strong local demand for steel products, such as re-bars, angles, wire, pipes and tubes and with the exception of indigenous iron ore, all the raw materials such as natural gas and coal.

Iron and steel

MICHEL A. BOUCHER

Crude steel production in Canada in 1978 increased 9.3 per cent over 1977. By comparison, world steel production increased 5.9 per cent. In the United States and in the European Economic Community (EEC) countries, production increased respectively by 9.5 and 5.0 per cent and decreased in Japan by 4.6 per cent.

Steel consumption in Canada increased 5.5 per cent in 1978, although real domestic product increased only 3.4 per cent. Demand was strong for steel products related to the construction (structural shapes, reinforcing bars), and to the automotive (hot- and cold-rolled sheets) industries. Demand was good for pipe and tube producers, and steel service centres were also active. Markets, however, were depressed for products used in the agricultural and natural resource industries.

Some hedge-buying occurred early in the year in anticipation of possible strikes at major Canadian steel producers; however, labour disputes were minimal.

The lower-valued Canadian dollar relative to the United States dollar and currencies of other major competitors stimulated Canadian exports, which increased by 29 per cent in terms of tonnage in 1978 over 1977. The decline in the dollar, however, increased the cost of imported raw materials such as iron ore and coal, and put upward pressure on interest rates, therefore restricting capital investment.

After a three-year period of relatively sluggish activity in North American steel markets there was a marked firming of steel demand in 1978. The much improved level of activity, coupled with higher prices, meant higher revenues and increased profits for most steel producers in Canada and in the United States.

Canada

Production. In 1978 Canada's crude steel furnace capacity was 17.98 million tonnes* and production of crude steel, at 83 per cent of capacity, was 14.9 million tonnes. Crude steel production increased 9.3 per cent to 14.9 million tonnes in 1978 and shipments, including castings and rolled steel products, increased 13.3 per cent to 11.8 million tonnes.

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Pig iron capacity in 1978 was 10.87 million tonnes and production, at 95 per cent of blast furnace capacity, was 10.34 million tonnes.

Producer shipments of rolled steel increased 13.2 per cent to 11.69 million tonnes. With the exception of rails and track material, shipments were up for all types of steel products, particularly for structural shapes, plates and wire rods. Shipments of these materials increased 34, 31 and 27 per cent respectively. Steel castings shipments increased 17 per cent to 157 231 tonnes.

Trade and consumption. In terms of value, exports of steel castings, ingots, rolled and fabricated products increased by 45 per cent to $1.18 billion in 1978 over 1977. Imports of these products increased by 28 per cent in 1978 to $965 million.

Consumption of crude steel increased 5.5 per cent to 13.63 million tonnes.

Developments. *Corporate.* Several companies were involved in modernizing or expanding their steel making facilities during the year. These developments are summarized in the accompanying table.

Bench-mark price system. For the past four years the world steel industry has experienced excess capacity as a result of a sustained weak demand for steel. In 1976 many offshore mills began selling steel in export markets at prices below operating costs in order to keep operating and maintain employment. In many cases these mills were government owned or government controlled. In response to these trading practices, the United States and the EEC established minimum prices or "trigger prices" for imports of steel mill products. Recognizing that steel diverted from the United States and the EEC could flood into Canada and disrupt domestic markets, the Department of National Revenue was given the responsibility, in February 1978, to monitor Canadian steel imports and to set up procedures to deal quickly with steel dumped into Canada that might adversely affect domestic steel producers. Accordingly, a bench mark price system was established. These prices establish a price threshold below which customs officials can suspect that dumping is taking place and can initiate an accelerated anti-dumping investigation.

Table 1. Canada, general statistics of the domestic primary iron and steel industry, 1976-78

		1976	1977	1978p
Production				
Volume indexes				
Total industrial production	1971 = 100	125.2	129.0	133.4
Iron and steel mills[1]	1971 = 100	117.7	122.6	138.3
		($ million)	($million)	($ million)
Value of shipments, iron and steel mills[1]		3 420.9	3 790.4	4 812.1
Value of unfilled orders, year-end, iron and steel mills		449.5	558.2	850.0
Value of inventory owned, year-end, iron and steel mills		998.4	1 030.4	1 142.5
Employment, iron and steel mills[1]		(number)	(number)	(number)
Administrative		10 561	10 981	11 159
Hourly rated		39 164	38 769	41 549
Total		49 725	49 750	52 708
Employment index, all employees,	1961 = 100	144.6	144.5	152.8
Average hours per week, hourly rated		39.7	39.4	39.9
		($)	($)	($)
Average earnings per week, hourly rated		279.36	305.32	333.89
Average salaries and wages per week, all employees		295.15	322.58	350.81
Expenditures, iron and steel mills[1]		($ million)	($ million)	($ million)
Capital: on construction		90.1	78.5	60.2
on machinery		301.9	313.7	273.5
Total		392.0	392.2	333.7
Repair: on construction		28.8	46.8	39.8
on machinery		370.8	394.3	482.8
Total		399.6	441.1	522.6
Total capital and repair		791.6	833.3	856.3
Trade, primary iron and steel[2]				
Exports		704.0	894.4	1 265.1
Imports		603.1	754.9	965.1

Source: Statistics Canada.
[1] S.I.C. Class 291 — Iron and Steel Mills: covers the production of pig iron, steel ingots, steel castings, and primary rolled products, sheet, strip, plate, etc. [2] Includes pig iron, steel ingots, steel castings, semis, hot and cold-rolled products, pipe, wire and forgings. Excludes sponge iron, iron castings and cast iron pipe. Compiled by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
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Anti-dumping. In December 1977, Canada's Anti-Dumping Tribunal ruled that certain wide flange shapes were being dumped into Canada by several countries and that injury was being caused to the only Canadian producer of these products (The Algoma Steel Corporation, Limited). Consequently, provisional duties that had been imposed on imports of these products in late September 1977 were to be continued. However, in February 1978, the Minister of Finance announced a limited and temporary remission of these duties for the period September 29, 1977 to June 29, 1978. The remission was in response to strong provincial representations regarding an adverse effect on steel fabricators in British Columbia, Alberta, Newfoundland and the Yukon. The remission expired on June 29, 1978.

The Anti-Dumping Tribunal ruled in January that stainless steel plate from South Africa and Japan was being dumped into Canada and that material injury was being caused to the only Canadian producer of this product, Atlas Steels Company Limited of Welland, Ontario. The Tribunal also ruled that injury was likely to occur to Atlas from dumping of stainless steel sheet produced in West Germany and Japan. As a result of these decisions, provisional duties imposed in October 1977 were to be maintained. Later in the year the Tribunal announced that Canadian production of graphite electrodes and graphite connecting pins had been adversely affected by dumping of such products by Japanese firms. These products are used by electric furnace operators and Union Carbide Canada Limited and Great

Table 2. Canada, pig iron production, shipments, trade and consumption, 1976-78

	1976	1977	1978P
		(tonnes)	
Furnace capacity, January 1[1]			
Blast	11 607 429	10 495 000	10 304 000
Electric	612 350	612 350	567 000
Total	12 219 779	11 107 350	10 871 000
Production			
Basic iron	9 166 807	9 099 156	9 512 985
Foundry iron[2]	659 611	561 769	825 281
Total	9 826 418	9 660 925	10 338 266
Shipments			
Basic iron	106 571	91 441	. .
Foundry iron[2]	589 900	611 898	684 439
Total	696 471	703 339	684 439
Imports			
Tonnes	8 836	11 913	2 556
Value ($000)	1 652	2 268	521
Exports			
Tonnes	281 557	505 277	544 713
Value ($000)	45 918	83 649	92 150
Consumption, pig iron			
Steel furnaces	8 971 013	8 896 744	9 346 645
Iron foundries	289 454	263 946	243 904
Consumption, iron and steel scrap			
Steel furnaces	6 548 070	6 846 788	7 698 640
Iron foundries	1 288 015	1 342 990	1 332 924

Sources: Statistics Canada; *Primary Iron and Steel* (monthly); *Iron and Steel Mills* (annual); *Iron Castings and Cast Iron Pipes and Fittings* (monthly).
[1] The capacity figures as of January 1 in each year take into account both new capacity and obsolete capacity anticipated for the year.
[2] Includes malleable iron.
P Preliminary; . . Not available.

Lakes Carbon Corporation (Canada), Ltd. are the only two producers in Canada. Provisional duties against Japanese imports imposed in June were to be maintained. In late December the Tribunal initiated an inquiry into whether the dumping of small diameter stainless steel pipe and tubing by producers in Japan, Australia, United Kingdom and Sweden had materially injured Canadian producers.

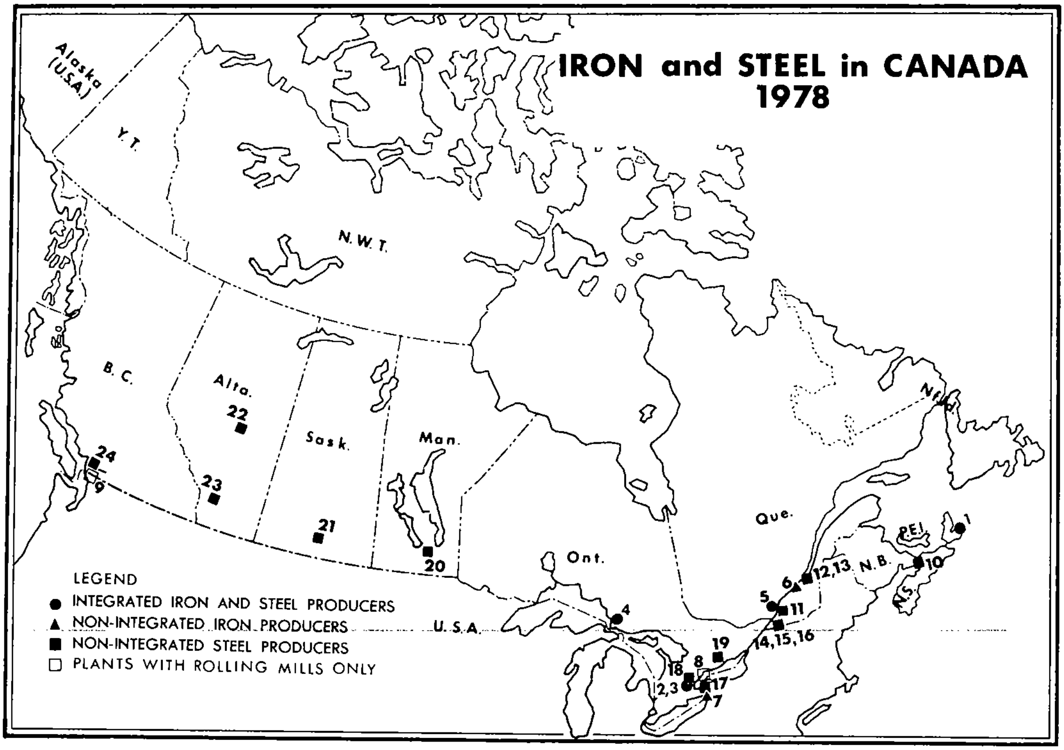
Arctic pipeline. In December, Foothills Pipe Lines (Yukon) Ltd. announced, with the approval of the Northern Pipeline Agency, that The Steel Company of Canada, Limited (Stelco) and Interprovincial Steel and Pipe Corporation Ltd. (IPSCO) had been chosen as the only two qualified bidders to supply about 900 000 tonnes of 1.42-metre (m) diameter, Arctic-grade pipe for the Canadian portion of the Alaska Highway pipeline project. Another 450 000 tonnes of 91 to 122-centimetre (cm) diameter pipe is also required, as is steel for associated infrastructure. Foothills had announced that only North American mills would be considered as prime suppliers. Earlier in the year the National Energy Board recommended that Foothills use 1.42-m diameter, 1.37-cm thickness, 7 447 kilopascal pipe for its main section of the pipeline. Later in the year, the United States government approved the gas pipeline as part of an overall legislative energy package.

Canadian Steel Industry Research Association (CSIRA). CSIRA was founded on June 1, 1978 with participation by

Table 3. Canada, crude steel production shipments, trade and consumption, 1976-78

	1976	1977	1978[p]
		(tonnes)	
Furnace capacity, January 1[1]			
Steel ingot			
Basic open-hearth	3 742 137	3 742 137	3 742 137
Basic oxygen converter	9 267 799	9 523 626	9 568 985
Electric	3 894 997	3 745 767	4 222 038
Total	16 904 933	17 011 530	17 533 160
Steel castings	418 938	445 973	450 327
Total furnace capacity	17 323 871	17 457 503	17 983 487
Production			
Steel ingot			
Basic open-hearth	2 971 118	2 879 758	3 029 062
Basic oxygen	7 945 811	7 952 828	8 413 641
Electric	2 206 095	2 649 558	3 285 253
Total	13 123 024	13 482 144	14 727 956
Continuously cast, included in total above	1 687 365	2 169 047	3 011 054
Steel castings[2]	166 526	149 099	170 493
Total steel production	13 289 550	13 631 243	14 898 449
Alloy steel in total	1 591 361	1 691 581	1 850 088
Shipments from plants			
Steel castings	156 861	133 870	157 231
Rolled steel products	9 820 728	10 327 360	11 692 504
Steel ingots included with rolled steel products	453 965	587 658	609 555
Total	9 977 589	10 461 230	11 849 735
		(000 tonnes)	
Exports, equivalent steel ingots	1 865.0	2 230.6	2 882.9
Imports, equivalent steel ingots	1 373.5	1 516.0	1 614.8
Indicated consumption, equivalent steel ingots	12 798.1	12 916.6	13 630.3

Source: Statistics Canada.
[1] The capacity figures as of January 1 in each year take into account both new capacity and obsolete capacity anticipated for the year.
[2] Produced mainly from electric furnaces.
[p] Preliminary.



Integrated iron and steel producers

(numbers refer to locations on map above)

1. Sydney Steel Corporation (Sydney)
2. Dominion Foundries and Steel, Limited (Hamilton)
3. The Steel Company of Canada, Limited (Hamilton)
4. The Algoma Steel Corporation, Limited (Sault Ste. Marie)
5. Sidbec Dosco Limited (Contrecoeur)

Nonintegrated iron producers

6. QIT-Fer et Titane Inc. (Sorel)
7. Canadian Furnace Division of Algoma (Port Colborne)

Plants with rolling mills only

8. Stanley Steel Company, Limited (Hamilton)
9. Pacific Continuous Steel Limited (Delta)

Nonintegrated steel producers

10. Enheat Limited (Amherst)
11. The Steel Company of Canada, Limited (Contrecoeur)
12. Atlas Steels Division of Rio Algom Limited (Tracy)
13. Colt Industries (Canada) Ltd. (Sorel)
14. Canadian Steel Foundries Division of Hawker Siddeley Canada Ltd. (Montreal)
15. Canadian Steel Wheel Limited (Montreal)
16. Sidbec Dosco Limited (Montreal)
17. Atlas Steels Company Limited (Welland)
18. Burlington Steel Division of Slater Steel Industries Limited (Hamilton)
19. Lake Ontario Steel Company Limited (Whitby)
20. Manitoba Rolling Mills Division of Dominion Bridge Company, Limited (Selkirk)
21. Interprovincial Steel and Pipe Corporation Ltd. (Regina)
22. The Steel Company of Canada, Limited (Edmonton)
23. Western Canada Steel Limited (Calgary)
24. Western Canada Steel Limited (Vancouver)

virtually all primary steel producers in Canada. The Association's principal aim is to identify the needs for technological improvements in the Canadian steel industry and to provide a forum for a joint approach to research and development amongst governments, companies, research institutions, and other interested associations.

Employee relations. In general, new contracts were signed without disruptions in production. In Hamilton, Stelco and the United Steelworkers of America reached agreement in late July on a new three-year contract to expire on July 31, 1981. The average wage rate increased by 20 cents in the first year and 10 cents in each of the remaining two years, over and above annual cost of living increases. It is estimated that the average hourly rate for Stelco workers will increase by about 27 per cent over the life of the contract. The contract also provides for improvements in pension plans, life insurance and health benefits as well as a greater role for the union in health and safety matters.

At Sault Ste. Marie, Ontario workers at The Algoma Steel Corporation Limited (Algoma) voted to accept a revised three-year contract, ending a 10-day strike which began on August 1, 1978. The agreement was similar to the package accepted at Stelco in Hamilton, but was rejected at that time by the Algoma workers. However, the workers accepted a new contract after slight modifications were made to vacation and pension provisions. Workers at Stelco's steel plant at Contrecoeur, Quebec agreed in early October to accept the company's contract proposal to end a two-month strike.

Prices. Most steel product prices in Canada were increased during 1978. Most prices for carbon steel products were increased in April by 3 to 8 per cent and by an average 4.5 to 5.0 per cent in October. At year-end some typical mill product selling prices per tonne were: hot-rolled sheet, $330; cold-rolled sheet, $380; galvanized sheet, $440; tinplate, $560; steel plate, $340; large structurals, $310 and basic pig iron, $205.

Prices of raw materials increased during the year, principally due to cost factors on the production side. A four-month coal miners' strike in the United States, which lasted until late March 1978, combined with a short strike affecting Canadian Great Lakes marine carriers affected supplies of coal. Canadian producers, who must stockpile coal in the fall because of the winter shutdown of the Great Lakes shipping system, weathered the strike relatively unscathed because the time of the strike coincided with this seasonal shutdown. Even with the strike, spot prices for coal were generally soft but long-term contracts were marginally increased in response to increases in production and transportation costs. At year-end, typical western Canadian medium volatile bituminous coking coals were selling on a long-term contract basis, at about $60 per tonne fob Vancouver.

Iron ore prices moved upward during 1978 as the Lake Erie Base Price increased by 4 per cent in April and by a similar amount in September. Pellets, which were selling for 54.6 cents a unit at the end of 1977, were selling for 59.4 cents a unit at the end of 1978. Iron ore was readily available during the year even though the iron ore mines in the Quebec-Labrador region were shut down for four months in the first half of the year due to a strike by mine workers.

Scrap prices in 1978 exhibited some volatility but not nearly as much as in 1976 and 1977. The composite price for No. 1 heavy melting steel scrap in the United States ranged between $U.S. 70 and $U.S. 75 per tonne for the first 10 months and then moved up near $U.S. 90 per tonne at year-end. Prices for oil and gas increased during the year, due mainly to the federal and provincial policies of gradually bringing the price of oil and gas in Canada to international levels.

Table 4. Producer shipments[1] of rolled steel[2], 1977 and 1978

	1977	1978	Growth
	(000 tonnes)		(%)
Ingots and semis	587.7	609.6	+ 3.7
Rails	317.9	263.7	−17.0
Wire rods	783.7	998.0	+27.3
Structural shapes	748.6	1 004.0	+34.1
Concrete reinforcing bar	495.1	574.6	+16.1
Other H.R. bars	996.7	1 143.3	+14.7
Track material	68.1	63.8	− 6.3
Plate	1 136.9	1 484.3	+30.6
Hot-rolled sheet and strip	2 441.4	2 475.6	+ 1.4
Cold finished bars	85.3	98.8	+15.8
Cold reduced sheet, strip, other and coated	1 774.0	1 912.2	+ 7.8
Galvanized sheet and strip	892.0	1 064.6	+19.3
Total	10 327.4	11 692.5	+13.2
Alloy steel in total shipments	759.2	947.8	+24.8

Sources: Statistics Canada; *Primary Iron and Steel* (monthly).
[1]Includes producer exports. [2]Includes ingots and semis, but not steel castings; comprises both carbon and alloy steels.

International developments

World raw steel production in 1978 increased by 5.9 per cent to 712.5 million tonnes. The 1978 figure also surpasses by 0.5 per cent the previous record year of 1974 when production reached 708.8 million tonnes.

In the United States production increased by a healthy 9.5 per cent to 123.8 million tonnes and capacity utilization improved from 78 per cent to 86.6 per cent. Also several producers including United States Steel Corporation, Bethlehem Steel Corporation, Republic Steel Corporation, and Kaiser Steel Corporation, reported higher earnings in 1978 as compared to 1977. This was due to increased domestic demand and to the success of the "trigger price" mechanism in reducing the growth rate of imports. Simply stated the trigger prices are based on steel production costs in Japan (a country considered to be a very efficient producer of steel) plus a normal profit, plus the cost of transporting such products to each of the four major importing regions in the United States. For example, in May 1978 the current trigger prices for cold-rolled sheets for each of the four regions of the United States were:

	Base price per tonne	Charges to CIF[1] Freight	Handling	Insurance	Total
West Coast	$297	$23	$3	$7	$330
Gulf Coast	297	23	5	8	333
East Coast	297	27	4	9	337
Great Lakes	297	35	4	11	347

[1] Cost, Insurance, Freight.

Under this mechanism steel is assumed to have been dumped if it is imported at a price below the trigger price, and an accelerated anti-dumping investigation ensues. Trigger prices are decreased or increased depending whether the U.S. dollar is revalued or devalued with respect to other currencies.

Unlike import quotas which affect both fair and unfair competition, trigger prices are designed to assist in the elimination of unfair import competition.

In Japan production of steel was virtually unchanged at 102.1 million tonnes in 1978 from the previous year (102.4 million tonnes). During the last three years capacity utilization in Japan has only been in the order of 70 to 75 per cent. There are no plans for expansion in Japan.

During the year the EEC countries continued their efforts to restore price stability in the European steel markets. On January 1, 1978 the European Commission implemented the Davignon Plan, which sets production quotas and minimum prices for domestic steel producers and basic prices "reference prices" for imported steel. The plan, however, was broken on numerous occasions by various member producers and production in the EEC increased by 5 per cent to 132.4 million tonnes. Countries such as the Netherlands, Belgium and Luxembourg increased their production by more than 10 per cent.

Other major steps aimed at modernizing and stabilizing the Community's steel industry were taken during the year, these included several amalgamations and reorganizations.

In Great Britain the government issued a White Paper on the government owned British Steel Corporation (BSC). The government had been concerned because of the heavy financial losses which BSC had incurred in the past several years (over $U.S. 800 million in fiscal year 1977-78). The main feature of the paper is a program of rationalization aimed at making BSC more competitive in international markets. Current projects will be completed and inefficient plants will be phased out.

In November, the Government of Belgium announced a package of industrial and financial measures to assist the country's troubled steel industry. These include partial state takeovers of major companies, a sizeable reduction of steel industry debt and creation of alternative employment opportunities for the workers affected by layoffs. A large part of the estimated $U.S. 2.5 billion steel industry debt, of which about $1 billion is owed to the government, will be rolled over or converted into shares or convertible bonds, thus substantially reducing the financial charges of the industry. Another part of the Belgium steel restructuring program includes a production agreement between Arbed, the major Luxembourg producer, and certain Belgium

Table 5. Canada, disposition of rolled steel products[1], 1977 and 1978

	1977	1978	Growth 1978/1977
	(tonnes)		(%)
Wholesalers, warehouses and steel service centres	1 357 969	1 809 126	+ 33.2
Automotive vehicles and parts	1 683 989	1 815 713	+ 7.8
Agricultural equipment	171 948	163 183	− 5.1
Contractors — building	492 843	616 713	+ 25.1
Construction — public and utility	33 127	76 473	+130.8
Structural steel fabricators	784 258	1 002 854	+ 27.9
Containers	508 650	592 824	+ 16.5
Machinery and tools	276 901	350 930	+ 26.7
Wire, wire products and fasteners	679 617	763 576	+ 12.4
Natural resources and extractive industries	208 325	206 432	− 0.9
Appliances and utensils	147 753	158 682	+ 7.4
Stamping, pressing and coating	651 543	479 836	− 26.4
Railway operating	298 823	188 012	− 37.1
Railroad cars and locomotives	75 392	122 431	+ 62.4
Shipbuilding	15 235	27 661	+ 81.6
Pipes and tubes	1 307 824	1 435 112	+ 9.7
Miscellaneous	65 078	54 216	− 16.7
Total domestic shipments	8 759 275	9 863 774	+ 12.6
Producer exports[2]	1 568 085	1 828 733	+ 16.6
Total producer shipments	10 327 360	11 692 507	+ 13.2

Sources: Statistics Canada; *Primary Iron and Steel* (monthly).
[1] Includes ingots and semis, but excludes steel castings, pipe and wire. [2] Total rolled steel exports amounted to 1.760 and 2.266 million tonnes in 1977 and 1978, respectively.

Table 6. Canada, trade in steel by product[1], 1976-78

	Imports			Exports		
	1976	1977	1978p	1976	1977	1978p
	(000 tonnes)					
1. Steel castings (including grinding balls)	13.4	21.6	16.1	22.8	16.9	23.4
2. Ingots	10.4	52.2	37.3	36.0	88.8	34.2
3. Semi-finished steel blooms, billets and slabs	12.0	9.1	16.6	94.0	151.0	245.3
4. Total (1 + 2 + 3)	35.8	82.9	70.0	152.8	256.7	302.9
5. Finished steel						
5. A) Hot-rolled						
Rails	18.8	19.8	22.6	165.1	122.5	178.0
Wire rods	157.6	176.4	190.4	166.5	195.3	312.9
Structurals	232.0	225.9	151.3	138.9	207.0	323.9
Bars	137.0	106.2	109.0	43.1	83.8	136.8
Track material	5.4	6.5	5.0	3.6	15.1	17.5
Plate	215.6	226.0	281.6	165.5	226.6	275.2
Sheet and strip	69.3	116.4	178.5	317.3	269.9	259.8
Total hot-rolled	835.7	877.2	938.4	1 000.0	1 120.2	1 504.1
B) Cold-rolled						
Bars	12.5	18.9	19.4	6.6	11.2	13.6
Sheet and strip	40.7	52.0	66.7	85.5	55.5	86.1
Galvanized	48.8	42.1	53.0	107.4	154.0	192.4
Other[1]	92.3	113.3	112.0	118.9	179.0	190.4
Total cold-rolled	194.3	226.3	251.1	318.4	399.7	482.5
6. Total finished steel (A + B)	1 030.0	1 103.5	1 189.5	1 318.4	1 519.9	1 986.6
7. Total rolled steel (2 + 3 + 6)	1 052.4	1 164.8	1 243.4	1 448.4	1 759.7	2 266.1
8. Total steel (4 + 6)	1 065.8	1 186.4	1 259.5	1 471.2	1 776.6	2 289.5
9. Total steel (raw steel equivalent)[2]	1 373.5	1 516.0	1 614.8	1 865.0	2 230.6	2 882.9
10. Fabricated steel products						
Steel forgings	8.3	7.6	9.1	42.5	42.2	40.7
Pipe	170.4	205.0	313.3	280.2	263.1	358.9
Wire	77.4	89.1	72.5	45.6	63.6	84.5
11. Total fabricated	256.1	301.7	394.9	368.3	368.9	484.1
12. Total castings, rolled steel and fabricated (8 + 11)	1 321.9	1 488.1	1 654.4	1 839.5	2 145.5	2 773.6

Source: Statistics Canada.
[1] Includes steel for porcelain enameling, terneplate, tinplate and silicon steel sheet and strip. [2]Calculation: finished steel (row 6) divided by 0.77 plus steel castings, ingots and semis (row 4).
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producers for the creation of a steel-making group that will have a production capability of 19 million tonnes.

The Government of France took steps late in the year to reorganize its heavily indebted steel industry. Three new holding groups will be created in which all creditors of existing groups, including the French State, will participate. In addition, the government has created an amortization fund called Caisse D'Amortissement de l'Acier, to be charged with ensuring payment of principal and interest owed by the three affected steel companies (Usinor, Sacilor and Chatillon-Neuves-Aisons) on debts of about $U.S. 3.1 billion. Caisse has initially budgeted about $U.S. 500 million. As a result of its new plan it is estimated that directly and indirectly the government will have control of about 75 per cent of the French steel industry.

Most countries of the EEC have no plans for expansion. Steel capacity is expected to decline during the next couple of years in France, Belgium and West Germany.

Production increased as planned in most of the member countries of the Council for Mutual Economic Assistance (COMECON) in 1978, and reached 211.9 million tonnes or 3.8 per cent above 1977 production of 204.1 million tonnes. Growth in steel production capacity is expected to continue, although at a reduced rate because of reported financial problems.

In the developing countries of Latin America, Asia, Africa and the Middle East, production continued to grow strongly, by 10.2 per cent over 1977, to a combined total of

Table 7. Canada, value[1] of trade in steel castings, ingots, rolled and fabricated products, 1976-78

	Imports			Exports		
	1976	1977	1978[p]	1976	1977	1978[p]
	($000)					
Steel castings	16 615	21 833	18 381	17 138	13 724	19 714
Steel forgings	16 344	17 459	20 357	49 076	56 960	60 681
Steel ingots	2 414	8 640	7 190	6 212	11 871	5 862
Rolled products						
Semis	4 547	4 412	8 715	17 844	26 852	52 024
Other	372 181	460 154	586 991	389 637	514 521	763 079
Fabricated						
Pipe and tube	131 144	169 832	263 416	152 064	146 777	215 745
Wire	58 756	71 030	60 082	29 173	43 453	61 204
Total steel	602 001	753 360	965 132	661 144	814 158	1 178 309

Source: Statistics Canada.
[1]The values in this table relate to the tonnages shown in Table 6.
[p] Preliminary.

Table 8. Canada, trade in steel[1] by country, 1976-78

	Imports			Exports		
	1976	1977	1978[p]	1976	1977	1978[p]
	(000 tonnes)					
United States	476.3	493.6	610.5	1 219.2	1 781.8	2 212.5
ECSC[2] countries	253.0	382.2	440.2	305.4	98.6	110.3
Japan	426.5	392.9	376.1	0.3	0.1	0.2
Other	166.1	219.4	227.6	314.6	265.0	450.6
Total	1 321.9	1 488.1	1 654.4	1 839.5	2 145.5	2 773.6

Source: Statistics Canada.
[1] Comprised of steel castings, ingots, semis, finished steel, forgings, pipe and wire. [2] European Coal and Steel Community (Belgium, Denmark, France, Ireland, Italy, Luxembourg, Netherlands, United Kingdom and West Germany).
[p] Preliminary.

46.4 million tonnes in 1978. During the next decade it is expected that both production and consumption in these countries will grow rapidly. Large increases in production capacity are expected to occur in Brazil, Venezuela, Mexico, China, South Korea, Iran and Algeria. With the exception of South Korea these countries possess the essential resources for making steel, that is, iron ore in combination with natural gas, oil or coal.

Many developing countries have been traditional suppliers of raw materials to Japan and to Western European countries. Competition for raw materials between Japan and Western Europe is expected to increase, as indigenous resources of these traditional suppliers become increasingly allocated for domestic steel production.

Multilateral Trade Negotiations (MTN). Talks continued during the year under the Tokyo Round of multilateral trade negotiations aimed at reducing tariffs and nontariff barriers to trade. The major participants are optimistic that a comprehensive agreement regarding tariffs can be reached before the end of 1979. The nearly one hundred participating countries are making efforts to substantially reduce nontariff barriers to trade such as government subsidies, government purchasing practices, technical standards and specifications, and customs valuation regulations. It is unlikely that any of these agreements will become operational before 1980. Some tariff reductions will be staged over a period of as many as 10 years.

Organization for Economic Cooperation and Development (OECD) Steel Committee. The first meeting of the Organization for Economic Cooperation and Development Steel Committee was held in Paris at the end of the year. The objective of the Steel Committee is to bring governments together in order to help understand the problems facing the steel industry.

These problems are characterized by: low prices paid for steel products; a persistent overcapacity in the industry; a continued low level of demand in the industrialized countries; major changes in traditional trade patterns; increasing governmental intervention in steel supply, trade and demand; major dislocations of labour in the industry; and finally depressed financial performance among producers, which had the effect of holding down investments needed for modernization and for building new plants.

Outlook

The outlook for the Canadian steel industry is for a year of continued growth. Crude steel production should increase by about 3.0 per cent to 15.3 million tonnes in 1979 and shipments should increase by about the same percentage. Exports will continue to be stimulated by the low value of the Canadian dollar. In the second half of the year, however, exports will probably weaken due to a forecast decline in economic activity in the United States.

The capital goods sector (machinery, equipment, construction, etc.) is expected to improve considerably in 1979 in view of a real increase in domestic business investment, increased export sales and continued import displacement due to the low Canadian dollar.

Demand for pipes and tubes in the oil and gas exploration sector should remain strong.

The automotive industry will continue to be competitive (due in part to the low Canadian dollar) and production and sales of vehicles should maintain last year's levels. Steel consumption per automobile, however, is slowly being reduced in order to cut weight and comply with government regulations requiring that by 1985 all passenger cars must be capable of travelling a distance of at least 11.7 kilometres per litre of gasoline.

In terms of raw materials, iron ore and coal should be available without interruption as most new contracts have been signed in late 1977 and in mid-1978.

Steel prices in the domestic market will probably increase during the next several years due to increased cost of imported raw materials and the need for an adequate return on investment in new and planned production capacity.

Table 9. World raw steel production, 1977 and 1978

	1977	1978p
	(million tonnes)	
U.S.S.R.	147.0	152.0
United States	113.1	123.8
Japan	102.4	102.1
West Germany	39.0	41.0
People's Republic of China	23.4	31.0
Italy	23.3	24.4
France	22.1	22.8
United Kingdom	20.4	20.2
Poland	18.0	19.5
Czechoslovakia	15.0	15.4
Canada	13.6	14.9
Belgium	11.3	12.6
Brazil	11.2	12.1
Romania	12.2	11.6
Spain	11.1	11.3
India	10.0	9.4
South Africa	7.3	7.9
Australia	7.3	7.6
East Germany	6.8	6.9
Mexico	5.5	6.8
Netherlands	4.9	5.6
Luxembourg	4.3	4.8
South Korea	4.2	4.7
Austria	4.1	4.2
Sweden	4.0	4.2
Hungary	3.7	3.9
Yugoslavia	3.2	3.5
Taiwan	1.8	3.5
North Korea	3.2	3.2
Argentina	2.7	2.7
Bulgaria	2.6	2.6
Finland	2.2	2.3
Turkey	1.8	2.3
Others	10.3	11.7
Total	673.0	712.5

Source: International Iron and Steel Institute.
p Preliminary.

Table 10. Canadian crude steel supply and demand, 1960, 1965, 1970 and 1975-78

	Crude Steel Production	Imports[1]		Exports[1]		Indicated Consumption[2]	
		A[3]	B[4]	A[3]	B[4]	A	B
		(000 tonnes)					
1960	5 253	1 059	1 227	849	902	5 463	5 578
1965	9 134	2 238	2 624	990	1 120	10 382	10 638
1970	11 200	1 524	1 986	1 696	2 086	11 028	11 100
1975	13 025	1 713	2 194	1 168	1 723	13 570	13 496
1976	13 290	1 374	1 825	1 865	2 393	12 799	12 722
1977	13 631	1 516	2 030	2 231	2 766	12 916	12 895
1978[p]	14 898	1 615	2 256	2 883	3 580	13 630	13 574

Source: Statistics Canada.
[1] Trade of Canada, adjusted to equivalent crude steel by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa. [2] Production plus imports, less exports, with no account taken for stocks. The two columns of figures depend on the two sets of values for trade. [3] Calculations: total finished steel (all hot- and cold-rolled steel but excluding wire, steel forgings, pipe and tube) divided by 0.77 plus steel castings, ingots and semis. See Table 6. [4] Calculations: total hot- and cold-rolled steel, steel forgings, wire, and steel pipe and tube divided by 0.75 plus steel castings (piston ring castings), ingots (ingot moulds and stools), and semis.
[p] Preliminary.

Table 11. Canada, exports of steel scrap, by province of lading, 1976-78

		1976		1977		1978[p]	
		World	U.S.A.	World	U.S.A.	World	U.S.A.
Newfoundland	tonne	—	—	3 802	—	168	168
	$000	—	—	168	—	16	16
Nova Scotia	tonne	8 418	—	388	388	940	486
	$000	455	—	46	46	196	107
New Brunswick	tonne	—	—	56	56	118	118
	$000	—	—	6	6	13	13
Quebec	tonne	299 814	37 549	135 019	18 370	225 949	18 195
	$000	24 422	2 188	10 151	1 769	16 479	1 480
Ontario	tonne	536 060	508 673	347 195	325 975	381 756	349 908
	$000	23 097	20 486	19 075	17 040	28 334	23 874
Manitoba	tonne	3 814	3 815	3 310	3 310	2 761	2 761
	$000	350	350	350	350	346	346
Saskatchewan	tonne	6 376	6 376	377	377	18	18
	$000	144	144	45	45	8	8
Alberta	tonne	1 453	1 453	1 094	880	1 524	1 504
	$000	77	77	59	40	121	118
British Columbia	tonne	35 451	35 238	79 696	79 381	94 930	92 282
	$000	2 060	2 027	4 429	4 321	6 889	6 487
Yukon	tonne	—	—	204	204	—	—
	$000	—	—	18	18	—	—
Canada total	tonne	891 386	593 104	571 141	428 941	708 164	465 440
	$000	50 605	25 272	34 347	23 635	52 402	32 449

Source: Statistics Canada.
[p] Preliminary; — Nil.

Table 12. Canada, imports of steel scrap by province, 1976-78

		1976		1977		1978^p	
		World	U.S.A.	World	U.S.A.	World	U.S.A.
Nova Scotia	tonne	—	—	—	—	152	152
	$000	—	—	—	—	9	9
New Brunswick	tonne	435	435	331	331	434	434
	$000	20	20	15	15	43	43
Quebec	tonne	49 076	234	44 866	44 866	64 267	64 263
	$000	2 583	32	2 538	2 538	3 336	3 296
Ontario	tonne	320 145	320 136	180 064	179 876	277 606	277 399
	$000	19 047	19 040	8 762	8 729	17 857	17 792
Manitoba	tonne	23 494	23 494	7 287	7 287	85 981	85 981
	$000	1 220	1 220	174	174	4 730	4 730
Saskatchewan	tonne	184 335	184 335	112 734	112 734	155 407	155 407
	$000	10 914	10 914	6 717	6 717	9 690	9 690
Alberta	tonne	1 570	1 570	1 433	1 433	81 864	81 864
	$000	60	60	47	47	3 722	3 722
British Columbia	tonne	1 333	1 333	868	830	2 272	2 249
	$000	110	110	98	98	158	156
Canada total	tonne	580 388	531 537	347 583	347 357	667 983	667 749
	$000	33 954	31 396	18 351	18 318	39 545	39 438

Source: Statistics Canada.
^{p} Preliminary; — Nil.

Table 13. Canada, exports of stainless steel scrap, by province of lading, 1976-78

		1976		1977		1978^p	
		World	U.S.A.	World	U.S.A.	World	U.S.A.
Nova Scotia	tonne	118	82	97	65	678	480
	$000	46	27	48	30	281	131
Prince Edward Island	tonne	—	—	—	—	17	17
	$000	—	—	—	—	13	13
New Brunswick	tonne	102	—	170	19	233	115
	$000	50	—	88	14	136	62
Quebec	tonne	3 980	1 928	4 955	3 267	6 497	4 300
	$000	2 035	964	2 987	1 993	2 415	1 452
Ontario	tonne	14 255	11 815	11 714	9 704	10 463	9 087
	$000	4 571	3 603	5 864	4 779	4 779	4 120
Manitoba	tonne	297	297	241	241	202	202
	$000	146	146	136	136	70	70
Saskatchewan	tonne	—	—	72	72	—	—
	$000	—	—	42	42	—	—
Alberta	tonne	18	18	123	123	74	74
	$000	8	8	59	59	76	76
British Columbia	tonne	832	224	1 187	679	2 743	2 375
	$000	375	111	461	182	1 118	860
Canada total	tonne	19 602	14 364	18 559	14 170	20 907	16 650
	$000	7 231	4 859	9 685	7 235	8 888	6 784

Source: Statistics Canada.
^{p} Preliminary; — Nil.

Table 14. Summary of developments in the Canadian steel industry

Company	Steel Plant Location	Raw Steel Furnace Capacity January 1978	Raw Steel Furnace Capacity Planned for 1980	Developments
		(Million tonnes)		
Stelco	Nanticoke, Ontario	Nil	1.0 (Total of 5.4 in the mid-to-late 80s)	The Nanticoke project, for which construction started in 1974, will include a 5 000-tonne blast furnace, a two-vessel basic oxygen steelmaking shop and a continuous slab caster. Only slabs will be produced and they will be transported to Hamilton for finishing into steel products.
Stelco	Welland, Ontario	—	—	Some equipment was modified and new equipment was added in order to meet stringent specifications for the Alaska natural gas pipeline.
Algoma	Sault Ste. Marie, Ontario	4.1	4.1	Rebuilt No. 9 coke oven battery; started construction of a new slab caster for completion in mid-1979; repaired No. 7 blast furnace.
Dominion Foundries and Steel, Limited (Dofasco)	Hamilton, Ontario	3.1	3.5	Start up of No. 2 B.O.F., No. 6 coke-oven battery and eight new soaking pits. Soaking pit capacity is now 3.3 million tonnes a year.
Sidbec-Dosco Limited	Contrecoeur, Quebec	0.9	1.2	Added a continuous casting machine for slabs; added two 150-tonne electric furnaces; started its second 600 000-tonne-a-year-capacity "Midrex" direct-reduction unit to produce sponge iron.
Sydney Steel Corporation (Sysco)	Sydney, Nova Scotia	1.1	1.0	Continued its $18 million modernization program aimed at improving production capability. Relined one furnace, reactivated one continuous slab casting machine and expanded storage facilities. Signed a six-year, $200 million contract with CNR for the supply of 80 000 to 110 000 tonnes of rails annually.
Ipsco	Regina, Saskatchewan	0.50	0.70	Phase one of a two phase expansion program consisting of a new rolling mill and some components of the smelt shop expansion was initiated in Sept. 1978. Phase two will comprise a fifth electric steel furnace, additional soaking pits and expansion of pipemaking capacity. The program will increase IPSCO's production capability of larger diameter pipe for the Alaska natural gas pipeline.
Lake Ontario Steel Company Limited (Lasco)	Whitby, Ontario	0.35	0.70	A new melt shop is to be built that will include a 135 tonne electric steelmaking furnace and a continuous billet-casting machine. Also, a new reheating furnace and a continuous bar mill will be built. Completion is scheduled for the middle of 1980.

Table 14. (cont'd)

Company	Steel Plant Location	Raw Steel Furnace Capacity January 1978	Planned for 1980	Developments
		(Million tonnes)		
Ivaco Ltd.	L'Orignal, Ontario	0.25	0.30	A new cooling system was installed that enables the company to produce fully annealed carbon wire rod directly from the mill without separate annealing operations.
Tree Island Steel Co. Ltd. (Tisco)	Richmond, British Columbia	—	0.22	Revealed plans to construct a $50 million steel wire rod mill for start-up in 1980. A 10 year contract was signed with Sysco for the supply of 1.6 to 2.2 million tonnes of steel billets as feed material for the new plant.
Stanley Steel Company Limited	Hamilton, Ontario	0.08	0.16	Announced plans to double production capacity by adding a new rolling mill. The $10 million project is expected to start in mid-79 and be completed in late 1980.

Source: Minerals and Metals Division, Department of Energy, Mines and Resources, Ottawa.
[1] Pipe mill.
— Nil.

Table 15. Canada, rolled steel supply and demand, 1975-78

	Producer or Mill Shipments[1]	Exports[2]	Imports[3]	Apparent Rolled Steel Consumption[4]	Raw Steel Production[5]
			(000 tonnes)		
1975	9 482	887	1 330	9 925	13 025
1976	9 821	1 448	1 052	9 425	13 290
1977	10 327	1 760	1 165	9 732	13 631
1978[p]	11 693	2 266	1 243	10 670	14 898
% change 1978/1977	+13.2	+28.8	+ 6.7	+ 9.6	+ 9.3

Sources: Statistics Canada; *Primary Iron and Steel* (monthly); *Trade of Canada*.
[1] Comprises domestic shipments plus producer exports. A portion of domestic shipments to warehouses and steel service centres is also exported. Excludes steel castings amounting to 195 000 tonnes in 1975, 157 000 tonnes in 1976, 134 000 tonnes in 1977, and 157 000 tonnes in 1978. [2] Total exports includes producer exports plus exports from warehouses and steel service centres. Excludes exports of pipe, wire, forgings and steel castings. [3] Excludes imports of pipe, wire forgings and steel castings. [4] Excludes apparent consumption of steel castings. [5] Includes production of steel castings amounting to 217 101 tonnes in 1975, 166 526 tonnes in 1976, 149 099 tonnes in 1977 and 170 493 tonnes in 1978.
[p] Preliminary.

Table 16. Canada, pig iron, raw steel, and continuous casting capacity by major producers, 1978 and 1980

Company Name and Location	Ownership	Pig Iron Capacity		Raw Steel Furnace Capacity		Continuous Casting Capacity	
		(million tonnes)		(million tonnes)		(million tonnes)	
		Jan. 78	Jan. 80	Jan. 78	Jan. 80	Jan. 78	Jan. 80
Stelco							
Hamilton	Public	3.81	3.81	5.26	5.26	—	—
Contrecoeur		—	—	0.23	0.23	0.23	0.23
Edmonton		—	—	0.23	0.23	0.23	0.23
Griffith Mine		0.36[1]	0.36[1]	—	—	—	—
Algoma							
Sault Ste-Marie	Canadian Pacific via Canadian Pacific Investments Limited (51%) Public (49%)	3.41	3.41	4.08	4.08	0.41	0.41
Port Colborne		0.22	0.22	—	—	—	—
Dofasco							
Hamilton	Public	2.72	3.18	3.10	3.54	—	—
Sidbec-Dosco	Quebec Gov't						
Contrecoeur	(100%)	1.0[1]	1.20[1]	0.90	1.20	0.54	1.09
Montreal, Que.		—	—	0.15	0.15	0.16	0.16
Longueuil		—	—	0.27	—	—	—
Sydney Steel	Nova Scotia						
Sydney	Gov't (100%)	0.76	0.76	1.00	1.00	0.68	0.68
Lasco	Co-steel International Limited						
Whitby, Ont.	Canada (50%) Private (50%)	—	—	0.36 (0.73in mid-80s)	0.36	0.36	0.36
Ipsco	Slater Steel (20%)						
Regina, Sask.	Public (40%) Sask. Gov't (20%) Steel Alberta Ltd. (20%)	—	0.42[1]	0.49	0.68	(0.45 in 1979)	0.68
Atlas Steels							
Welland, Ont.	Rio-Algom via	—	—	0.20	0.20	0.02	0.02
Tracy, Que.	Rio-Tinto Zinc	—	—	0.073	0.073	0.06	0.06
Burlington Steel[2]							
Hamilton	Slater Steel	—	—	0.27	0.27	0.27	0.27
Western Canada Steel Limited	Canadian Pacific via Cominco Ltd.						
Richmond, B.C.		—	—	0.18	0.18	0.11	0.12
Calgary, Alta.		—	—	0.05	0.05	0.06	0.06
Manitoba Rolling Mills	Canadian Pacific via Dominion Bridge						
Selkirk, Man.	Company, Limited	—	—	0.15	0.15	0.16	0.16
Ivaco							
L'Orignal, Ont.	Public	—	—	0.25	0.30	—	—

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Sponge iron. [2] Division of Slater Steel Industries Limited, a subsidiary of British Steel Corporation.
— Nil.

Table 17. Structure of Operating Costs[1] in Major Steel-producing Countries, 1970, 1974 and 1977

		Labour	Raw Materials	Energy	Total Costs
			($U.S.)		
United States	1970	81.75	31.59	24.26	137.60
	1974	115.61	63.76	49.82	229.19
	1977	175.48	63.51	87.71	326.70
European Economic Community[2]	1970	43.52	22.99	32.51	99.02
	1974	75.83	46.22	63.79	185.84
	1977	110.22	38.65	94.48	243.35
Japan	1970	25.80	33.80	21.36	80.96
	1974	46.91	55.86	46.88	149.65
	1977	72.76	45.40	72.43	190.59

Source: Organization for Economic Cooperation and Development, Paris, December 1978 (unpublished material).
[1] Unit costs of input per tonne of finished steel. [2] Seven countries.

Lead

GORDON R. PEELING

Steady demand coupled with continuing supply difficulties worked to bring producer and merchant stocks of lead to minimum-operating levels during the year. The price reacted accordingly to these favourable conditions and established new highs in all markets by year-end.

Canadian developments

Canada's production of lead, in all forms, increased 9.7 per cent by volume in 1978 and 28.4 per cent by value, compared with 1977 (see accompanying table). Mine output increased 11.7 per cent to 365 782 tonnes* and primary refined production increased a more modest 3.5 per cent to 194 054 tonnes. Capacity utilization in the smelting and refining sector was 86 per cent in 1978, up 3 percentage points from 1977 and resulted in a record 194 054 tonnes of metal production.

Export of lead contained in concentrates increased 3.5 per cent in 1978 to 142 641 tonnes compared with 1977, with 63 per cent by volume going to Japan, 16 per cent to the United States and 10 per cent to West Germany. Export of refined metal, which totalled 131 955 tonnes, was virtually unchanged from the previous year's total, with 50 per cent directed to the United States and 29 per cent to the United Kingdom. Scrap exports increased 10 per cent to 17 606 tonnes, with 27 per cent of the total directed to the United States market, 20 per cent to Sweden and 17 per cent to Japan.

Imports of lead-in-concentrate in 1977, the last year for which data are available, were 30 236 tonnes. Scrap imports in the same year totalled 41 521 tonnes.

The pattern and level of consumption of lead products in 1978 is estimated to be similar to that of 1977, when 110 763 tonnes were consumed.

Mine production

Newfoundland. ASARCO Incorporated operates the province's sole lead producer, the Buchans mine located in central Newfoundland. Output in 1978 was slightly above 1977 levels. The mine is approaching the end of its reserve life and was scheduled to close in the first quarter of 1979; however, rising lead prices and improving zinc prices will likely keep the mine going into 1980.

Nova Scotia. There are no lead producers presently operating, but two are scheduled to come on stream in 1979. Canada Wide Mines Limited, a subsidiary of Esso Resources of Canada Limited, will have its Gays River property in production by the fourth quarter at the rate of 12 000 tonnes per year of lead in concentrate. The capital cost of the project is $32 million. The other new producer will be Yava Mines Limited, a subsidiary of Barymin Explorations Limited. The company is bringing on the Silvermines property on Cape Breton Island at a cost of $3 million and at a planned production level of 10 000 tonnes of lead-in-concentrate per year by mid-year. Reserves at the two properties are given in the accompanying table.

New Brunswick. The $53 million expansion program at the No. 12 mine of Brunswick Mining and Smelting Corporation Limited has been rescheduled for completion by January 1981. The expansion will increase production capacity of lead-in-concentrate from 78 000 to 87 000 tonnes per year. Ore reserves at the No. 6 mine are limited and should be exhausted by 1981. As of December 1978, reserves at No. 6 were 0.6 million tonnes grading 7.25 per cent zinc, 2.64 per cent lead, 0.27 per cent copper and 85 grams (g) of silver per tonne, and at No. 12, were 98 million tonnes grading 9.2 per cent zinc, 3.8 per cent lead, 0.3 per cent copper and 96 g of silver per tonne.

Production at Heath Steele Mines Limited was similar to year-ago-levels. Ore reserves as of December 31, 1978 were 25.5 million tonnes grading 1.06 per cent copper, 1.62 per cent lead, 4.80 per cent zinc and 57 g of silver per tonne.

Quebec. Both the Manitou Division and the Louvicourt Division of Louvem Mining Company Inc. produced small quantities of lead in 1978. Weakening zinc and copper prices resulted in the closure of the Louvicourt Division in mid-1978, and declining ore reserves will result in the closure of the Manitou Division by mid-1979. However, the company announced early in 1979 that the Louvicourt operation was scheduled to be reopened by mid-1979 as a result of improved zinc and copper prices.

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* The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Ontario. All lead production in Ontario is a byproduct of copper and zinc production. Output increased at two producers, Sturgeon Lake Mines Limited and the Geco Division of Noranda Mines Limited, and declined at two producers, Mattabi Mines Limited and Texasgulf Canada Ltd.

Reserves of Ontario producers at year-end were: Falconbridge, 0.5 million tonnes grading 2.34 per cent copper, 1.30 per cent lead, 8.98 per cent zinc, 161 g of silver and 0.5 g of gold per tonne; Geco, 21.7 million tonnes grading 1.87 per cent copper, 0.11 per cent lead, 3.78 per cent zinc and 48 g of silver per tonne; Mattabi, 1.4 million tonnes of ore grading 0.47 per cent copper, 0.88 per cent lead, 8.14 per cent zinc and 101 g of silver per tonne in the open-pit zone, and 1.3 million tonnes underground grading 0.56 per cent copper, 0.84 per cent lead, 7.31 per cent zinc and 99 g of silver per tonne.

The Lyon Lake zone of Mattagami Lake Mines Limited will be in production by mid-1980 at a rate of 2 000 tonnes per year of lead-in-concentrate. Reserves are 2.5 million tonnes grading 1.33 per cent copper, 0.67 per cent lead, 6.89 per cent zinc and 113 g of silver per tonne.

Manitoba and Saskatchewan. A small amount of byproduct lead was produced from the operations of Hudson Bay Mining and Smelting Co., Limited. Hudson Bay operated 11 ore sources in 1978, only two of which report lead production – Ghost Lake and Chisel Lake. Production was 777 tonnes compared with 415 tonnes in 1977.

British Columbia. The HB mine of Cominco Ltd. was closed on September 1, 1978 due to exhaustion of reserves. Production at other producers was normal during the year although favourable lead zones at the Sullivan mine of Cominco allowed an increase in concentrate production over 1977 levels.

Ore reserves at the Sullivan mine at year-end were 50.8 million tonnes grading 4.6 per cent lead, 5.8 per cent zinc and 37 g of silver per tonne.

Northair Mines Ltd. (N.P.L.) enjoyed an excellent year. Ore reserves are listed as 0.2 million tonnes grading 2.63 per cent lead, 3.69 per cent zinc, 29 g of silver and 12 g of gold per tonne.

The ore reserves at the property of Western Mines Limited were 1.2 million tonnes grading 1.1 per cent copper, 1.2 per cent lead, 7.9 per cent zinc, 117 g of silver and 2 g of gold per tonne.

Table 1. Canada, lead production, trade and consumption, 1977 and 1978

	1977		1978^p	
	(tonnes)	($)	(tonnes)	($)
Production				
All forms[1]				
Yukon	68 622	47 627 667	80 643	65 466 000
British Columbia	78 173	54 256 735	71 251	57 842 000
New Brunswick	55 525	38 537 560	70 877	57 539 000
Northwest Territories	58 833	40 833 313	70 071	56 884 000
Newfoundland	11 097	7 702 122	8 123	6 595 000
Ontario	8 138	5 648 504	6 570	5 333 000
Manitoba	436	302 545	565	458 000
Quebec	131	91 083	227	184 000
Total	280 955	194 999 529	308 327	250 301 000
Mine output[2]	327 593		365 782	
Refined production[3]	187 457		194 054	
Exports				
Lead contained in ores and concentrates				
Japan	86 427	31 315 000	89 712	35 229 000
United States	18 042	6 963 000	22 154	8 071 000
West Germany	16 974	4 842 000	14 533	3 705 000
United Kingdom	6 658	1 788 000	6 901	2 411 000
Brazil	—	—	4 004	1 330 000
Other countries	9 719	3 212 000	5 337	1 772 000
Total	137 820	48 120 000	142 641	52 518 000

Table 1. (cont'd)

	1977		1978ᵖ	
	(tonnes)	($)	(tonnes)	($)
Exports (cont'd)				
Lead pigs, blocks and shot				
United States	66 242	44 044 000	65 413	50 024 000
United Kingdom	40 948	23 543 000	38 107	27 257 000
Italy	6 038	2 899 000	7 733	4 071 000
U.S.S.R.	—	—	5 748	3 928 000
West Germany	575	364 000	2 931	2 448 000
People's Republic of China	500	283 000	3 681	2 188 000
Other countries	16 516	8 388 000	8 342	4 969 000
Total	130 819	79 521 000	131 955	94 885 000
Lead and alloy scrap (gross weight)				
United States	2 736	1 228 000	4 731	2 468 000
Sweden	1 742	677 000	3 535	1 554 000
Japan	351	60 000	3 004	965 000
South Korea	1 926	415 000	2 035	588 000
Spain	—	—	1 367	562 000
Taiwan	270	65 000	1 246	330 000
Denmark	445	247 000	926	313 000
Other countries	8 493	2 623 000	762	294 000
Total	15 963	5 315 000	17 606	7 074 000
Lead fabricated materials not elsewhere specified				
United States	7 434	5 665 000	8 375	7 350 000
United Kingdom	1	3 000	199	163 000
Venezuela	—	—	27	29 000
Netherlands	18	16 000	88	22 000
Other countries	364	139 000	69	42 000
Total	7 817	5 823 000	8 758	7 606 000
Imports				
Lead pigs, blocks and shot	821	575 000	1 715	1 413 000
Lead oxide, dioxide and tetroxide	336	349 000	321	402 000
Lead fabricated materials not elsewhere specified	2 505	3 066 000	2 270	3 020 000
Lead in concentrates	30 236	12 474 000	..	..
Lead in dross, skimmings and sludge	373	98 000	..	..
Lead and lead alloy scrap	41 521	8 257 000	..	..

Table 1. (cont'd)

	1976			1977[p]		
	Primary	Secondary[4]	Total	Primary	Secondary[4]	Total
	(tonnes)					
Consumption						
Lead used for, or in the production of:						
antimonial lead	1 633	15 654	17 287	480	13 618	14 098
battery and battery oxides	25 511	4 821	30 332	35 761	5 742	41 503
cable covering	2 158	x	2 158	2 506	x	2 506
chemical uses; white lead, red lead, litharge, tetraethyl lead, etc.	20 646	x	20 646	18 828	x	18 828
copper alloys; brass, bronze, etc.	348	82	430	259	90	349
lead alloys:						
solders	2 056	5 358	7 414	1 234	10 204	11 438
others (including babbitt, type metals, etc.)	180	3 219	3 399	213	3 209	3 422
semifinished products: pipe, sheet, traps, bends, blocks for caulking, ammunition, etc.	2 682	x	2 682	3 267	x	3 267
other lead products	6 943	16 363	23 306	2 095	13 257	15 352
Total	62 157	45 497	107 654	64 643	46 120	110 763

Source: Statistics Canada.
[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable lead in domestic ores and concentrates exported. [2] Lead content of domestic ores and concentrates produced. [3] Primary refined lead from all sources. [4] Includes all remelt scrap lead and scrap lead used to make antimonial lead.
[p] Preliminary; — Nil; .. Not available; x Confidential, but included in "other".

Table 2. Canada, lead production, trade and consumption, 1960, 1965, 1970 and 1975-78

	Production		Exports				
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total	Imports Refined[3]	Consumption[4]
	(tonnes)						
1960	186 563	143 798	46 571	87 497	134 068	562	65 396
1965	264 723	169 175	97 036	117 086	214 122	64	81 799
1970	353 063	185 637	186 219	138 637	324 856	1 995	84 765
1975	349 133	171 516	211 909	110 882[r]	322 791[r]	1 962	89 193
1976	256 324	175 720	140 933	114 421[r]	255 354[r]	1 941	107 654
1977	280 955	187 457	137 820	130 819	268 639	821	110 763
1978[p]	308 327	194 054	142 641	131 955	274 596	1 715	..

Source: Statistics Canada.
[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus the estimated recoverable lead in domestic ores and concentrates exported. [2] Primary refined lead from all sources. [3] Lead in pigs and blocks. [4] Consumption of lead, primary and secondary in origin.
[p] Preliminary; [r] Revised; .. Not available.

Yukon Territory. Cyprus Anvil Mining Corporation announced in late November that it had agreement in principle with Kerr Addison Mines Limited and Canadian Natural Resources Limited to acquire the Grum, Vangorda and Swim Lake properties from the latter two companies. Cyprus will pay $13.8 million to Kerr Addison and $7.0 million to Canadian Natural Resources. In addition Cyprus will make a takeover bid for the outstanding 30 per cent of Vangorda Mines Limited at a cost of $0.9 million. The properties in question contain sizeable identified deposits: Grum, 26.1 million tonnes grading 4.1 per cent lead, 6.4 per cent zinc and 65 g of silver per tonne; Swim Lake, 4.5 million tonnes grading 4.0 per cent lead, 5.5 per cent zinc and 51 g of silver per tonne; and Vangorda, 8.5 million tonnes grading 3.18 per cent lead, 4.96 per cent zinc, 0.27 per cent copper and 60 g of silver per tonne. Cyprus Anvil also carried out a diamond drill program on its DY deposit, which returned favourable results. However, the overall tonnage and grade of material that might eventually be economically blended with Faro ore remains inconclusive and a further diamond-drilling program is planned for 1979. Production at United Keno Hill Mines Limited was similar to levels in 1977, but production from underground operations continues to decline while open-pit production expands.

Northwest Territories. In the Northwest Territories production from both Pine Point Mines Limited and Nanisivik Mines Ltd. compared favourably with prior levels.

Negotiations continued throughout 1978 between Cominco Ltd. and the federal government concerning the development of the Polaris project on Little Cornwallis Island in the high Arctic by the former's 75 per cent owned subsidiary, Arvik Mines Ltd. Significant progress was made during the year and a decision should be forthcoming in 1979. The deposit contains 22.7 million tonnes ore grading 14.1 per cent zinc, 4.1 per cent lead and 34 g of silver per tonne. If a favourable decision is taken the project could be on stream by the mid-1980s, with an annual output of about 25 000 tonnes of lead contained in concentrate.

Metal production

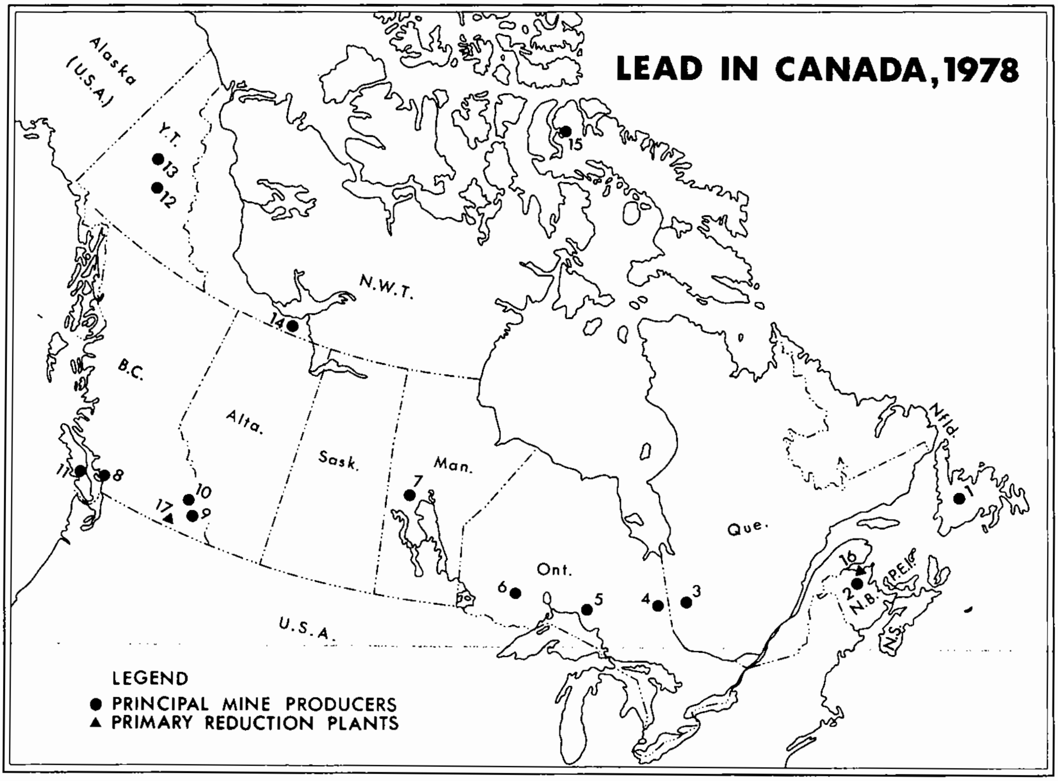
Refined metal production in 1978 at primary plants surpassed the 1977 record level of 187 457 tonnes by 3.5 per cent, to reach 194 054 tonnes.

The domestic secondary lead producers suffered shortages of scrap supply at various times during the year, but particularly so in the fourth quarter when a number of plants were forced to close for short periods to allow the accumulation of sufficient feedstocks. The scrap supply problem appears to be a result of currency exchange rate movements which, on the one hand, made it costly to import battery plates from the United States and, on the other hand, encouraged the continued export of scrap from Canada to foreign markets to take advantage of stronger foreign currencies. Another aspect to the scrap shortage was speculation that scrap merchants, in a rising market, may have hoarded supplies in the hope of obtaining a better price in the future. Scrap exports from Canada in 1978 totalled 17 606 tonnes with a value of $7.1 million, up 1 643 tonnes from 1977; however, the 1978 value exceeded that of 1977 by 33 per cent. The unit value showed a year-over-year increase of 21 per cent.

The Foreign Investment Review Agency gave approval in November to a proposal by Preussag AG of West Germany and the Singerman Group to establish a new secondary lead plant near Montreal. The 40 000-tonne-per-year plant will cost about $14 million and employ 200 persons when it comes on stream in October 1979. The operating company will be Ballast Metals Canada Inc., jointly owned by the two principals. The addition of this plant will bring Canada's secondary lead production capacity up to the range of 100 000 to 110 000 tonnes per annum.

Domestic consumption

Consumption of both primary and secondary lead in 1978 is estimated to be unchanged from year-ago-levels of 64 643 tonnes and 46 120 tonnes, respectively.



Principal mine producers
(numbers refer to numbers on map above)

1. ASARCO Incorporated (Buchans Unit)
2. Brunswick Mining and Smelting Corporation Limited (Nos. 12 & 6 mines)
   Heath Steele Mines Limited
3. Louvem Mining Company Inc. (Manitou-Barvue Division)
4. Texasgulf Canada Ltd.
5. Noranda Mines Limited (Geco Division)
6. Mattabi Mines Limited
   Sturgeon Lake Mines Limited
7. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake, Ghost Lake mines)
8. Northair Mines Ltd.
9. Cominco Ltd. (Sullivan and H.B. mines)
10. Silvana Mines Inc. (Silmonac mine)
11. Western Mines Limited
12. Cyprus Anvil Mining Corporation
13. United Keno Hill Mines Limited
14. Pine Point Mines Limited
15. Nanisivik Mines Ltd.

Primary reduction plants

16. Brunswick Mining and Smelting Corporation Limited, Smelting Division
17. Cominco Ltd.

Table 3. Principal lead mines in Canada, 1978 and (1977)

Company and Location	Mill Capacity	Copper	Lead	Zinc	Silver	Gold	Ore Milled	Lead Concentrates Produced	Lead Concentrates Grade	Lead Concentrates Content	Lead Content all[1] Concentrates	Destination[2] of Concentrates
	(tonnes/ day)	(%)	(%)	(%)	(grams/ tonne)	(grams/ tonne)	(tonnes)	(tonnes)	(%)	(tonnes)	(tonnes)	
Newfoundland												
ASARCO Incorporated,	1 100	1.04	6.07	10.78	95.18	0.72	183 251	16 601	54.47	9 043	10 346	1,5,7
Buchans Unit, Buchans	(1 100)	(0.99)	(6.12)	(10.76)	(97.04)	(0.68)	(174 179)	(16 077)	(55.84)	(8 977)	(10 082)	(1,5,7)
New Brunswick												
Brunswick Mining and	9 050	0.29	3.56	8.88	93.94	—	3 058 301	198 888	33.26	66 150	80 101	1,8
Smelting Corporation	(8 950)	(0.37)	(3.12)	(7.82)	(76.83)	(—)	(3 134 388)	(182 395)	(31.78)	(57 965)	(71 432)	(1)
Limited,												
Nos. 6 and 12 mines								31 365	17.46			5,7
Bathurst	Bulk Concentrate							(32 252)	(15.17)	Included above		(5,7)
Heath Steele Mines	3 650	1.03	1.53	4.43	70.29	0.81	1 137 767	30 923	24.10	7 452	10 424	3,5,6,8
Limited, Newcastle	(3 650)	(1.19)	(1.50)	(3.83)	(60.03)	(0.62)	(1 150 318)	(30 942)	(26.82)	(8 299)	(10 878)	(1,3,5,6)
Sullico Resources Ltd.	Closed August 26, 1977											
Bathurst	(1 050)	(0.15)	(2.39)	(2.54)	(77.76)	(—)	(179 457)	(7 257)	(50.00)	(3 629)	(3 861)	(2)
Quebec												
Louvem Mining Company	900	0.15	0.29	5.33	79.62	1.59	248 073	859	32.22	277	523	3
Inc. (SOQUEM),	(900)	(0.12)	(0.16)	(5.95)	(37.95)	(0.93)	(277 837)	(889)	(17.93)	(159)	(320)	(3)
Val d'Or												
Ontario												
Mattabi Mines Limited,	2 700	0.83	0.67	6.49	84.60	0.37	871 675	9 696	31.76	3 079	4 333	3
Sturgeon Lake	(2 700)	(1.01)	(0.84)	(8.40)	(110.42)	(0.31)	(938 417)	(12 488)	(31.20)	(3 896)	(5 467)	(3)
Noranda Mines Limited,	4 550	1.54	0.12	2.19	35.15	0.16	1 572 458	1 003	51.14	513	1 240	2,3
Geco, Manitouwadge	(4 550)	(1.94)	(0.11)	(2.62)	(37.95)	(0.16)	(1 591 673)	(578)	(60.57)	(350)	(1 062)	(3)
Sturgeon Lake Mines	1 100	2.73	1.17	9.14	155.83	0.65	370 087	4 593	39.12	1 797	3 646	1
Limited,	(1 100)	(3.46)	(1.26)	(10.44)	(206.40)	(. .)	(383 885)	(4 556)	(32.27)	(1 470)	(4 837)	(1)
Sturgeon Lake												
Texasgulf Canada Ltd.,	9 050	1.62	0.22	6.12	78.85	—	2 585 282	18 319	11.37	2 083	4 178	3
Kidd Creek Mine,	(9 050)	(1.83)	(0.22)	(7.26)	(94.18)	(—)	(3 299 051)	(28 170)	(11.76)	(3 313)	(5 418)	(3)
Timmins												

Table 3. (cont'd)

Company and Location	Mill Capacity	Copper	Lead	Zinc	Silver	Gold	Ore Milled	Lead Concentrates Produced	Lead Concentrates Grade	Lead Concentrates Content	Lead Content all[1] Concentrates	Destination[2] of Concentrates
	(tonnes/day)	(%)	(%)	(%)	(grams/tonne)	(grams/tonne)	(tonnes)	(tonnes)	(%)	(tonnes)	(tonnes)	
Manitoba and Saskatchewan												
Hudson Bay Mining and	7 250	2.26	0.13	3.16	20.57	..	1 679 001	942	56.41	531	778	2
Smelting Co., Limited	(7 250)	(2.18)	(0.22)	(2.79)	(17.48)	(1.12)	(1 652 526)	(676)	(61.42)	(415)	(1 745)	(2)
Flin Flon concentrator												
British Columbia												
Cominco Ltd.,	6 350	—	4.64	3.31	56.30	—	2 107 876	136 270	62.40	85 033	90 061	2
Sullivan Mine,	(6 350)	(—)	(3.74)	(3.83)	(42.30)	(—)	(2 194 230)	(106 701)	(62.76)	(66 966)	(75 495)	(2)
Kimberley												
H.B. mine,	1 100	—	1.10	4.87	4.60	—	200 889	3 934	31.40	1 235	1 494	2
Salmo	(1 100)	(—)	(0.67)	(3.86)	(3.11)	(—)	(357 258)	(4 811)	(32.20)	(1 549)	(1 933)	(2)
Northair Mines Ltd.,	250	0.20	1.30	1.96	64.07	11.01	93 397	2 781	37.49	1 043	1 120	2,3
Squamish	(250)	(—)	(1.45)	(2.05)	(127.52)	(13.53)	(92 130)	(2 489)	(46.45)	(1 156)	(1 215)	(3)
Silvana Mines Inc.,	100	—	5.81	4.34	461.58	—	15 966	1 460	60.45	882	896	2
Silmonac mine, Sandon	(100)	(—)	(7.42)	(6.11)	(608.38)	(—)	(15 996)	(1 893)	(59.16)	(1 120)	(1 145)	(2)
Western Mines Limited,	1 000	1.25	1.33	8.24	126.90	2.58	269 035	6 635	43.05	2 856	3 417	2
Lynx and Myra Falls	(1 000)	(1.14)	(1.34)	(7.58)	(133.43)	(2.46)	(269 069)	(6 446)	(44.12)	(2 844)	(3 366)	(2)
mines, Buttle Lake												
Yukon Territory												
Cyprus Anvil Mining	9 050	0.20	3.17	5.14	18.04	0.12	3 280 660	134 327	60.68	81 510	92 454	3,4,5,7,8
Corporation, Faro	(9 050)	(0.19)	(2.74)	(4.88)	(18.04)	(0.12)	3 116 004	(100 389)	(64.11)	(64 359)	(75 204)	(4,5)
	............Also Bulk Concentrate	....	....	....	....	....	....	32 931	19.02	Included		Included
								(36 855)	(19.12)	above		above
United Keno Hill Mines	450	—	5.50	0.79	1 111.02	—	81 721	6 931	49.76	3 449	3 449	3
Limited, Elsa	(450)	(—)	(4.57)	(1.12)	(1 103.86)	(—)	(82 995)	(5 723)	(49.60)	(2 839)	(2 846)	(3)
Northwest Territories												
Nanisivik Mines Ltd.,	1 350	—	1.44	13.24	55.99	—	574 314	11 507	62.91	7 239	7 810	5,6
Baffin Island	(1 350)	(—)	(1.98)	(13.27)	(63.45)	(—)	(546 085)	(15 281)	(60.77)	(9 286)	(10 069)	(5,6)
Pine Point Mines	9 050	—	2.62	5.91	—	—	2 985 072	90 673	76.50	69 365	74 237	2,3,4,5,8
Limited, Pine Point	(9 050)	(—)	(2.14)	(5.29)	(—)	(—)	(3 123 437)	(77 111)	(73.49)	(56 669)	(62 272)	(2,3,4,5,6,8)

Sources: Data supplied by companies to Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1]Includes lead in zinc, copper, silver and bulk concentrates. [2]Destination: (1) Brunswick Mining and Smelting Corp., (2) Cominco Ltd., (3) U.S.A., (4) Japan, (5) Germany, (6) Belgium, (7) United Kingdom, and (8) Other or unspecified.
– Nil; . . Not available.

Table 4. Prospective Canadian lead producing mines

Company and Location	Year Production Expected	Mill or Mine Capacity	Indicated Ore Reserves	Grade of Ore: Zinc	Lead	Copper	Silver	Remarks
		(tonnes ore/day)	(tonnes)	(%)	(%)	(%)	(grams/ tonne)	
Nova Scotia								
Canada Wide Mines Limited, Gays River	1979	1 350	4 780 000	4.23	2.78	—	. .	Capital cost of $27 million. Production by fourth quarter.
Barymin Explorations Limited, Cape Breton Island	1979	600	1 120 000	—	5.40	—	—	In production by mid-year.
Ontario								
Mattagami Lake Mines Limited,								
Sturgeon Lake – Lyon Lake	1980	—	3 578 845	6.53	0.63	1.24	117	Milling for both mines will be at the Mattabi mill.
– 'F' zone	1981	—	571 527	8.10	0.49	0.98	62	
Northwest Territories								
Arvik Mines Ltd., Little Cornwallis Island	1985	2 000	22 700 000	14.10	4.10	. .	34	Cominco Ltd. 75%, Bankeno Mines Limited 25%. Feasibility study completed. Decision on mining depends on negotiations with federal government.

Sources: Company reports and technical press.
— Nil; . . Not available.

Table 5. United States consumption of lead by end-use 1977 and 1978

	1977	1978[p]
	(tonnes)	
Storage batteries	858 085	696 932
Gasoline antiknock additives	211 292	178 331
Solder, type metal, terne metal and bearing metals	82 079	63 257
Pigments	90 702	82 746
Ammunition and collapsible tubes	63 905	56 687
Sheet and pipe	25 760	12 228
Cable covering	13 705	13 368
Weights and ballast	17 320	7 436
Caulking	8 725	5 791
Other uses	63 900	41 312
Total reported[1]	1 435 473	1 158 088
Estimated undistributed consumption	—	174 112
Grand Total	1 435 473	1 332 200

Source: United States Bureau of Mines, Mineral Industry Surveys, Lead Industry in December 1978.
[1] Includes lead content of scrap used directly in fabricated products.
[p] Preliminary; — Nil.

Canadian consumption has more than doubled from 49 600 tonnes in 1950 to 110 763 tonnes in 1977, an annual growth rate of 3.0 per cent. The most spectacular growth has been in battery production, at an annual rate of 3.9 per cent, and in chemical uses, at 4.6 per cent. On the negative side, the production of tetraethyl lead peaked in 1973 and has declined by almost 25 per cent since. Cable coverings, as an end use, has declined from 11 600 tonnes in 1950 to a modest 3 000 tonnes in 1977. The size of the Canadian market and the limited number of producers and consumers has resulted in a data base that is difficult to compare with other markets because of confidentiality considerations. Nonetheless these trends are similar to those in the United States and most other industrialized countries.

World industry

The International Lead and Zinc Study Group (ILZSG) reported that mine production in 1978 was 2 497 000 tonnes, less than one per cent below the 1977 level of 2 511 000 tonnes. Metal production was down 2 per cent in 1978, at 3 699 000 tonnes, and consumption was down less than one per cent, at 3 650 000 tonnes. With net trade to socialist countries of lead in all forms (concentrate, bullion and refined metal) totalling 166 000 tonnes, the balance between production and consumption shows a statistical shortfall of 130 000 tonnes. Producer stocks declined from 178 000 tonnes at the end of 1977 to 148 000 tonnes at the end of 1978. During the same period stocks on the London Metal Exchange (LME) declined dramatically from 66 925 tonnes to 15 475 tonnes. The difference between these visible stock movements and the statistical shortfall was probably covered by consumer holdings.

The decline in metal production resulted from strikes at producers in the United States and tightness in concentrate supplies, particularly in Europe where production problems in Sweden and supply disruptions in Ireland affected the flow of feedstocks to smelters. The Ronnskar plant of Boliden AB in Sweden, with a capacity of 55 000 tonnes of refined metal was closed in the fourth quarter to allow the accumulation of sufficient feedstock. Demand for metal from eastern Europe also added to the tight supply conditions.

There were 13 lead mine closures in 1978, which removed 37 500 tonnes of annual capacity from production. The closures were located in Canada, 2 000 tonnes; Japan, 2 500 tonnes; Germany, 4 000 tonnes; South West Africa, 4 000 tonnes; and the United States, 25 000 tonnes. These closures were partially offset by new mine capacity coming on stream in 1978 in Algeria, with 4 000 tonnes and in Australia, with 23 000 tonnes.

When adjustments are made for declining ore grades at existing producers, the western world mine capacity is likely to have diminished by more than the 11 500 tonnes statistically shown.

New and expanded lead smelting capacity, which came on stream in 1978, totalled 149 000 tonnes, of which 139 000 was secondary capacity. There were no plant closures during the year. The major additions occurred in

Table 6. Non-communist world mine production of lead, 1977 and 1978

	1977	1978[p]
	(000 tonnes)	
United States	550	540
Australia	417	375
Canada	328	366
Peru	183	179
Mexico	160	164
Yugoslavia	118	110
Morocco	105	91
Sweden	87	82
Spain	65	72
Japan	55	58
Ireland	42	47
Republic of South Africa	41	38
Iran	30	35
France	32	32
Italy	31	31
Denmark	29	31
West Germany	37	30
Other countries	201	216
Total	2 511	2 497

Sources: Statistics Canada; International Lead and Zinc Study Group, Monthly Bulletin, March 1978.
[p] Preliminary.

the United States, where four plants with 99 000 tonnes of new or expanded capacity came on stream. Other additions were in Brazil, with 40 000 tonnes and in India, with 10 000 tonnes.

United States. Mine production declined for the fourth year in succession to 540 000 tonnes, a decline of 1.8 per cent from 1977. The 1978 decline was due to labour strikes and the closure of several zinc mines that produced byproduct lead. Metal production and consumption followed similar trends, as the former declined 4.2 per cent to 1 120 000 tonnes and the latter declined 2.5 per cent to 1 270 000 tonnes. The decline in consumption is mainly a result of fall-off in use in the two major-use categories – storage batteries and tetraethyl lead additives in gasoline. The former is a result of market factors and the latter is a legislative phenomenon.

Regulatory developments in the United States have been the focus of activities in the lead industry in recent years. Late in the year the United States industry received a double blow as both the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA) brought forward stringent regulations on ex-plant lead emissions and worker exposure limits. The EPA regulations limit emissions of lead in air at plant gates to 1.5 micrograms per cubic metre (m^3), measured over a 90-day period. Industry has pressed for a level of 5.0 micrograms per m^3. The OSHA regulations limit worker exposure to airborne lead to a level of 50 micrograms per m^3 on an eight-hour, time-weighted basis. The initial proposal from OSHA was for a 100 microgram standard, but this now becomes an interim standard. Industry will have several years in which to meet the new levels. Nonetheless preliminary estimates suggest that the capital expenditures necessary for compliance will total almost $1.5 billion and that the production costs at plants will increase significantly as a result. Even if these cost figures are over-stated, the adjustment process for the U.S. industry is likely to be a difficult one with some, if not many, smaller producers with older plants being forced to close. Increased dependence upon imports and greater concentration of the industry could result.

Europe. The nine EEC members continued to show economic gains in 1978 from the recessionary levels of 1975, although this was not reflected in the lead industry as conditions were static. Mine production was 174 000 tonnes in 1978, as strikes hampered production in Ireland. Metal production in 1978 was 1 036 000 tonnes, a slight decrease from the 1977 level of 1 056 000 tonnes, mainly a result of raw materials supply problems at some producers. Consumption was also down slightly (1.4 per cent) to 1 117 000 tonnes.

Japan. Mine production of lead increased 3.6 per cent to 57 000 tonnes in 1978, metal production 3.2 per cent to 228 000 tonnes and consumption, 8.5 per cent to 267 000 tonnes. The large supply deficit between mine and metal production is largely made up by Canada from mines in British Columbia and the Territories.

Table 7. Non-communist world production[1] of refined lead, 1977 and 1978

	1977	1978[p]
	(000 tonnes)	
United States	1 169	1 120
West Germany	307	302
United Kingdom	264	247
Australia	218	239
Japan	221	228
Mexico	206	204
Canada	187	194
France	184	184
Yugoslavia	138	125
Spain	116	114
Italy	118	106
Belgium	104	104
Brazil	80	80
Peru	79	73
Republic of South Africa	67	64
Other countries	324	315
Total	3 782	3 699

Sources: Statistics Canada; International Lead and Zinc Study Group, Monthly Bulletin, March 1978.
[1] Total production by smelters or refineries, or refined pig lead, plus the lead content of antimonial lead, including production on toll in the reporting country, regardless of the type of source material, i.e., whether ores, concentrates, lead bullion, lead alloys, mattes, residues, slag or scrap. Remelted pig lead and remelted antimonial lead are excluded.
[p] Preliminary.

Table 8. Non-communist world consumption[1] of refined lead, 1977 and 1978

	1977	1978[p]
	(000 tonnes)	
United States	1 303	1 270
West Germany	280	275
Japan	246	270
Italy	260	243
United Kingdom	241	242
France	190	192
Spain	120	114
Yugoslavia	88	90
Brazil	86	88
Mexico	88	86
Canada	64	74
Other countries	714	706
Total	3 680	3 650

Source: International Lead and Zinc Study Group, Monthly Bulletin, March 1978.
[1] Consumption of those types of metal as reported under production in Table 7.
[p] Preliminary.

Prices

The producers' price of lead in North America, after some hesitation in the second quarter, responded to favourable demand conditions and moved from the year's low of 31 cents per pound in the U.S. market at mid-year to a level of 38 cents in November, which held through year-end. At one point in the fourth quarter, secondary producers in the U.S. priced their product at a 1 to 2 cent premium to primary lead in recognition of rising scrap prices and lack of feed. In November, the secondary producers moved back to the 38-cent-level to reestablish a common price with the primary sector. In the Canadian market, the price in Canadian funds moved from 35.25 cents per pound in January to 42 cents in November, where it stayed through year-end. Scrap supplies were also tight in the Canadian market during the year and secondary metal commanded up to a 3 cent premium during the fourth quarter. The London Metal Exchange (LME) spot price, in U.S. funds, moved from a monthly average of 30.0 cents per pound in January (£ 342.4 per tonne) to a low of 24.7 cents in May (£ 299.2 per tonne). Subsequent physical demand brought the price up to 38.9 cents for the month of December (£432.1 per tonne).

Outlook

Information released by the International Lead and Zinc Study Group (ILZSG) shows new lead mine capacity coming on stream in 1979 totalling 61 000 tonnes, a 2 per cent increase over 1978 production capacity. The new capacity is located in: Canada, with 22 000 tonnes; Spain, 23 000 tonnes; Thailand, 12 000 tonnes and Yugoslavia, with 4 000 tonnes.

New lead mines to be brought into production in 1980 will have a combined capacity of 138 000 tonnes per year and will be located in: Canada, 10 000 tonnes; Japan, 4 000 tonnes; Mexico, 16 000 tonnes; South Africa, 90 000 tonnes and Yugoslavia, 18 000 tonnes. In 1981, new additions to production capacity will total 17 000 tonnes, while in 1982, two projects planned for India will total 18 000 tonnes. Thus in the 1979-82 period, plans firmly in place will result in additions to capacity of 234 000 tonnes. However, when closures and declines in output from existing producers are taken into account, the net addition is likely to be much smaller than this total, perhaps by as much as 50 per cent. This relatively small increase in capacity is likely to leave concentrates in chronically short supply during the period.

The recently released report on the Joint Production of Lead and Zinc in the period 1957-76 by the ILSZG indicates that the ratio of lead to zinc in mixed ores, zinc ores and even lead ores has been declining over time. With the mine developments scheduled for the 1979-82 period, this trend is not likely to be reversed. This may put added pressure on such regions as the New Missouri lead belt to expand output from predominantly lead ores.

Table 9. World production of lead metal, 1800-2000

Decade	Production Per Decade	Decade	Production Per Decade
	(000 tonnes)		(000 tonnes)
1801-1810	218.6	1901-1910	9 907.9
1811-1820	304.8	1911-1920	10 894.6
1821-1830	817.5	1921-1930	14 610.9
1831-1840	1 023.3	1931-1940	14 606.6
1841-1850	1 190.3	1941-1950	14 848.3
1851-1860	1 651.8	1951-1960	22 977.2
1861-1870	2 412.7	1961-1970	32 933.1
1871-1880	3 373.8	1971-1980	41 702.1
1881-1890	4 675.9	1981-1990	57 796.6
1891-1900	7 004.0	1991-2000	75 125.1
Sub-total	22 672.7	Total	297 669.6

Sources: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa; Summarized Data of Lead Production, Economic Paper No. 5, Bureau of Mines, Washington, D.C.; Metallgesellschaft Aktiengesellschaft, *Metal Statistics*; World Bureau of Metal Statistics, *World Metal Statistics*, Forecast to year 2000 by Mineral Policy Sector.

Table 10. Lead metal prices, 1978

	London Metal Exchange Spot	United States Domestic Delivered Price	Canada Delivered Carlots
Month	(£ per tonne)	(¢ per pound)	(¢ per pound)
January	342.4	33.0	35.25
February	300.6	33.0	35.25
March	305.0	33.0	35.25
April	309.6	33.0	35.25
May	299.2	31.0	34.25-35.25
June	310.3	31.0	34.25
July	307.3	31.0	34.25
August	329.3	32.2	35.40
September	353.6	34.1	34.50-39.50
October	413.7	36.6	41.5
November	410.5	38.0	42.0
December	432.5	38.0	42.0
1978 Average	342.8	33.7	36.8
1977 Average	353.9	30.7	31.3

Source: International Lead and Zinc Study Group, Monthly Bulletin, March 1979.

Additions to smelter capacity in the 1979-82 period total 170 000 tonnes and of this total 61 000 tonnes is primary capacity, with the remainder secondary. Sizeable expansion plans in the secondary sector scheduled for the United States have been deferred pending an assessment of the impact of the new EPA and OSHA regulations.

Demand for batteries and for lead from the transportation sector in general is expected to remain strong and compensate for the loss of lead usage in gasoline. There is added pressure on the secondary industry to fill the gap between mine supply and metal demand because of the trend to mine orebodies with lower lead to zinc ratios. This trend is expected to continue through 1985. In addition, the secondary industry is faced with the difficult and costly adjustment to the new EPA and OSHA regulations in the United States.

Table 9 shows cumulative lead metal production by decades during the period from 1801 on, with a forecast to the year 2000. In the 1801-1978 period production totalled 176.7 million tonnes. A forecast to the year 2000 indicates that demand could increase this total by 62 per cent to 292.7 million tonnes.

The cumulative total is achieved by forecasting a best fit straight line to the data for 1950-78 and projecting to the year 2000. The annual compound growth rate using this method is 2.1 per cent, with production-demand in the year 2000 being 6 581 000 tonnes. The upper and lower limits that bracket the "most likely" outcome and reflect the expected range of effects of population and western world economic growth rates are 7 513 000 tonnes and 5 222 000 tonnes, respectively. These upper and lower limits in the year 2000 represent annual compound growth rates during the period 1979-2000 of 2.7 per cent and 1.4 per cent, respectively.

Tariffs

Canada

Item Number		British Preferential	GSP[1]	GATT[2]	General
32900-1	Ores of lead	Free	Free	Free	Free
33700-1	Lead, old scrap, pig and block	Free	Free	Free	1¢ per lb
33800-1	Lead, in bars and in sheets	5%	3%	5%	25%
33900-1	Manufactures of lead, not otherwise provided for	17½%	11½%	17½%	30%

United States

TSUS Number		GSP	GATT
		(¢/lb on lead content)	
602.10	All lead bearing ore	Free	0.75
	Unwrought lead		
624.02	Lead bullion (on 99.6% of lead content)	Free	1.0625
624.03	Other	1.0625	1.0625
624.04	Lead waste and scrap (on 99.6% of lead content)	Free	1.0625

European Economic Community (EEC)

Brussels Tariff Nomenclature (BTN) Number		GSP	GATT
26.01	Lead ores and concentrates	Free	Free
78.01	Unwrought lead		
	For refining (i.e. argentiferous)	Free	Free
	Other	3.5%	3.5%
	Lead waste and scrap	Free	Free

Japan

Brussels Tariff Nomenclature (BTN) Number		GSP	GATT
26.01	Lead ores and concentrates	Free	Free
78.01	Unwrought lead		
	Unalloyed	Free	7.5%
	Alloyed	Free	7% to 12%
	Lead waste and scrap	Free	5%

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated, 1978, ITC Publication 843; Official Journal of the European Communities, Volume 21, No. 33511, 1978; Customs Tariff Schedules of Japan, 1978.

[1]GSP Generalized System of Preferences extended to all, or most developing countries; some GSP rates are subject to quotas or withdrawals. [2]GATT General Agreement on Tariffs and Trade (most favoured nation treatment).

Lime

D.H. STONEHOUSE

Canadian industry and developments

Lime is a high-bulk, low-cost commodity and it is uncommon to ship it long distances when the raw material for its manufacture is available in so many localities. The preferred location for a lime plant is obviously near the principal lime markets, adjacent to a source of high-quality raw material and close to a supply of energy. The more heavily populated and industrialized provinces of Ontario and Quebec together produced over 80 per cent of Canada's total lime output in 1978, with Ontario contributing about two-thirds of Canada's total. Commercial lime (lime that is normally produced for shipment and use off the producing plant site) was not produced in 1978 in Nova Scotia, Prince Edward Island, Newfoundland or Saskatchewan; the needs in each of these provinces being supplied from plants in neighbouring provinces or states.

During 1978, 18 companies operated a total of 24 lime plants in Canada; one in New Brunswick, four in Quebec, ten in Ontario, three in Manitoba, four in Alberta and two in British Columbia. A total of 84 kilns was available: 31 rotary, 49 vertical, one vibratory grate and three rotary grate. Preliminary returns indicate that lime production in 1978 was slightly greater than in 1977 because of improved performance of both the steel and pulp and paper industries, each of which are major consumers of lime. Production figures do not include some captive production such as that from pulp and paper plants that burn sludge to recover lime for reuse in the causticization process. With the addition of some new and larger capacity over the last two or three years the industry could produce between 10 000 and 12 000 tonnes* per day or about 3.5 million tonnes per year.

Operation of a new kiln at the Joliette, Quebec plant of Domtar Inc's Lime Division began in June 1978. The new unit will increase plant capacity by 400 tonnes per day.

BeachviLime Limited purchased the Guelph dolomite lime plant of Canadian Gypsum Company, Limited. The plant will continue operation as Guelph DoLime Limited, a wholly-owned subsidiary of BeachviLime.

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Markets, outlook and trade

The metallurgical industry provides the largest single market for lime. With increased application of the basic oxygen furnace (BOF) in the steel industry, lime consumption increased greatly in certain areas of the United States and Canada. An increase in the demand for steel will result in the need for more fluxing lime and will encourage the development of captive sources by steel producers. The pulp and paper industry is currently the second-largest consumer of lime, most of which is used in the preparation of digesting liquor and in pulp bleaching. Any reduction of activity in either of these two industry sectors, brought on by strikes or lack of product demand, can have an immediate and serious effect on the lime industry, at least regionally. Developments in mechanical fiberizing in the pulp industry could reduce the current lime requirements of this industry significantly.

The uranium industry uses lime to control hydrogen-ion concentrations during uranium extraction, to recover sodium carbonate and to neutralize waste sludge. In the production of beet sugar, lime is used to precipitate impurities from the sucrate. It is used also in the manufacture of many materials such as calcium carbide, calcium cyanamide, calcium chloride, fertilizers, insecticides, fungicides, pigments, glue, acetylene, precipitated calcium carbonate, calcium hydroxide, calcium sulphate, magnesia and magnesium metal.

The rapidly-growing concern for the safeguarding and treatment of water supplies and the appeal for enforced antipollution measures should result in greater use of lime for water and sewage treatment. The removal of sulphur dioxide (SO_2) from hydrocarbon fuels, either during the burning procedure, or from stack gases by either wet or dry scrubbing, could necessitate the use of lime. This may become a major market for this commodity as SO_2 emission regulations are developed. Lime is effective for this purpose, inexpensive, and can be regenerated in systems where the economics would so dictate. The creation of large amounts of gypsum waste sludge during SO_2 removal will present a disposal problem. Paradoxically, the lime industry is itself caught up in the clean-up campaigns sponsored by various levels of government, particularly efforts directed at dust removal.

invest in a new lime plant in Delta, Utah. The new plant will cost $7 million, will provide quicklime for use in power plant flue gas scrubbers and will be on stream in 1980.

Technology

Carbonate rocks are basic to industry. They form about 15 per cent of the earth's crust and fortunately are widely distributed and easily exploitable. The principal carbonate rocks utilized by industry are limestones — sedimentary rocks composed mainly of the mineral calcite ($CaCO_3$) — and dolomites — sedimentary rocks composed mainly of the mineral dolomite ($CaCO_3 \cdot MgCO_3$). Commonly termed limestones, they can be classified according to their content of calcite and dolomite. Their importance to the construction industry is not only as building stone and aggregate but as the primary material in the manufacture of portland cement and lime. Limestones are also used as flux material, in glass manufacture, as refractories, fillers, abrasives, soil conditioners and in the manufacture of a host of chemicals.

Quicklime (CaO or $CaO_3 \cdot MgO$) is formed by the process of calcination, in which limestones are heated to the dissociation temperature of the carbonates (as low as 402°C for $MgCO_3$ and as high as 898°C for $CaCO_3$) and held at that temperature over sufficient time to release carbon dioxide. Although the word "lime" is used generally, and wrongly, to refer to pulverized limestone as well as to forms of burned lime, it should refer only to calcined limestone (quicklime) and its secondary products, slaked lime and hydrated lime. Slaked lime is the product of mixing quicklime and water, hydrated lime is slaked lime dried and, possibly, reground.

Calcining is done in kilns of various types, but essentially those of vertical or rotary design are used, having had many adaptations to the standard designs incorporated into them over the years. Of comparatively recent design are the rotary hearth, travelling grate, fluo-solid and inclined vibratory types. The high cost of energy has made it imperative to include preheating facilities in any new plant design, and environmental regulations have necessitated the incorporation of dust collection equipment.

Although quicklime and hydrated lime are not of relatively high monetary value, they are transported considerable distances in bulk or in packages if a market exists. Freight costs can represent a large part of the consumer's cost. Production costs have increased significantly as a result of higher energy costs. The industry, on average, uses about 6.4 gigajoules* per tonne of production. New plants have incorporated preheater systems, and the need to replace some of the older less-efficient production capacity with fuel-conserving equipment is well recognized. A new-design, short-rotary kiln (65 metres) and preheater system can reduce energy consumption to about 5.1 gigajoules per tonne of product. The industry is aiming at a 14 per cent improvement in fuel utilization by 1980, over the base year 1973.

Table 4. Canada, consumption of lime, quick and hydrated, 1976 and 1977 (producers' shipments and quantities used by producers, by use)

	1976		1977[p]	
	(tonnes)	($000)	(tonnes)	($000)
Chemical and metallurgical				
Iron and steel plants	650 774	19 290	652 865	22 376
Pulp mills	208 483	7 320	265 690	10 921
Uranium plants	84 673	2 732	82 594	2 878
Water and sewage treatment	76 570	2 551	56 404	2 421
Nonferrous smelters	73 660	2 473	76 304	2 770
Cyanide and flotation mills	50 548	1 454	57 253	2 158
Sugar refineries	38 362	1 212	34 135	1 204
Other industrial[1]	648 953	20 712	659 198	23 258
Construction				
Finishing lime	22 193	1 373	22 863	1 562
Mason's lime	24 948	1 067	17 970	818
Sand-lime brick	16 950	461	17 283	504
Agricultural	11 166	469	10 559	510
Road stabilization	6 841	241	14 774	634
Other uses	16 272	315	32 152	1 187
Total	1 930 393	61 670	2 000 044	73 201

Source: Statistics Canada.
[1]Includes glass works, fertilizer plants, tanneries and other miscellaneous industrial uses.
[p] Preliminary.

*One British thermal unit is equal to 1 055 joules (approximately).

Table 5. World production of quicklime and hydrated lime, including dead-burned dolomite sold and used, 1977 and 1978

Country	1977^p	1978^e
	(000 tonnes)	
U.S.S.R.	23 500^e	. .
United States	18 096	18 300
West Germany	9 700^e	9 800
Japan	9 022	9 100
Poland	8 200	. .
Brazil	4 500	5 400
France	4 400	4 600
East Germany	3 450^e	. .
Romania	3 350^e	. .
Czechoslovakia	3 000^e	. .
Belgium	2 311	2 400
Yugoslavia	2 118^e	. .
Italy	1 929	1 900
Canada	1 900	2 100
Other countries	14 899	58 800
Total	110 375	112 400

Sources: U.S. Bureau of Mines, Mineral Commodity Summaries, January 1979; U.S. Bureau of Mines, Mineral Trade Notes, Vol. 75, Nos. 10-11; Statistics Canada.

^{p} Preliminary; ^{e} Estimated; . . Included in other countries.

Canadian lime price quoted in "Canadian Chemical Processing" of December 1978

Lime, carloads, fob[1] works, per tonne

		$
Ontario, quicklime	— bulk	38.56
	— bags	57.70
Ontario, hydrated	— less than 10 tonnes	60.00
	— more than 10 tonnes	41.49

[1] fob Free on board.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
29010-1	Lime	free	free	25%	free

United States

Item No.		Most Favoured Nation
512.11	Lime, hydrated	free
512.14	Lime, other	free

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated, (1978), USITC Publication 843.

Magnesium

D. PEARSON

Primary magnesium is produced by two basic processes in the world today. The first is by electrolysis of magnesium chloride derived from seawater and brines. The second method is by the reduction of magnesium-containing ores, such as dolomite or magnesite, by ferrosilicon (Pidgeon process). Canada uses the latter process whereas in the United States three out of four producers use the electrolytic process. Power requirements to produce magnesium electrolytically are 8- to 9-kilowatt hours per pound, which is considerably higher than the silicothermic process, even allowing for the production cost of ferrosilicon.

Canada

Chromasco Limited is the only Canadian producer of primary magnesium. This company has operated a mine and smelter at Haley, Ontario, 80 kilometres (km) west of Ottawa since 1942.

A high-quality (98% pure) dolomite, low in impurities such as silica and the alkali metals, is mined from an open pit and calcined. The calcined material, "dolime" is mixed with ferrosilicon and charged in batches into retorts, which are heated by natural gas. Under vacuum and at high temperature, the magnesium content is reduced and accumulated as crystalline rings known as "crowns" in the water-cooled head sections of the retorts. The plant has an annual capacity of 10 800 tonnes* of magnesium metal. Part of the furnace capacity of the plant is used to produce calcium and strontium.

The company produces ingots of magnesium metal in the following grades and purities: commercial, 99.90 per cent; high purity, 99.95 per cent; and refined, 99.98 per cent. Magnesium alloys are produced to all specifications. Other magnesium products include master alloys, rods, bars, wire and structural shapes. The Pidgeon process is particularly suited for production of the purer forms.

To produce commercial-grade magnesium, the crowns are simply remelted and cast into ingots. This grade is suitable for general fabrication purposes and for alloying with aluminum, and represents the major proportion of production. The high-purity grade is mostly used for the formation of Grignard reagents (alkyl-magnesium-halides) which react to form a variety of organic and inorganic compounds. The refined grade is in demand for chemical laboratory use and as a reducing agent for titanium, zirconium, uranium and beryllium.

Production of magnesium in 1978 was 8 269 tonnes with a value of $19 638 000, compared with 7 633 tonnes in 1977 valued at $17 766 000. Canada exported and imported more magnesium metal in 1978 than in 1977. Metal imports totalled 1 942 tonnes, compared with 1 478 tonnes in 1977. These came mainly from the United States. Exports increased 9.6 per cent to 4 753 tonnes, compared with 4 320 tonnes in 1977. Domestic consumption was down compared with that of 1977, due to a strike in the aluminum industry.

Exports of magnesium metal increased 10 per cent over those of 1977. Of the 4 753 tonnes exported, approximately 75 per cent went to the United Kingdom, West Germany and Japan. Imports of both metal and alloys into Canada also increased substantially, with the major portion coming from the United Kingdom and the United States. Canada continued to trade at a disadvantage as the import duty into the United States remained at 20 per cent, compared with a 5 per cent import duty for United States exports into Canada. Negotiations were continuing at year-end at the Tokyo round of the General Agreement of Tariff and Trade (GATT), with one of the aims being to reduce this disparity.

The two projects being considered last year were shelved due to a poor economic condition. Chromasco Limited's intention to increase production to 35 400 tonnes by 1985 in two stages is still being actively considered by the company. A Quebec government partnership with Société Generale de Suceries et Raffineries en Roumaine S.A. to construct a 12 700-tonne-per-year magnesium smelter has been shelved because of lack of financing.

During the year there were several press releases, based upon research done at the University of Sherbrooke, concerning magnesium extraction from asbestos tailings. At this time the Quebec government is studying the feasibility of operating a pilot plant to recover magnesium compounds such as magnesium oxide and carbonate from such tailings.

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, magnesium production and trade, 1977 and 1978

	1977		1978p	
	(tonnes)	($000)	(tonnes)	($000)
Production[1] (metal)	7 633	17 766	8 269	19 638
Imports				
Magnesium metal				
United States	1 405	3 427	1 829	4 724
United Kingdom	. . .	. . .	31	231
Norway	73	140	82	184
Total	1 478	3 567	1 942	5 139
Magnesium alloy				
United Kingdom	101	648	251	1 827
United States	619	2 128	331	1 221
Denmark	—	—	2	17
Total	720	2 776	584	3 065
Exports				
United Kingdom	1 710	4 321	1 194	3 207
West Germany	659	1 352	1 292	2 940
Japan	—	—	1 065	2 419
United States	620	1 654	526	1 927
France	376	920	209	546
Switzerland	443	1 008	210	492
Spain	18	37	70	154
Australia	21	95	28	114
Israel	48	179	27	102
Greece	—	—	34	74
Taiwan	—	—	35	73
South Africa	—	—	20	67
South Korea	23	48	23	51
Uruguay	6	32	5	27
India	33	77	9	24
Other countries	363	774	6	31
Total	4 320	10 497	4 753	12 248

Source: Statistics Canada.
[1] Magnesium metal in all forms and in magnesium alloys produced for shipment, less remelt.
[p] Preliminary; — Nil; . . . Negligible.

World review

World production of primary magnesium in 1978 is estimated at about 276 200 tonnes, compared with 250 035 tonnes in 1977. The United States produced 131 500 tonnes or slightly less than 50 per cent of the above total, followed by the U.S.S.R. at 25 per cent and Norway at 14 per cent.

In the United States, four companies produced at about 80 per cent of capacity. The Dow Chemical Company, the largest producer, extracts magnesium from seawater at its Freeport, Texas plant. This company is making efforts to significantly reduce the energy requirements by 35 to 50 per cent. By year-end, they had accomplished a 15 per cent reduction by modifications to the electrolytic cell and anodes, and by improved cell feed technology. N L Industries, Inc. completed the first full year of production after making major improvements in operating efficiencies; approximately full capacity of 22 680 tonnes was achieved. A subsidiary of the Aluminum Company of America, Northwest Alloys, Inc., plans to increase capacity from 21 800 tonnes to 30 000 tonnes by 1980. The electrolytic plant of American Magnesium Company has an annual capacity of 9 000 tonnes. This company announced in 1977 their intentions to expand production to 27 000 tonnes by 1980. There has been no confirmation in the press that the projects of Northwest Alloys, Inc., or American Magnesium were proceeding during 1978.

Table 2. Canada, magnesium production, trade and consumption, 1965, 1970 and 1975-78

	Production[1]	Imports		Exports		Consumption
	Metal	Alloys	Metal	Metal		Metal
	(tonnes)	(tonnes)		(tonnes)	($)	(tonnes)
1965	9 169	150	1 488	. .	4 456 255	4 081
1970	9 392	232	1 847	6 957	5 562 000	4 477
1975	3 826	886	7 500	3 875r	9 480 000r	5 404
1976	6 092	684	1 128	3 397r	7 450 000r	4 230
1977	7 633	720	1 478	4 320	10 497 000	6 222
1978p	8 269	584	1 942	4 753	12 248 000	3 607

Source: Statistics Canada.
[1] Magnesium metal in all forms and in magnesium alloys produced for shipments, less remelt. [2] Consumption as reported by consumers.
. . Not available; r Revised; p Preliminary.

Table 3. Canada, consumption of magnesium, 1965, 1970 and 1975-78

	1965r	1970	1975	1976	1977	1978p
			(tonnes)			
Castings and wrought products[1]	1 020	1 200	1 301	1 087	879	951
Aluminum alloys and other uses[2]	3 061	3 277	4 103	3 143	5 343	2 656
Total	4 081	4 477	5 404	4 230	6 222	3 607

Source: Statistics Canada.
[1] Die, permanent mould and sand castings, structural shapes, tubing, forgings, sheet and plate. [2] Cathodic protection, reducing agents, deoxidizers and other alloys.
p Preliminary; r Revised.

Norsk Hydro-Elektrisk Kvaelstofaktieselskab of Norway, the largest magnesium producer in Europe, increased its capacity by 10 000 tonnes by installing larger electrolytic cells. The company's capacity is now 50 000 tonnes. They are also using a new technique whereby anhydrous magnesium chloride is made directly by concentrating the magnesium chloride brine, thus yielding a valuable by-product, chlorine, which is used in the company's petrochemical plants. Norsk exports 90 per cent of its production, supplying about 40 to 50 per cent to West European markets. They also make shipments to Japan, United States, Canada and others. Their plans to construct a 100 000-tonne-per-year magnesium smelter at Mongstad, Norway, have been set aside because of world economic conditions.

Table 4. World primary magnesium production, 1968, 1977 and 1978

	1968	1977	1978p
		(000 tonnes)	
United States[e]	89.3	114.3	131.5
U.S.S.R.[e]	41.7	64.4	69.9
Norway	31.3	38.2	39.2
Japan	5.7	8.5	9.4
France	4.5	8.7	8.5
Canada	9.0	7.6	8.3
China[e]	1.0	1.0	1.0
Other non-communist	10.0	7.3	7.7
Total	192.5	250.0	275.5

Sources: Statistics Canada; American Bureau of Metal Statistics Inc.; U.S. Bureau of Mines.
p Preliminary; e Estimated.

In Japan, there are two producers of virgin magnesium, with a combined capacity of about 13 000 tonnes. This country imported 8 820 tonnes of magnesium in 1978. The metal is used mainly in the aluminum and iron industry, although small amounts are used for magnesium castings. In addition, 10 939 tonnes of recycled metal was used in the manufacture of titanium sponge and for refining zirconium.

Last year it was reported that Brazil and Yugoslavia were constructing magnesium smelters having capacities of 4 500 and 5 000 tonnes respectively. Currently, the Brazilian smelter is to come on stream in 1982 and that of Yugoslavia in 1980.

Table 5. Estimated world primary magnesium capacity, 1978

	Company	Location	Annual Capacity
Canada	Chromasco Limited	Haley, Ontario	10 900(F)
France	Société Générale du Magnesium (Pechiney Group)	Marignac	9 000(F)
Italy	Societe Italiana per il Magnesio e Leghe di Magnesio, Milan	Bolzano	10 900(F)
Japan	Furukawa Magnesium Company	Koyama	6 500(F)
	Ube Kosan KK	Yamaguchi	6 500(F)
Norway	Norsk Hydro-Elektrisk Kvaelstofaktieselskab	Heroya (near Porsgrunn)	50 000(E)
United States	The Dow Chemical Company	Freeport, Texas	110 000(E)
	N L Industries, Inc.	Rowley, Utah	23 000(E)
	American Magnesium Company	Snyder, Texas	9 000(E)
	Northwest Alloys, Inc.	Addy, Washington	25 000(F)
China[e]	Various		2 700
USSR[e]	Various		70 000(E)

Sources: American Bureau of Metal Statistics Inc.; and others.
Process: (F) Ferrosilicon; (E) Electrolytic.
[e] Estimated.

Uses

Magnesium is used primarily as an alloying ingredient in other metals. In aluminum it imparts hardness and strength to the alloys. The high strength-to-weight ratio of magnesium alloys is ideal for structural applications where weight is a consideration, such as in transportation, especially in aircraft construction. Magnesium is used as both a deoxidizer and desulphurizer in the ferrous industry and is finding increasing use in the manufacture of ductile iron. As a reducing agent it finds application in the production of titanium. Pure magnesium is also used for cathodic protection of metal structures and in the chemical industry for the production of magnesium compounds. Magnesium is used in the formation of Grignard reagents and as an anti-knock fuel additive.

Prices

The Canadian price of commercial grade magnesium (99.8 per cent magnesium) in carload lots of fob Haley, Ontario was \$1.01 at the beginning of the year. There were price increases on March 1 and September 1, and by December 1 it was \$1.15 per pound.

In the United States, the price in 10 000 pound lots of 99.8 per cent metal fob Freeport, Texas on January 1 was 99 cents U.S. per pound, and increased on January 4 to \$U.S.1.01, where it remained to the end of the year. The price of diecasting alloy AZ91B was the same as pure metal for the same periods.

Outlook

Alloying with aluminum will continue to be the major use for magnesium and this use should increase proportionally with the anticipated increases in production of the aluminum industry. Magnesium consumption in the ferrous industry will also increase, especially in the production of nodular iron. Greater use of magnesium in the automobile

United States magnesium prices, in United States currency, as quoted in "Metals Week"

	¢/lb
Magnesium metal, in 10 000-pound lots:	
Primary ingot 99.8%	
January 1 to January 3, 1978	99.00
January 4 to December 19, 1978	101.00
Die casting alloy AZ91B ingot	
January 1 to January 3, 1978	99.00
January 4 to December 29, 1978	101.00

Magnesium Prices in Canada (99.8% ingot)

	(Canadian ¢/lb)
July 1, 1977	1.01
March 1, 1978	1.05
Sept. 1, 1978	1.10
Dec. 1, 1978	1.15

Source: Chromasco Limited.

industry is expected because of the current oil situation, which has initiated a trend to lighter vehicles, although this substitution may take some time pending availability of larger hot-chamber diecasting machines and the acceptance by manufacturers of a metal with which they are unfamiliar. Consumption of magnesium alloys for structural use and magnesium in chemicals is expected to remain at about the same level as in previous years. Price, compared with that of aluminum, continued to constrain greater consumption of magnesium in some of the above markets however, the industry is well aware of this fact and is making every effort to reduce their production costs.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
35105-1	Magnesium metal, not including alloys, in lumps, powders, ingots or blocks	5%	5%	25%	3%
34910-1	Alloys of magnesium; ingots, pigs, sheets, plates, strips, bars, roads and tubes	5%	5%	25%	3%
34911-1	Magnesium alloy ingots, for use in the production of magnesium castings (from 1/3/78 to 30/6/79)	free	free	25%	free
34912-1	Hardener alloys for use in the manufacture of magnesium castings (from 1/3/78 to 30/6/79)	free	free	25%	free
34915-1	Magnesium scrap	free	free	free	free
34920-1	Sheet or plate, of magnesium or alloys of magnesium, plain, corrugated, pebbled, or with a raised surface pattern, for use in Canadian manufactures (expires 30/6/80)	free	free	25%	free
34925-1	Extruded tubing, of magnesium or alloys of magnesium, having an outside diameter of five inches or more, for use in Canadian manufactures (expires 30/6/80)	free	free	25%	free

United States

Item No.		Most Favoured Nation
628.55	Magnesium, unwrought, other than alloys; and waste and scrap (duty on waste and scrap suspended to June 30, 1981)	20%
628.57	Magnesium, unwrought alloys, per pound on magnesium content	8¢ + 4%
628.59	Magnesium metal, wrought, per pound on magnesium content	6.5¢ + 3.5%

Sources: Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978), USITC Publication 843.

Manganese

D.G. LAW-WEST

Manganese is essential in the production of nearly all types of steel. Because there are no acceptable substitutes, manganese is considered to be a strategic commodity. Because nearly 95 per cent of all manganese produced is consumed by the iron and steel industry, the demand for manganese ores is determined by the world's production of iron and steel. Although the steel industry recovered somewhat during 1978, stocks of manganese ore and ferromanganese remained fairly substantial.

Canada

Canada has no economic deposits of manganese, given the present state of technology and market conditions, but several low-grade deposits have been identified in Nova Scotia, New Brunswick and British Columbia. The largest of these deposits, located near Woodstock, New Brunswick, has resources estimated at 45 million tonnes*, grading 11 per cent manganese and 14 per cent iron. Although techniques have been developed to utilize such low-grade deposits, production is not warranted at today's manganese prices.

The two ferromanganese producers in Canada, Union Carbide Canada Limited (UCC) and Chromasco Limited, import metallurgical grade manganese ore as feed material. Both have plants at Beauharnois, Quebec and production is allocated principally to domestic steel producers. Canada also imports manganese metal, an important additive in speciality steels as well as in aluminum alloys. The main consumers of manganese metal are Atlas Steel, a division of Rio Algom Limited; Aluminum Company of Canada, Limited and Reynolds Aluminum Company of Canada Ltd. High-purity manganese dioxide and battery grade manganese ores are imported into Canada by various companies including, Mallory Battery Company of Canada Limited, Cerlite Burgess, Ray-O-Vac Division of ESB Canada Limited, Cominco Ltd. and Canadian Electrolytic Zinc Limited.

World developments

World production of manganese reached 21 million tonnes in 1978. The Soviet Union maintained its position as the largest producer, with an output of 8.6 million tonnes. While this is unchanged from the previous year, the Soviet Union did remain the largest ore producer in the world.

South Africa, the second-largest manganese-producing nation, with 4.3 million tonnes, has two major producers, S.A. Manganese Amcor Ltd. (Samancour) and The Associated Manganese Mines of S.A. Ltd. In response to reduced ore demand, Samancour closed the open-pit portion of the Hotazel Mine, reduced production at the Mamatwan Mine and delayed the sinking of a second shaft at the Wessels Mine. Associated Manganese continued the development of new mines to replace its two small mines where ore reserves are depleted. The Anglo American Corporation of South Africa Ltd. will become a new producer when its one million-tonne-per-year underground mine begins production in 1979.

In Gabon, as a result of the delay in completing the Trans-Gabon Railway and the associated deep-water port at Santa Clara, the Comilog mine at Moanda has postponed plans to double capacity of its 2 million-ton-per-year plant.

Lack of sufficient financing has stalled the development of the Tambao mine in Upper Volta. This project, owned 51 per cent by the government and 49 per cent by international consortia, includes a 650 000 tonne-per-year mine, a new (320 kilometre) rail link from the mine site to the existing railhead as well as new port facilities at Abidjan (Ivory Coast).

India continued its ban on exports of high-grade manganese ore because reserves are sufficient for only 26 years of production at current rates of domestic consumption. The Brazilian government maintained its conservation policy for manganese ores by further reducing exports 30 per cent from 1977. This policy was adopted in 1976 to meet the needs of its expanding domestic steel and ferromanganese industries. The domestic demand for ore has been increasing at an annual rate of 9.5 per cent.

Australian shipments of manganese ore from the Groote Eylandt Mining Company Proprietary Ltd. mine were down 24 per cent to 1.2 million tonnes in 1978. A new open-pit mine has been brought into production and this new ore will be blended with the ore from two other pits in order to meet the feed specifications for the concentrator.

Cia Minera Autlan S.A. de C.V. of Mexico plans to expand manganese ore production 40 per cent by 1980. Its current annual production of 500 000 tonnes as well as most

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, manganese trade and consumption, 1977 and 1978

	1977		1978p	
	(tonnes)	($)	(tonnes)	($)
Imports				
Manganese in ores and concentrates[1]				
Brazil	1 013	147 000	38 757	6 415 000
United States	5 993	1 294 000	24 637	4 563 000
South Africa	8 749	935 000	33 251	3 733 000
Gabon	18 041	2 886 000	39 760	3 718 000
Mexico	4 313	556 000	40	13 000
France	9 535	1 566 000	4	1 000
French Africa, nes	10 000	1 675 000	—	—
Total	57 644	9 059 000	136 449	18 443 000
Manganese metal				
South Africa	6 506	6 008 000	7 539	6 585 000
United States	206	258 000	179	248 000
Japan	135	123 000	201	229 000
Netherlands	—	—	18	7 000
Other countries	3	2 000	2	4 000
Total	6 850	6 391 000	7 939	7 073 000
Ferromanganese, including spiegeleisen[2]				
South Africa	8 314	2 958 000	11 803	5 454 000
Norway	5 312	4 013 000	6 957	4 635 000
United States	8 064	3 843 000	5 862	3 300 000
Portugal	3 324	1 119 000	1 500	450 000
Other countries	4 390	1 891 000	687	300 000
Total	29 404	13 824 000	26 809	14 139 000
Silicomanganese, including silicospiegeleisen[2]				
United States	2 693	1 569 000	6 309	2 902 000
Norway	1 139	431 000	5 779	2 412 000
South Africa	—	—	507	721 000
Brazil	—	—	1 745	673 000
Other countries	1 003	357 000	1 502	470 000
Total	4 835	2 357 000	15 842	7 178 000
Exports				
Ferromanganese[2]				
United States	19 550	6 902 000	19 878	5 960 000
Jamaica	62	37 000	46	26 000
Venezuela	3 492	1 080 000	—	—
Total	23 104	8 019 000	19 924	5 986 000
Consumption				
Manganese ore				
Metallurgical grade	179 727	..	..	..
Battery and chemical grade	2 430	..	..	..
Total	182 157	..	..	..

Source: Statistics Canada.
[1] Mn content. [2] Gross weight.
p Preliminary; — Nil; .. Not available; nes Not elsewhere specified.

of its additional supplies will be used by the company's ferromanganese operations.

Uses

The excellence of manganese as a desulphurizer makes it irreplaceable in the steel industry. Steels containing excess sulphur are not homogenous and tend to crack and tear during rolling and forming. Manganese combines with the sulphur to produce a manganese sulphide slag that is readily separated from the steel. Manganese also acts as a deoxidizer during the steelmaking process.

Manganese is usually added to steel in the form of a ferroalloy, such as ferromanganese or silicomanganese. Steel manufacturers in Canada add about 5.8 kilograms (kg) of manganese per tonne of crude steel produced.

Manganese is often added to specialty steels to increase strength and hardness. Manganese metal, instead of ferromanganese, is used in making these specialty steels because it provides better control of the manganese content and the level of impurities.

Hadfield steels, a type of specialty steel, contain between 10 and 14 per cent manganese. These steels are extremely hard and tough and are particularly suited for such applications as rock crusher parts and teeth in earth-moving machinery.

Iron used for castings is desulphurized with manganese, as sulphur causes surface imperfections and makes precision casting very difficult.

Manganese can also form alloys with nonferrous metals: aluminum-manganese alloys are noted for their strength, hardness and stiffness; manganese-magnesium alloys are hard, stiff and corrosion-resistant; and manganese-bronzes are used in the production of ship propellers.

Manganese also has many nonmetallurgical applications, such as manganese dioxide in dry cell batteries. In batteries, manganese dioxide provides oxygen which combines with hydrogen to allow the battery to operate at maximum efficiency. Manganese ores used for batteries must grade above 85 per cent manganese dioxide and have a low iron content. Since very few natural manganese dioxide ores are satisfactory for battery purposes, most batteries contain a blend of natural ore and synthetic manganese dioxide.

The normal classification of manganese ore is as follows:

(1) *Manganese ores containing more than 35 per cent manganese*. These are used in the manufacture of both low- and high-grade ferromanganese. Although battery grade ores are included in this class, the ores must contain no less than 85 per cent manganese dioxide. (2) *Ferrogenous manganese ores containing 10 to 35 per cent manganese*. These are used in the manufacture of spiegeleisen. (3) *Manganiferous iron ores containing 5 to 10 per cent manganese*. These are used to produce manganiferous pig iron.

All types of manganese ores, including manganese dioxide ores, are used in the production of manganese chemicals such as: potassium permanganate, a powerful oxidant used in the purification of public water supplies; manganous oxide, an important addition to welding rods and fluxes; and an organometallic form of manganese, which inhibits smoke formation and improves combustion of fuel oil.

Various manganese chemicals are employed to produce various colour effects in face bricks and, to a lesser extent, to colour or decolour glass and ceramics. They are also used in paint and varnish driers, and in the production of dyes, fungicides and pharmaceuticals.

Table 2. Canada, manganese imports, exports and consumption, 1960, 1965, 1970 and 1975-78

	Imports			Exports	Consumption	
	Manganese Ore[1]	Ferro-manganese	Silico-manganese	Ferro-manganese	Ore	Ferromanganese and Silicomanganese
	(gross weight, tonnes)					
1960	51 120	14 057	2 146	661	66 242	36 448
1965	81 175	31 354	714	3 463	108 217	70 186
1970	115 052	17 891	975	510	153 846	97 952
1975	69 773	35 701	5 732	1 168	160 976	95 869
1976	118 972	25 098[r]	12 056[r]	9 861	238 629	83 687
1977	57 644	29 404	4 835	23 104	182 157	82 467
1978[p]	136 449	26 809	15 842	19 924	201 320	..

Source: Statistics Canada.
[1] Mn content.
[p] Preliminary; .. Not available; [r] Revised.

Table 3. World production of manganese ores, 1975-77

	Mn	1975	1976	1977[p]
	(%)		(000 tonnes)	
U.S.S.R.	35	8 459	8 636	8 500
Republic of South Africa	30 +	5 769	5 452	5 048
Gabon	50-53	2 245[r]	2 217	1 851
India	10-54	1 577[r]	1 760	1 774
Australia	37-53	1 555	2 154	1 387
People's Republic of China[e]	30 +	998	998	998
Brazil	38-50	2 155	1 696	898[e]
Mexico	35 +	428	453	487
Ghana	30-50	409	312	267
Hungary	18-28	182	165	161
Japan	26-44	158	142	126
Morocco	50-53	131	117	114
Thailand	46-50	25	50	77
Argentina	25-30	31	53	53
Zaire	30-57	309	182	41
Iran	33 +	36	40	40
Bulgaria	30 −	35	40	40[e]
Other countries[1]		151	166	152
Total		24 653[r]	24 633	22 014

Source: U.S. Bureau of Mines, Mineral Industry Surveys, November, 1978.
[1] Includes 14 countries, each producing less than 40 000 tonnes per year.
[p] Preliminary; [e] Estimated; [r] Revised.

Manganese nodules

Manganese nodules have been found in both marine and freshwater environments. Although they are widely distributed, potentially exploitable manganese nodules are found only in a few areas and at depths of more than 3 000 metres. Nodules are formed by the accretion of manganese and iron oxides along with smaller amounts of minerals such as nickel, copper and cobalt, around a nucleus. Over a long period of time they form into spheres or lenses from 2 to 10 centimetres (cm) in diameter with a wet density of 2 grams/cm^3. They have a high porosity and may contain up to 30 per cent water by weight.

Manganese nodules are not homogeneous in that they vary both in density and chemical composition, especially with respect to nickel, copper and cobalt.

The presence of manganese nodules on the deep seabed has been known since the 1872-76 oceanographic expedition of the British *HMS Challenger*, however, it was not until 1958 that nodules were considered potentially economic. Various consortia have been formed because of the high capital cost of demonstrating an effective mining and processing system. Each consortium will spend an estimated $40-$80 million to complete feasibility studies scheduled for 1978-79. The studies will include: delineation of nodule reserves and researching suitable ocean-mining and nodule-processing systems.

Two of the consortia have successfully recovered nodules from the deep Pacific Ocean floor. Ocean Management Inc. (OMI) recovered 635 tonnes of manganese nodules from a depth of 5 200 m, using both hydraulic and pneumatic lift systems. Although the systems

Table 4. Principal manganese ferroalloys

	Manganese	Silicon	Carbon
		(%)	
Ferromanganese			
High-carbon	74-82	1.25 max	7.5 max
Medium-carbon	74-85	1.50 max	1.5 max
Low-carbon	80-85	7.00 max	0.75 max
Silicomanganese	65-68	18-20 max	0.6-2.0
Spiegeleisen	16-28	1.0-4.5	0.65 max

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.

were claimed to be technically feasible, it will be at least the mid-1980s before economic systems can be developed. OMI has suspended operations for three to five years pending recovery of the nickel market as well as the development of parameters with respect to ocean mining by the Law of the Sea Conference.

Ocean Minerals Co., (Omco) succeeded in retrieving several thousand kilograms of nodules from a floor depth of 5 500 m in the Pacific Ocean. The consortium has leased two research ships to carry out ocean floor surveys and initial development operations with a test miner.

Outlook

The outlook for manganese is closely tied to that for steel, the demand for which, in the short term, will remain stable. While consumer and producer stocks of manganese ore and ferromanganese are lower than in the previous year, markets can be expected to remain highly competitive.

In the longer term, ore-producing countries will continue to integrate forward into ferroalloy production, either for the export market or for supply to domestic steel industries. In addition some of the ore-producing countries, such as India and Brazil, have limited ore exports in order to conserve reserves and assure future domestic supplies. There will be a two-fold effect from these trends: (1) higher ore prices from the shortfall in supplies; and (2) lower ferroalloy prices caused by excess production over demand.

Technological changes in the steel-making industry such as internal desulphurization and new continuous-casting procedures may reduce the demand for manganese. The annual growth rate for world manganese demand is expected to be about 3 per cent to the year 2000.

Table 5. The four major consortia involved in seabed mining

Consortium	Companies
Ocean Mining Associates	United States Steel Corporation, U.S.A. Union Minière S.A., Belgium Deepsea Ventures Inc., (contracted)
Kennecott Joint Venture	Kennecott Copper Corporation, U.S.A. Noranda Mines Limited, Canada Mitsubishi Corporation, Japan Rio Tinto Zinc Corp. Group, U.K. British Petroleum Company Limited, U.K. Consolidated Gold Fields Ltd., U.K.
Ocean Management Inc.	Inco Limited, Canada Arbeitsgemeinschaft Meeres-technische gewinnbare Rohstoff, W. Germany SEDCO, Inc., U.S.A. Deep Ocean Mining Company Ltd., Japan
Ocean Mineral Co.	Lockhead Missiles & Space Co., U.S.A. Amco Ocean Minerals Co., U.S.A. Billiton Int. Metals, Netherlands

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.

Prices

United States manganese and manganese alloy prices in U.S. currency, as quoted in "Metals Week" of December 1977 and December 1978

	December 1977	December 1978
	(¢)	(¢)
Manganese ore, per long-ton unit (22.4 lb) cif U.S. ports, Mn content		
Min. 48% Mn (low impurities)	148.00-153.00	138.00-142.00
Ferromanganese, fob shipping point, freight equalized to nearest main producer, carload lots, lump, bulk	($)	($)
Standard 78% Mn, per long ton	399.50	425.00-440.00
	(¢)	(¢)
Medium-carbon, per lb. Mn	40.75-41.50	42.00
Silicomanganese, per lb. of alloy, fob shipping point, freight equalized to nearest main producer, carload lots, lump, bulk		
16-16.5% Si, 2% C	18.75	20.00-21.50
Manganese metal, electrolytic metal, 99.9%, per lb. Mn, boxed fob shipping point		
Regular	58.00	58.00
6% N	61.00	61.00

Tariffs

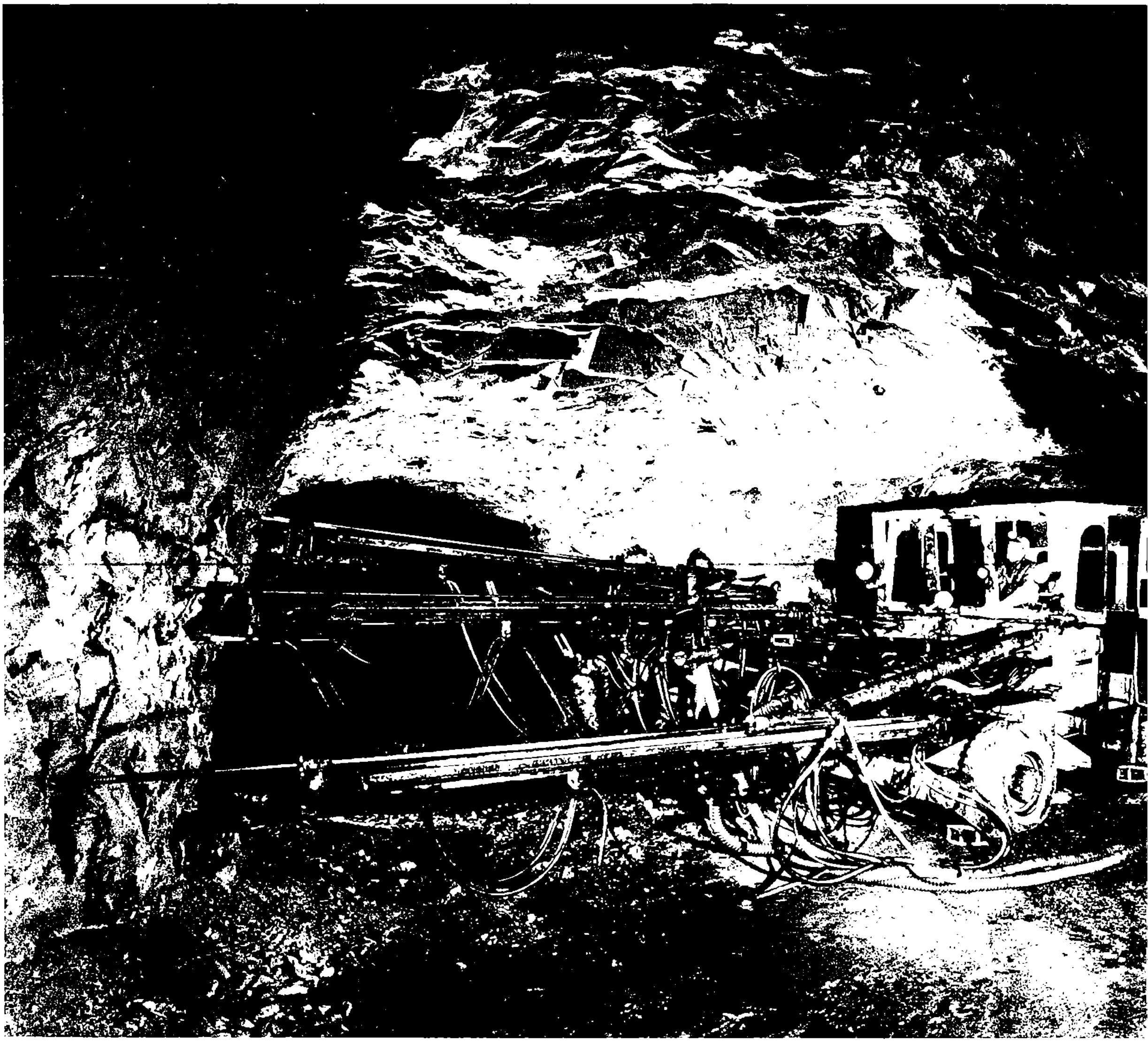
Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
32900-1	Manganese ore	free	free	free	free
33504-1	Manganese oxide	free	free	free	free
35104-1	Electrolytic manganese metal	free	free	20%	free
37501-1	Ferromanganese, spiegeleisen and other alloys of manganese and iron, not more than 1% Si in the Mn content, per lb.	free	0.5¢	1.25¢	free
37502-1	Silicomanganese, silico spiegel and other alloys of manganese and iron more than 1%, Si on the Mn content per lb.	free	0.75¢	1.75¢	free

United States

Item No.		(¢ per lb. on Mn content)
601.27	Manganese ore, including ferruginous manganese ore and manganiferous iron ore, all the foregoing containing over 10 per cent by weight of manganese (duty temporarily suspended to end of June 1979)	0.12
607.35	Ferromanganese, not containing over 1% C	0.3 + 2% ad valorem
607.36	Ferromanganese, containing over 1% but not over 4% C	0.46
607.37	Ferromanganese containing over 4% C	0.30
632.32	Manganese metal, unwrought, waste and scrap	1.5¢ per lb. + 10% ad valorem

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States, Annotated (1978), ITC Publication 843.



A rubber-tired jumbo mounting three 20-foot booms is shown drilling blast-holes at Cominco Ltd.'s Sullivan lead-zinc mine at Kimberley, British Columbia.

Cominco photo

Mercury

J.J. HOGAN

There has been no mine output of mercury in Canada since July 1975 when the Pinchi Lake mine of Cominco Ltd., located 48 kilometres (km) north of Fort St. James, British Columbia, suspended operations indefinitely. The mine's closure resulted from a significant decline in mercury prices caused by a sharp drop in demand for the metal. The Pinchi Lake property is being kept on standby pending an improvement in demand and price.

Canadian imports of mercury metal in 1978, at 43 046 kilograms (kg) (1 249 flasks*) were considerably greater than the 21 908 kg (636 flasks) imported in 1977. Partial consumption of mercury metal in Canada, as reported by Statistics Canada, was 29 904 kg (867 flasks) in 1978 compared with 30 447 kg (883 flasks in 1977).

World review

The United States Bureau of Mines (USBM) estimated world production to be 175 980 flasks in 1978, considerably lower than the 198 633 flasks produced in 1977. The U.S.S.R. retained its position as the world's largest mine producer of mercury in 1978, producing an estimated 60 050 flasks compared with 31 040 for Spain, the world's second-largest producer. Other large producers in 1978 were Algeria, Mexico, the United States and the People's Republic of China. The mercury mines of Italy and Yugoslavia, along with those of Canada, have been substantial contributors to the world's output of mercury in the past, but operations at these mines have been suspended until the market improves.

The Almaden mine of Minas de Almaden y Arrayanes in Spain is the largest producer of mercury in the non-communist world. The company is preparing a new mine, El Entredicho, located about 17 km from the present plant site, for production in 1980. The ore, which is reported to be higher grade than that at Almaden, will be mined by open-pit methods and treated at the existing furnaces. This mine will allow a certain flexibility to the operation and the company will be able to regulate production to meet market demand as well as to the long-term advantage of the company. Output at Almaden mine has been curtailed and it is reportedly operating at about 75 to 80 per cent of its normal capacity of approximately 60 000 flasks per year. In November, Almaden posted a mercury price of $U.S. 160 per flask, fob Spanish ports to be effective until December 31, 1978. At the same time the company announced its intention to withhold output, estimated to be about 20 per cent of production, that normally goes to the free market. The company considered the free market prices published in New York and London did not reflect the market situation.

United States output of mercury decreased in 1978 as a result of a planned reduction at the McDermitt mine, the only major producer in the United States, located in northern Humbolt county, Nevada, and the closure of most of the smaller mines because of environmental and economic problems. The McDermitt property is a joint venture operation in which Placer Amex Inc., a wholly-owned subsidiary of Placer Development Limited, a Canadian company, has a 51 per cent interest and Minerals Exploration Company of New Jersey holds the remaining 49 per cent. The ore is mined by open-pit methods and treated at a 635-tonne-per-day plant.

The United States is believed to be the world's largest consumer of mercury, but in recent years has produced less than its requirements. Total consumption in 1978 in the United States of primary, redistilled and secondary mercury was estimated to be 47 915 flasks, a decrease of about 22 per cent from the 61 259 flasks consumed in 1977. A large portion of the U.S. requirements was again derived from imports, which totalled 42 874 flasks in 1978 compared with 28 603 flasks in 1977.

World consumption of mercury in 1978 is believed to have been slightly above the estimated consumption of 240 000 flasks in 1977. Growth in the consumption of mercury has been dampened because of environmental problems, especially in paints, the agricultural industry and the chlor-alkali plants in the United States. Other major importers of mercury in 1978 were Japan, West Germany, United Kingdom and India.

For the past few years delegates from several of the major producing countries have held meetings in different countries at least once a year. The meetings have been producer-oriented and one of the main items on each agenda has always been an attempt to bring about more stability to the mercury market, mainly by agreeing on concerted measures to control

*The flask containing 76 net pounds avoirdupois (34.473 kilograms) is used throughout.

Table 1. Canada, mercury production, trade and consumption, 1977 and 1978

	1977		1978^p	
	(kilograms)	($)	(kilograms)	($)
Mine production	—	—	—	—
Imports (metal)				
United States	16 284	108 000	17 282	101 000
Netherlands	—	—	21 727	89 000
Spain	5 488	26 000	3 992	35 000
United Kingdom	136	1 000	45	...
Total	21 908	135 000	43 046	225 000
Consumption[1] (metal)				
Heavy chemicals	16 245	..	5 385	..
Electrical apparatus	12 275	..	13 415	..
Gold recovery	233	..	265	..
Miscellaneous	1 694	..	10 839	..
Total	30 447	..	29 904	..

Source: Statistics Canada.
[1] Partial consumption only.
[p] Preliminary; .. Not available; — Nil; ... less than 500.

supplies and regulate prices. In October 1977 this group of world producers, known as the International Association of Mercury Producers (ASSIMER), met again in Geneva, Switzerland and reportedly decided to take measures to curb speculators and adapt exports to the needs of traditional consumers. The member countries of the organization, established in 1975 with headquarters in Geneva, are Spain, Italy, Turkey, Yugoslavia, Algeria and Peru, and together account for about 90 per cent of the non-communist countries' exports of mercury. Among the objectives of the association are stabilization of prices by curtailing production or withholding supplies from the market, the development of new uses for mercury and improvement of its environmental image. The next major meeting of the association will be held in January 1979. World pricing will be one of the main topics of discussion at this meeting.

At the end of 1978 the United States strategic and critical materials stockpile contained a total of 191 587 flasks of mercury. The stockpile goal is 54 004 flasks, leaving a surplus of 137 583 flasks, none of which may be released, however, without authorization of the United States Congress. Surplus mercury released by other government agencies was auctioned on a monthly basis by the General Services Administration (GSA) in 1978 and totalled 6 700 flasks. Stocks held by United States producers, consumers and dealers on December 31, 1978 were 40 690 flasks.

On April 6, 1973, the United States Environmental Protection Agency (EPA) published the final air emission standard for mercury at 2 313 grams (g) per day, per plant, released to the atmosphere. In 1974, EPA proposed an amendment to the emission standard for hazardous air pollutants in which mercury emissions from the incineration and drying of wastewater treatment plant sludges would be limited to a maximum of 3 200 g per day. Further, the National Institute for Occupational Safety and Health submitted criteria for a recommended standard on the occupational exposure to inorganic mercury. On March 14, 1975, EPA proposed National Interim Primary Drinking Water Regulations and held hearings thereafter on the proposed regulations. In addition, comments and information were received from representatives of state agencies, public interest groups and others. The regulations proposed

Table 2. Canada, mercury production, trade and consumption, 1969-78

	Production, Metal	Imports, Metal	Exports, Metal	Consumption, Metal
	(kilograms)			
1969	727 380	60 600	..	140 076
1970	841 141	69 536	..	154 474
1971	637 750	55 338	..	87 982
1972	504 581	79 243	..	51 998
1973	430 913	48 171	..	32 959
1974	482 622	108 817	..	37 786
1975	413 676	73 527	..	32 869[1]
1976	—	62 641[r]	..	26 039[1]
1977	—	21 908	..	30 447[1]
1978^p	—	43 046	..	24 904[1]

Sources: Statistics Canada for all figures except for metal production statistics; 1969-1971 figures obtained directly from Cominco Ltd., and represents output from its Pinchi Lake mine in British Columbia.
[1] Partial consumption only.
[p] Preliminary; [r] Revised; — Nil; .. Not available.

maximum contaminant levels in public drinking water and set the mercury level at 0.002 milligrams per litre.

In March 1974 the EPA promulgated its final effluent limitation guidelines for existing and new sources in the inorganic chemicals manufacturing category. The daily effluent limitation is 0.000 28 g of mercury per 1 000 g of product for mercury-cell plants in existence since March 1974. The limitation is 0.000 14 g of mercury per 1 000 g of product for new producing plants. One of the stated goals of the Federal Water Pollution Control Act of 1972 is the elimination of all pollutant discharges by 1985.

In 1975, EPA concluded its hearings on the cancellation of biocidal uses of mercury, including mildewcides in paint. Early in 1976, the agency ordered an immediate halt to the use of mercury compounds in pesticides. Later in the same year, EPA rescinded its ban on the use of mercury compounds in some agricultural products and postponed the ban for other uses. The use of mercury in winter disease control products for golf courses was reinstated permanently. For other agricultural uses – summer disease control and seed protection – the manufacturers of the control products could continue to use mercury until August 1978. EPA also reinstated the use of mercury compounds in latex (water-based) paints but continued the ban on their use in nonwater-based paints. The agency also requested a review of the uses of mercury in other pesticides.

In Canada, legislation, known as the "Chlor-Alkali Mercury Regulations" (P.C. 1972-576), was passed by the federal government on March 28, 1972 and became effective 60 days after that date. This legislation restricted the quantity of mercury that may be discharged in the effluent from any chlor-alkali plant in Canada using the mercury-cell process. It stipulates that mercury in the liquid effluent, from any such chlor-alkali plant, deposited in any one day in waters frequented by fish, shall not exceed 2.5 g per tonne of chlorine produced by the plant in that day.

Also in Canada, the Food and Drugs Act, a federal statute (Chapter F-27 R.S.C., 1970, as amended) is designed, among other things, to protect Canadians against health hazards related to foods. The act is administered by the Health Protection Branch of the Department of National Health and Welfare. Section 4(a) of the act provides legal authority for the branch to determine those levels in foods of substances such as mercury, which are considered to represent a hazard to human health, and to prohibit the sale of foods containing unsafe levels of the substances in question. After a study of the available data on the toxic effects to humans of mercury-contaminated fish, the consumption of fish by Canadians, and action taken by other countries on this matter, the Health Protection Branch decided in 1969 that, as a temporary measure, it would take

Table 3. World, production of mercury, 1974, 1977 and 1978

	1974	1977	1978[e]
		(flasks)	
U.S.S.R.	54 000[e]	58 015	60 050
Spain	54 354	35 012	31 040
Algeria	14 000	30 023	29 990
United States	2 189	28 244	24 190
People's Republic of China	26 000	20 305	17 410
Czechoslovakia	5 541	5 308	5 220
Germany, Federal Republic	3 365	2 872	2 440
Mexico	25 933	9 660	2 200
Turkey	8 833	4 509	1 710
Finland	183	630	1 140
Italy	25 991	406	90
Yugoslavia	15 838	3 133	—
Canada	14 000	—	—
Other countries	7 250	516	500
Total	257 477	198 633	175 980

Sources: Preprint from the 1976 U.S. Bureau of Mines, Minerals Yearbook for 1974 statistics; U.S. Bureau of Mines, Mineral Trade Notes, Vol. 76, No. 5 for 1977 and 1978; Statistics Canada.
[e]Estimated; — Nil.

Table 4. United States, mercury consumption by uses, 1974, 1977 and 1978

	1974	1977	1978[p]
		(flasks)	
Agriculture[1]	980	584	..
Catalysts	1 298	1 545	444
Dental preparations	3 024	1 230	885
Electrical apparatus	19 678	29 180	10 897
Electrolytic preparation of chlorine and caustic soda	16 897	10 744	11 320
General laboratory use	476	406	265
Industrial and control instruments	6 202	5 221	3 193
Paint:			
Antifouling	6	—	—
Mildew proofing	6 807	8 365	6 864
Pharmaceuticals	597	..	..
Other[2]	2 452	2 589	11 763
Total known uses	58 417	59 864	45 631
Total uses unknown	1 062	1 395	2 284
Grand total[3]	59 479	61 259	47 915

Sources: Preprint from the 1976 U.S. Bureau of Mines, Minerals Yearbook for 1974 statistics; U.S. Bureau of Mines, Mineral Industry Surveys, "Mercury in the First Quarter of 1978" for 1977 statistics; U.S. Bureau of Mines, Mineral Industry Surveys, "Mercury in the Fourth Quarter 1978", for 1978 statistics.
[1]Includes fungicides and bactericides for industrial purposes. [2]Includes mercury used in the manufacture of chemicals and allied products and lubricating oils. [3]The individual items do not add to the total which has been increased to cover approximate total consumption.
[p]Preliminary; — Nil; .. Not available.

no exception to the sale of fish containing not more than 0.5 parts per million (ppm) of mercury determined on a wet basis. In effect, this 0.5 ppm mercury level represents an administrative guideline applicable to fish only, and is legally binding only at the point of sale. Apparently this same 0.5 ppm mercury level in fish was subsequently adopted by the United States government authorities.

Outlook

Historically the performance of mercury on the world market has been erratic. It appears that the producers association (ASSIMER) may, through mutual agreement, exert more control on the market by better regulation of production and sales and thereby instal some degree of stability to the market. Environmental considerations have placed constraints on the use of mercury in some of its applications, especially in its use in the production of chlorine and caustic soda. The use of mercury in the electronics field and in batteries is expected to remain strong.

In the latter part of 1978 the price of mercury moved upwards and this trend carried into 1979. The main reason for this situation was the withholding of mercury from the market and the suspension of mining operations by some countries. Early in 1979, Almaden stopped publishing a producer price and offered its output on the open market. At that time the price was about $U.S. 200 per flask. The producers objective at their January meeting was to establish a tentative price of $U.S. 230 per flask. By mid-March 1979 the mercury price had risen to this price range and a continuing upward trend was indicated.

Ample stocks in the hands of the producers and with many of the recently closed mines on a standby basis should insure the availability of adequate supplies in the short- to medium-term. No problems of supply are expected in the long-term. Also available to the market is the surplus mercury in the United States strategic stockpile. To date no decision has been made on its eventual disposal.

Uses

Mercury's two major uses in recent years have been for use in electrical apparatus and for the electrolytic production of chlorine and caustic soda. Together, these two applications accounted for almost 53 per cent of mercury consumed in the United States in 1978. Electrical uses include mercury lamps, batteries, rectifier bulbs, oscillators, and various kinds of switches, including "silent" switches for use in housing. Because mercury lamps are more adaptable to higher voltage supply lines than are incandescent lamps, they are used as fluorescent lamps and for industrial and street lighting purposes. The mercury battery invented in 1944 is basically a dry-cell battery. It has a relatively long shelf life and can withstand high temperature and high humidity. It is used in Geiger-Muller counters, portable radios and two-way communications equipment, digital computers, electronic measuring devices, hearing aids, guided missiles and spacecraft.

Other applications are in mildew-proofing paints, industrial and control instruments, pharmaceuticals, insecticides, fungicides, bactericides and dental preparations, although in some countries some of these uses have already been restricted or banned by government regulations. Several mercury compounds, especially chloride, oxide and sulphate, are good catalysts for many chemical reactions, including those involved in the making of plastics. Because of its capacity to absorb neutrons, the metal has been used as a shield against atomic radiation. New technologies could open up new areas of use in the nuclear, metal-chloride vapour, plastic, chemical, amalgam and ion exchange fields. Substitutes for mercury include nickel-cadmium or other battery systems for use in electrical apparatus, diaphragm cells for mercury cells in the chlor-alkali industry, organotin compounds in paint and solid-state devices for industrial and control instruments.

Table 5. Average monthly prices of mercury in 1978 at New York and cif main European port

	New York[1]	cif main European port[2] Low	High
	($U.S./flask)		
January	147.810	128.875	133.875
February	157.333	128.500	133.500
March	147.000	127.750	132.250
April	148.500	130.000	135.000
May	150.000	128.750	133.750
June	148.909	122.667	128.000
July	156.550	125.500	129.500
August	156.478	126.000	130.000
September	150.600	125.000	129.333
October	150.000	123.667	128.667
November	155.100	134.750	140.000
December	171.550	148.125	154.625

Sources: *Metals Week*; *Metal Bulletin* (London).
[1] Consensus of fixed price prompt sales of 20 or more flasks of prime virgin metal in the United States. Price includes delivery, United States import duty, plus any applicable surcharges. [2] Prices are cif main European port, min. 99.99 per cent.

Prices

The mercury market, after displaying relatively minor price fluctuations until October 1978, moved sharply upwards in the last two months of the year. The *Metals Week*, New York price rose from a price level in the range of $U.S. 149 to $U.S. 152 per flask in mid-November to $U.S. 179 to $U.S. 185 per flask at the end of 1978. The main reason for the price rise was that the market was beginning to feel the effect of production suspension in some countries and the withholding of mercury from the market in others. Also, in November the world's major producer, Las Minas de Almaden y Arrayanes of Spain announced that it would not sell mercury on the European market below a price of $U.S. 160 per flask fob Spanish ports. The opening dealer price for mercury in 1978 as quoted by *Metals Week* was $U.S. 131 to $U.S. 135 per flask, the low for the year. The average dealer price of mercury per flask, in New York, as quoted in *Metals Week* was $U.S. 153.32 in 1978 compared with an average price of $U.S. 135.70 in 1977, an increase of 12.9 per cent. In 1978, the cif main European port price as quoted in *Metal Bulletin* (London) ranged between a low of $U.S. 123.50 per flask on June 6, 1978 and a high of $U.S. 160 per flask on December 28, 1978.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
92805-2	Mercury metal	free	free	free	free
92828-4	Mercuric oxide for manufacture of dry-cell primary batteries (expires February 28, 1981)	free	free	25%	free

United States

Item No.		Non-communist countries	Communist countries[1]
601.30	Mercury ore	free	free
632.34[2]	Mercury metal, unwrought and waste and scrap	12.5 cents per pound	25 cents per pound

European Economic Community

Item No.		Autonomous	Conventional
28.05	Mercury, in flasks of a net capacity of 34.5 kg, of a fob value per flask not exceeding 224 EUA[3]	8.40 EUA per flask	6.72 EUA per flask
28.28	Mercury oxides	7%	5.6%

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978), ITC Publication 843; Official Journal of the European Communities, volume 21, No. L. 335, December 1978.

[1] Present exceptions: Yugoslavia, Romania and effective July 7, 1978, Hungary. [2] The suspension of duty on waste and scrap was extended until June 30, 1981. [3] EUA – European unit of account.

Molybdenum

A.J. WEBB

Molybdenum (Mo) markets experienced another year of vigorous growth in 1978. Molybdenum-bearing steels were in particularly strong demand for use in oil and gas transmission lines, petroleum refineries, electrical-generating plants and chemical-processing facilities.

Western world mine production increased by about 4.4 per cent in 1978, while demand increased by over 6 per cent. This imbalance resulted in a continuing drawdown of producer and consumer inventories and an approximate 50 per cent increase in producer prices during the year. Canada's production represented about 16 per cent of the Western world total.

High prices and prospects for continuing strong molybdenum demand prompted considerable efforts in both exploration for new deposits and improved molybdenum recovery from existing operations.

Canada, production, trade and consumption

Canadian 1978 mine shipments of molybdenum contained in concentrates, oxides and ferromolybdenum were 14 068 tonnes*, down appreciably from the record high level of 16 568 tonnes shipped the previous year. Notwithstanding the 15 per cent decline, the value of shipments increased from $150.6 million to $169.9 million as a result of substantially higher prices. Mine production in 1978 was adversely affected by prolonged strikes at two facilities. Gibraltar Mines Ltd. shut down in May and Gaspé Copper Mines Limited in September, with neither strike being settled by year-end. As a result of a slope stability problem in a portion of the open pit at Brenda Mines Ltd., production was temporarily halted. The problem also resulted in an overall reduction in the molybdenum grade of ore mined in 1978 and a concomitant reduction in molybdenum production. In August, Bethlehem Copper Corporation put into production a new molybdenum recovery circuit at its Highland Valley copper mine in British Columbia. Bethlehem's Iona orebody, where mining began in late 1978, reportedly contains 0.42 per cent copper and 0.012 per cent molybdenum. Production from Iona will be about 450 tonnes per year of molybdenum contained in concentrates.

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Development work is proceeding at Kitsault, British Columbia, where AMAX Inc. is reopening the mine which had been operated until 1972 by British Columbia Molybdenum Limited. AMAX plans to double milling capacity to 11 000 tonnes per day and to produce 3.6 to 4.5 million kilograms (kg) per year of molybdenum in concentrates. Startup is scheduled for 1981.

A promising molybdenite property, located about 60 kilometres (km) south of Revelstoke, B.C., was explored in 1978. The project, known as Trout Lake, is a joint venture of Imperial Oil Limited and Newmont Exploration of Canada Limited. Mineralization grading 0.2 to 0.4 per cent molybdenite was encountered in drill core over a thickness of 300 metres (m). Additional diamond drilling is planned for 1979.

Considerable further processing of molybdenum concentrates is done in Canada. There are two roasters in Canada that convert molybdenite to molybdic oxide, the most useable form of molybdenum. One, with a capacity of 7.7 million kg of molybdic oxide, is owned and operated by Placer Development Limited at the Endako mine site. It roasts Endako concentrates as well as a small quantity of feed from other B.C. producers. Placer has announced plans to increase its roasting capacity to 10.8 million kg. Construction will begin in 1979 and be completed in 1980. A second roaster, owned by Eldorado Gold Mines Inc., is located at Duparquet in Quebec. It is operated on a toll-conversion basis with the oxide being sold at dealer prices. The Duparquet roaster has a rated annual capacity of 4.5 million kg of molybdic oxide, but the bulk of the molybdenite concentrates roasted are sourced outside of Canada and the molybdic oxide product is almost entirely reexported.

Ferromolybdenum, another end-use form of molybdenum, is produced in Canada by Masterloy Products Limited of Ottawa. Masterloy can produce a variety of ferroalloys using the thermite process. Total ferroalloy production capacity is approximately 1.8 million kg per year, though in recent years the plant has only been operating at about 50 per cent of capacity. Masterloy produces ferromolybdenum on a toll-conversion basis and over the past three years has converted between 0.1 million and 0.18 million kg of molybdenum per year.

Canada normally consumes the equivalent of only 10 to 12 per cent of its mine production, with the remainder being marketed elsewhere. Exports of molybdenum in ore concentrates and oxides in 1978 were 15 143 tonnes valued at $137.1 million.

Major consumers in Canada include Atlas Steels Company Limited, Steel Company of Canada Limited, Ford Motor Company of Canada Limited, Dominion Colour Corporation Limited, Abex Industries Ltd. and Colt Industries (Canada) Ltd. Together these companies account for well over two thirds of Canadian consumption, much of it in the form of technical grade molybdic oxide. Most of the remainder is consumed by a large number of iron foundries, which require molybdenum principally in the form of ferromolybdenum.

Canada also consumes high-purity molybdenum disulphide in lubricants. Currently all domestic requirements must be met through imports from the United States. Placer has commenced construction of a $2.2 million lubricant grade molybdenite plant at Endako, with a capacity of about 450 000 kg of molybdenum disulphide. Production will be sold in Canada, the United States, Australia and Japan.

As a result of the tightening of the world molybdenum market, the voluntary supply allocation system, initially set up in 1977 with the cooperation of the Departments of Industry, Trade and Commerce and Energy, Mines and Resources, was continued in 1978. The system helped to ensure that the basic requirements of the Canadian iron and steel industry were met. Another step taken to minimize the impact of tight markets and rising prices on the consumer was the granting of a tariff remission on Canadian molybdenum in molybdic oxide reimported into Canada during the period January 1 to September 30, 1978.

Table 1. Canada, molybdenum production, trade and consumption, 1977 and 1978

	1977		1978p	
	(kilograms)	($)	(kilograms)	($)
Production (shipments)[1]				
British Columbia	15 522 055	141 575 699	13 255 000	160 669 000
Quebec	1 045 500	9 006 284	813 000	9 270 000
Total	16 567 555	150 581 983	14 068 000	169 939 000
Exports				
Molybdenum in ores and concentrates and scrap[2]				
Japan	3 920 400	41 739 000	4 262 600	53 443 000
Belgium and Luxembourg	5 797 400	40 844 000	4 214 800	30 496 000
United States	1 222 900	9 781 000	3 364 800	20 065 000
United Kingdom	2 267 500	16 049 000	1 654 200	12 036 000
Germany, West	1 156 300	8 866 000	728 500	9 480 000
U.S.S.R.	—	—	357 300	4 463 000
France	356 300	3 111 000	300 500	3 482 000
Australia	147 100	1 645 000	91 400	1 525 000
Other countries	442 500	3 559 000	166 900	2 063 000
Total	15 310 400	125 594 000	15 141 000	137 053 000
Imports				
Molybdic oxide (containing less than 1 per cent impurities)	192 100	1 221 000	329 500	3 069 000
Molybdenum in ores and concentrates[3] (Mo content)	237 668	1 702 635	613 788	6 128 263
Ferromolybdenum[3] (gross weight)	74 330	498 485	55 294	420 139
Consumption (Mo content)				
Ferrous and nonferrous alloys	875 686	..	..	..
Electrical and electronics	2 719	..	..	..
Other uses[4]	49 442	..	..	..
Total	927 847	..	..	..

Source: Statistics Canada, except where noted.
[1] Producers' shipments (Mo content) of molybdenum concentrates, molybdic oxide and ferromolybdenum. [2] Includes molybdenite, molybdic oxide in ores and concentrates. [3] United States exports of molybdenum to Canada, reported by the U.S. Bureau of Commerce, Exports of Domestic and Foreign Merchandise (Report 140), value in U.S. currency. These imports are not available separately in official Canadian trade statistics. [4] Chiefly pigment uses.
p Preliminary; .. Not available; — Nil.

World production, consumption and developments

In 1978 Western world molybdenum mine production was nearly 87 000 tonnes, an increase of just over 4 per cent from the previous year. After conversion losses etc., available molybdenum supply is estimated at 86 100 tonnes. Approximately 56 per cent of the molybdenum was produced from primary molybdenum mines with the remaining 44 per cent being recovered as a byproduct or coproduct of copper mining. Growth in demand was limited in 1978 by the available supply. Western world apparent consumption, plus molybdenum exports to Eastern Europe, were together estimated at 86 200 tonnes. As a result of the imbalance, producer and consumer stocks were at low levels.

The United States continues to be the leading producer, accounting for over two thirds of the Western world total. Production in 1978 was over 58 000 tonnes, up about 4.5 per cent from the previous year.

AMAX Inc. is the world's largest producer of molybdenum. In 1978, AMAX produced 38 100 tonnes of molybdenum from its Climax and Henderson mines. The Henderson mine produced only 14 500 tonnes, an increase of 40 per cent over 1977, but design capacity production of 22 700 tonnes is expected to be reached by the end of 1979.

Production of molybdenum in the Western world in 1978 was as follows:

Company	Country	Per cent of production
AMAX Inc.	U.S.A.	44
Corporacion Nacional del Cobre (Codelco-Chile)	Chile	15
Duval Corporation	U.S.A.	11
Placer Development	Canada	7
Kennecott Copper Corporation	U.S.A.	6
Noranda Mines Limited	Canada	5
Molycorp Inc.	U.S.A.	3
Others		9
		100%

AMAX will retain its predominance as a molybdenum producer over the next decade, as it expects to bring on stream or commence development of three additional mines. These include the Kitsault mine in British Columbia, scheduled for a 1981 startup at 4 500 tonnes of molybdenum per year, and Mount Tolman in Washington, possibly commencing operations in 1983 at 7 900 tonnes per year. The other potential AMAX producer is Mount Emmons, Colorado, with indicated reserves of 150 million tonnes grading over 0.4 per cent molybdenite. However, Mount Emmons is located in an environmentally sensitive area and its development is encountering strong opposition from some local residents.

Table 2. Canada, molybdenum production, trade and consumption, 1965, 1970 and 1975-78

	Production[1]	Exports[2]	Imports		Consumption[5]
			Molybdic Oxide[3]	Ferro-molybdenum[4]	
			(kilograms)		
1965	4 335 069	. .	344 500	180 738	772 281
1970	15 318 593	13 763 800	33 500	29 619	1 036 940
1975	13 323 144[r]	15 710 300	56 400	269 281	1 436 883
1976	14 618 607	14 554 000	110 600	128 845	1 260 329
1977	16 567 555	15 310 400	192 100	74 330	927 847
1978[p]	14 068 000	15 141 000	329 500	55 294	. .

Source: Statistics Canada, except where noted.
[1] Producers' shipments (Mo content) molybdenum concentrates, oxide and ferromolybdenum. [2] Mo content, ores and concentrates. [3] Gross weight. [4] U.S. exports to Canada, reported by the U.S. Bureau of Commerce, Exports of Domestic and Foreign Merchandise (Report 410), gross weight. [5] Mo content of molybdenum products reported by consumers.
. . Not available; [p] Preliminary; [r] Revised.

Table 3. Canada, mine production in 1978

Company and Mine Name	Location	Type of Producer	Mill Capacity (TPD)	Ore Milled		Concentrates Produced			Year-end Stocks (tonnes Mo contained in concentrates)
				Tonnes	Grade (% Mo)	Tonnes	Grade (% Mo)	Contained Mo Tonnes	
Placer Development Limited, Endako Mine	Endako, B.C.	Primary	32 500	10 656 880	0.081	11 954	53.23	6 363	1 564[1]
Noranda Mines Limited, Boss Mountain Division	Williams Lake, B.C.	Primary	1 800	541 938	0.152	1 370	55.15	756	—
Brenda Mines Ltd.	Peachland, B.C.	Coproduct	22 000	9 995 801	0.040	5 820	56.91	3 312	779
Lornex Mining Corporation Ltd., Lornex Mine	Highland Valley, B.C.	Byproduct	43 600	15 927 148	0.016	3 443	53.40	1 839	171
Utah Mines Ltd., Island Copper Mine	Port Hardy, B.C.	Byproduct	37 200	14 200 278	0.015	2 273	40.70	925	140
Gibraltar Mines Ltd.	McLeese Lake, B.C.	Byproduct	36 300	5 135 682	0.010	257	50.50	130	7
Bethlehem Copper Corporation, Iona Mine	Highland Valley, B.C.	Byproduct	16 100	6 490 760	0.004	383	51.27	196	58
Gaspé Copper Mines, Limited, Needle Mountain and Copper Mountain	Holland Twp. Gaspé, Qué.	Byproduct	32 800	7 985 272	0.027	1 617	51.08	826	. .
Total								14 347	

Sources: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa; Company Annual Reports.
[1] Mo contained in molybdic oxide.
TPD tonnes of ore per day; . . Not available; — Nil.

Molycorp Inc. is another important U.S. molybdenum producer planning substantial development. In 1978 Molycorp announced a $U.S.200 million program to develop an underground mine at Questa, New Mexico, adjacent to its existing open-pit operations. The new mine is expected to open early in 1983 and to produce about 8 600 tonnes of molybdenum per year. The Questa open pit began phasing out operations in 1978, although molybdenum production from stockpiled ores will reportedly continue through to 1980.

Other sizeable U.S. properties which could come on stream in 1983 or later are The Anaconda Company's Hall mine in Nevada and Cyprus Mines Corporation's Thompson Creek mine in Idaho. Each deposit could be expected to produce from 6 800 to 9 000 tonnes of molybdenum per year.

With the continuing strong demand and the rising price of molybdenum, it is expected that several copper producers will install new molybdenite recovery circuits or improve existing recovery procedures. Kennecott Copper plans to undertake an extensive modernization of its copper operations in the United States that will indirectly improve molybdenum recovery.

Production in Chile in 1978 reached a record 13 200 tonnes, up significantly from the estimated production of 11 000 tonnes in 1977. It is reported that Codelco currently recovers about 52 per cent of the molybdenum contained in its copper ores. Therefore, further increases could be expected if improvements in the byproduct molybdenum recovery circuits were implemented.

Prices

In response to the tightening market situation, the producer price of technical grade molybdic oxide, as set by the Climax Molybdenum Company, rose from $U.S. 4.31 per pound to $U.S. 5.55 per pound for the United States market and to $U.S. 6.56 per pound for export markets. At 1978 year-end, Canadian producer prices were competitive with the Climax export price. During 1978 dealer prices increased threefold to about $U.S. 18.00 per pound.

Outlook

Western world molybdenum consumption in 1979 and 1980 will be limited by available mine production. At the time of writing a prolonged strike at the Endako Mine, British Columbia, which commenced in February 1979, was still in progress. Primarily because of this strike, Canadian production in 1979 will be significantly below the already reduced level of 1978. The decline in Canadian production will partially offset an expected increase of 10 per cent in the United States. Overall, Western world mine production will increase less than 6 per cent in 1979.

Prices in U.S. currency, per pound of contained molybdenum, fob shipping point, as reported in "Metals Week"

	1977[1]	1978[1]
	($)	
Molybdenum concentrates 95% MoS_2	4.01	5.86
Molybdic oxide (MoO_3) in cans	4.31	5.55
Ferromolybdenum, 60% Mo 5 000-lb lots Climax lump	4.99	6.38
Dealer export (fas port)	5.56-6.40	17.00-18.00

[1] As at December 31.

Table 4. World production of molybdenum in ores and concentrates, 1976-78

Country[1]	1976	1977	1978[p]
	(tonnes Mo content)		
Australia[e]	11	11	11
Bulgaria	140	150	150
Canada (shipments)	14 619	16 568	14 068
Chile	10 899	11 000	13 197
People's Republic of China	1 500	1 500	1 500
Japan[e]	150	150	150
South Korea	119	101	100
Mexico	16	18	11
Peru	450	463	729
U.S.S.R.	9 350	9 700	10 000
United States	51 362	55 523	59 803
Total	88 616	95 184	99 719

Sources: U.S. Bureau of Mines Mineral Trade Notes, May 1978; U.S. Mineral Commodity Summaries, January 1979; Statistics Canada.
[1] In addition to the countries listed, North Korea, Nigeria, Romania and the Philippines are believed to produce molybdenum, but output is not reported quantitatively.
[e] Estimated; [p] Preliminary.

The molybdenum market will remain tight until 1981 (see accompanying table) after which a surplus is expected to develop. New planned and forecast mine capacity may result in a 12.5 million kg molybdenum surplus by 1985, but much of the excess production will be utilized to rebuild stocks earlier depleted.

In Canada, molybdenum consumption could more than double if the Alaska Highway Gas Pipeline is built. The Canadian portion of the pipeline will require, over a three-year period, about 1.4 million tonnes of steel containing about 5.3 million kg of molybdenum. Construction is expected to commence in 1980, but the decision to start is dependent on a number of factors: the resolution of the energy debate in the U.S. Congress; a decision by the National Energy Board on the export of Canadian natural gas via a "pre-build" portion of the pipeline and the negotiation of financing.

Worldwide, molybdenum consumption has been growing at a rate of 6 to 7 per cent per year, as the demand for new molybdenum-bearing steels, largely alloy and stainless steels, is increasing. Growth in demand is expected to moderate by 1985, reflecting rising prices, substitution by columbium and vanadium and a general maturing of the molybdenum market.

Table 5. Forecast of western world supply-demand balance, 1979-1981 and 1985

	1979	1980	1981	1985
	(million kilograms Mo)			
Mine production				
United States	67.5	69.5	68.1	92.4
Canada	11.3	15.5	18.2	24.5
Chile	12.7	12.7	13.2	13.6
Others	0.8	2.0	4.0	8.5
Total	92.3	99.7	103.5	139.0
Apparent consumption[1]				
United States	32.0	34.0	36.0	44.0
Western Europe	31.0	33.0	35.0	44.0
Japan	12.0	13.0	13.0	16.0
Canada[2]	1.8	3.5	3.5	2.5
Exports to Eastern Europe	8.0	8.0	8.0	10.0
Others	7.0	8.0	8.0	10.0
Total	91.8	99.5	103.5	126.5

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Includes exports to Eastern Europe. [2] Assumes construction of the Alaska Highway Gas Pipeline commencing in 1980.

Tariff profile (most favoured nation under GATT)

Item	European Economic Community	United States	Japan	Canada
Molybdenum ores and concentrates	Free	12¢ per lb on Mo content	—	Free
A. Quota	—	—	Free	—
B. Other	—	—	7.5%	—
Molybdenum oxides and hydroxides	8%	10¢ per lb on Mo content + 3%	—	15%
A. Molybdenum trioxide	—	—	5%[1]	—
B. Other	—	—	12.5%[2]	—
Ferromolybdenum	7%	10¢ per lb on Mo content + 3%	7.5%[1]	5%
Molybdates	11.2%	10¢ per lb on Mo content + 3%	7.5%[1]	15%
Molybdenum carbides	9.6%	10¢ per lb on Mo content + 3%	5%[1]	5%
Molybdenum metal				
A. Unwrought: powder	6%	10¢ per lb on Mo content + 3%	5%[1]	Free
other	5%	10¢ per lb on Mo content + 3%	5%[1]	Free
waste and scrap	5%	10.5%[2]	5%[1]	Free
B. Wrought: bars, angles, plates, sheets	8%	12.5%	7.5%[1]	Free
wire	8%	12.5%	7.5%[1]	Free
C. Other	10%	12.5%	7.5%[1]	Free

Sources: Official Journal of the European Communities, Common Customs Tariff; Tariff Schedules of the United States Annotated (1978) USITC Publication 843; Customs Tariff Schedules of Japan, 1978; Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
[1] Temporarily reduced by 20%. [2] Temporarily suspended.
GATT General Agreement on Tariffs and Trade.

Natural Gas

R.L. THOMAS

The year 1978 proved to be successful for the Canadian natural gas industry, especially in terms of additions to reserves and production revenue. Although the volume of production decreased, the amount of revenues increased by 14 per cent to a record high of $4 498 million, reflecting increases in both export and domestic natural gas prices. Expenditures by the industry for exploration and development of oil and gas, including royalty payments, increased by $1 315 million to $8 173 million, with most of the expenditures being made in Alberta.

A record number of exploration wells were drilled with a subsequent increase in aggregate metreage drilled. Development wells and total metreage were also higher than that of the previous year, with much of the activity occurring in Alberta. British Columbia and Saskatchewan also recorded an increase in activity, whereas Manitoba and the frontier regions faced another decline.

Net reservoir withdrawals decreased by approximately 3 per cent to 88 000 million cubic metres (m^3). Exports of natural gas decreased by 8 million cubic metres per day (m^3/d) and domestic sales increased only slightly. The total demand for Canadian natural gas in 1978 was 208 million m^3/d, with 140 million m^3/d being the domestic requirement.

Gross additions to marketable reserves amounted to 157 213 million m^3, primarily because of revisions and extensions to existing fields. New discoveries amounted to 28 702 million m^3, with Alberta accounting for 82 per cent of the total gross additions. The remaining reserves of marketable natural gas by year-end had risen by 91 371 million m^3 to a net total of 2 322 213 million m^3.

Outlook

Currently, the additions to gas reserves from established producing areas is well above the annual consumption rate and it is expected that this trend will continue as some new gas discoveries have not yet been fully evaluated. The National Energy Board (NEB) has been conducting a number of hearings to determine each province's demand for natural gas in the future. Exports to the United States can only be approved for the amount that is surplus to future Canadian requirements. The present surplus of natural gas offers possibilities of substituting gas for oil in eastern Canada, thereby reducing Canada's dependence on imports of insecure, high-cost oil. The country's natural gas resource potential offers much promise of increased energy self-sufficiency.

Production

In 1978 the net withdrawals of natural gas amounted to 88 324 million m^3, or 242 million m^3/d. Alberta continued to be the largest-producing province, accounting for 86 per cent of Canada's marketable gas production. British Columbia accounted for 12 per cent of the total production with the balance coming from Saskatchewan, Ontario and the Northwest Territories.

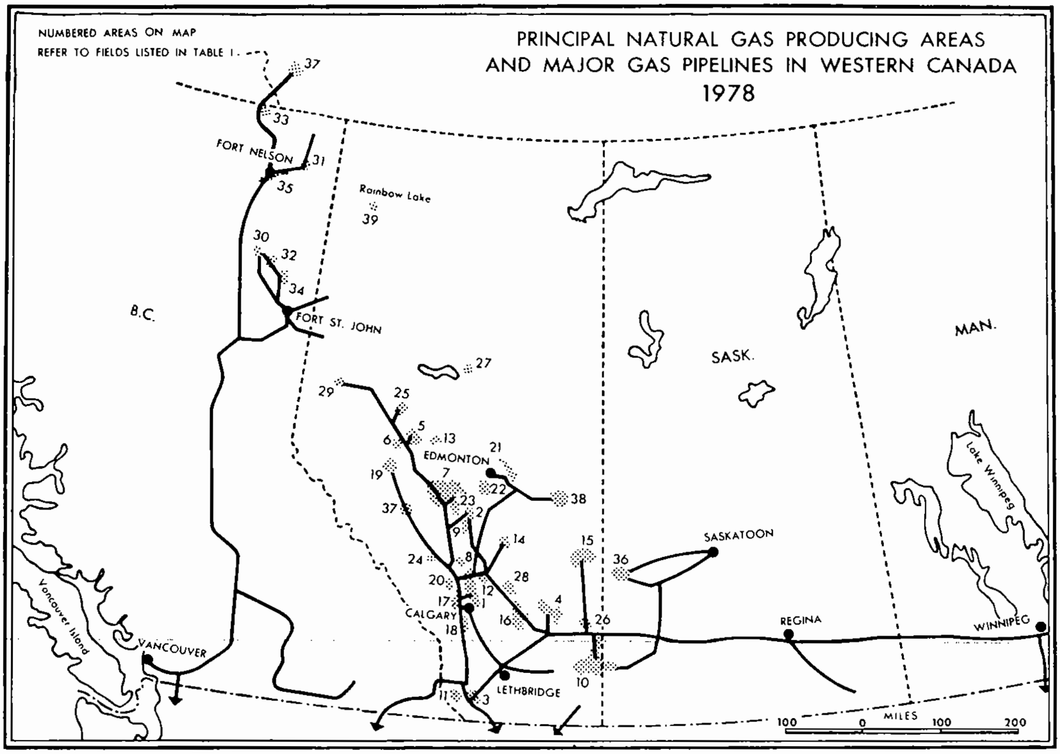
The Kaybob South field in Alberta was again the largest gas-producing area in Canada. British Columbia's largest field was Yoyo. These two fields alone were able to produce over 8 000 million m^3 in the year. Industry is exploring in great detail the Wapiti deep basin area in northwestern Alberta and northeastern British Columbia. Based on the total number of successful wells to date, it could prove to be one of the largest gas-producing areas in Canada.

The accompanying table shows the amount of gas injected into reservoirs, either as a conservation measure to increase the ultimate recovery of liquid hydrocarbons, or as part of distributors' storage operations. The Kaybob South field project is an example of a conservation scheme to maximize ultimate recovery of the liquid constituents of field gas. Here, gas is produced and processed to remove the liquid hydrocarbons and sulphur, after which most of the residual gas is reinjected to maintain pressure in the original producing reservoir. This operation is to ensure the maximum possible recovery of natural gas liquids before the reservoir is depleted by the sale of the gas. Similarly, gas may temporarily be reinjected into producing oil reservoirs, thereby maintaining reservoir pressure to maximize production of crude oil where this is possible. The volumes shown as distributors' storage represents gas that is stored by gas utilities during low-demand periods, usually in the summer, and later withdrawn as required to meet peak demand in the winter. This process assists in levelling out the utilities' demand on the trunk carriers over the year. In Alberta and Ontario, most of the gas is stored in

Table 1. Canadian natural gas fields producing 281 740 cubic metres[1] or more, 1977 and 1978

(numbers in brackets refer to map locations)	1977	1978
	(000 cubic metres)[2]	
Alberta		
Kaybob South (25)	6 747 379	6 242 350
Waterton (11)	4 040 133	3 802 771
Crossfield (1)	3 547 425	2 978 304
Edson (19)	2 811 317	2 167 502
Medicine Hat (10)	3 479 709	3 507 190
Strachan (24)	2 347 417	2 005 880
Ricinus West (24)	2 799 802	2 985 963
Westerose South (2)	1 871 450	1 672 420
Brazeau River (37)	1 759 720	1 550 330
Harmattan Elkton (8)	2 192 334	2 109 288
Harmattan East (8)	2 034 568	1 909 659
Dunvegan	1 028 277	1 087 753
Homeglen-Rimbey (9)	1 173 224	999 519
Carstairs (12)	1 157 167	976 374
Gilby (9)	1 261 072	989 008
Crossfield East (1)	1 052 690	1 069 833
Nevis (14)	943 188	907 258
Jumping Pound West (17)	1 452 918	1 360 445
Marten Hills (27)	1 134 225	1 119 087
Provost (15)	1 183 487	1 189 424
Windfall (5)	1 109 681	1 173 769
Cessford (4)	784 202	740 294
Minnehik-Buck Lake (23)	841 542	684 879
Wildcat Hills (20)	820 372	667 379
Pembina (7)	947 259	920 908
Ferrier (8)	672 062	621 521
Sylvan Lake (2)	721 703	672 630
Bonnie Glen (22)	1 640 198	1 699 374
Alderson (10)	1 040 291	1 052 978
Lone Pine Creek (1)	582 151	497 073
Pine Creek (6)	624 332	600 754
Viking Kinsella (38)	1 056 492	567 738
Swan Hills (13)	538 250	527 856
Judy Creek (13)	692 975	765 306
Kaybob (25)	538 250	391 585
Rainbow (39)	653 902	734 262
Swan Hills South (13)	644 123	645 922
Ricinus	799 989	786 146
Westlock (21)	619 455	555 842
Ghost Pine (28)	361 344	440 166
Quirk Creek	579 225	565 767
Carson Creek	542 911	435 954
Burnt Timber (20)	784 918	1 059 325
Lookout Butte (3)	261 951	224 617
Bantry	132 281	591 275
Jumping Pound (17)	454 843	567 741
Suffield	557 297	852 533
Paddle River	440 227	608 886
Tweedie	405 961	390 690
Hotchkiss	364 739	539 465
Plain	344 183	312 003
Garrington	341 022	375 059
Verger	328 841	341 296
Cache	314 475	370 348
Twinning	305 758	317 755
Wimborne (12)	306 581	264 361
Warwick	328 522	285 925
Hussar (16)	252 976	283 279
Fort Saskatchewan (21)	175 803	171 897
Leduc-Woodbend (22)	366 790	371 698
Bindloss (26)	262 372	212 660
Bruce	396 225	466 206
Olds (12)	259 091	260 822
Medicine River	297 187	270 162
Countess (16)	370 075	322 465
Carson Creek North (13)	272 582	287 678
Wayne-Rosedale (3)	231 144	280 447
Whitecourt	218 730	214 763
Bigstone (25)	257 254	254 372
Craigend (27)	340 902	323 803
Willesden Green	285 992	315 677
Princess	1 003 246	711 600
Hairy Hill	342 530	413 123
Coleman	227 070	228 641
British Columbia		
Clarke Lake (35)	1 665 935	1 407 461
Yoyo (31)	1 904 121	1 845 927
Sierra (13)	1 015 509	811 597
Laprise Creek (30)	742 599	674 521
Rigel (34)	425 497	359 557
Buick Creek (32)	327 774	362 770
Jedney (30)	335 732	255 852
Stoddart (34)	268 557	267 794
Northwest Territories		
Pointed Mountain (37)	768 797	588 925

Sources: Provincial government reports.
[1]Thousand cubic metres ($m^3 \times 10^3$). [2]14.65 pounds per square inch absolute (psia), or 101.325 kilopascals (kPa).



former-producing fields that have been depleted. However, in Saskatchewan much of the storage is in large man-made subsurface caverns that have been leached from salt beds specifically to provide storage facilities near major-consuming areas.

Exploration and development

Alberta. The number of wells and metres drilled increased substantially in Alberta in 1978. Statistics show that of a total of 5 519 wells drilled during the year, 3 090 were successful gas wells, an increase of 137 wells over the previous year. In the search for oil and gas, the industry drilled 2.79 million metres (m) compared with 2.31 million m in 1977. In development drilling, a total depth of 3.22 million m was attained, an increase of 11 per cent. A total of 6 million m were drilled in the province, establishing a new record for the drilling industry.

The foothills of the Rocky Mountains and the deep basin areas of western Alberta were again the principal regions for activity. Canadian Hunter Exploration Ltd., the major operator in the Elmworth-Wapiti region, continued to drill wells in that area to establish reserves of natural gas. The Company predicts that this basin could ultimately yield approximately 400 000 million m^3.

There are also other gas plays in Alberta which, through further exploration, could yield sizeable additions to reserves. Although West Pembina is mainly an oil field, there have been considerable reserves of natural gas discovered, primarily in the Bigoray area. Another area that could see increased activity is the Primrose military range in northeastern Alberta.

British Columbia. The total number of wells completed increased by 27 per cent to 386 while total metres drilled were 535 841, an increase over 1977 of 9 per cent. Drilling incentives and a modified royalty structure coupled with tax write-offs for exploration costs aided British Columbia's gas reserves development, with discoveries being made at Grizzly, Helmet and Dahl. More delineation wells are required before these fields can be fully evaluated.

Yukon Territory, Northwest Territories and Arctic islands. Exploration in the territorial regions continued at a subdued pace in 1978, down to 17 wells from 26 in the previous year, with a total drilled depth of 51 795 m.

In the Pointed Mountain region of the Northwest Territories, Columbia Gas Development of Canada Ltd. further developed its Kotaneelee gas field. A well, Columbia *et al* Kotaneelee E-37, was successful in producing natural gas. This well, along with the discovery well Kotaneelee H-38, will assist in proving up the reserves contained in the Pointed Mountain area.

Table 2. Pressure maintenance projects and storage of natural gas in Canada, 1977 and 1978

	1977 Input	1978 Input		1977 Input	1978 Input
	(000 cubic metres)			(000 cubic metres)	
Alberta			Pembina	33 251	29 207
Aerial	11 253	9 856	Rainbow	382 141	349 114
Ante Creek	45 979	40 979	Rainbow South	83 421	89 294
Bellshill Lake	18 773	21 754	Ricinus	444 624	416 828
Bigstone	476	494	Swan Hills South	242 990	282 173
Bonnie Glen	1 266 544	1 358 073	Turner Valley	37 614	33 086
Bow Island	36 586	—	Viking Kinsella	191 750	—
Carson Creek	113 601	218 556	Waterton	311 175	370 178
Carbon	397 543	—	Willesden Green	344 651	342 858
Carstairs	70 211	101 110	Windfall	955 139	768 402
Cessford	1 763	—	Wizard Lake	517 003	480 318
Crossfield East	66 022	124 339	Zama	170	4 707
Duhamel	16 321	12 110			
Golden Spike	210 862	298 417	Total	12 673 994	11 467 721
Harmattan East	1 224 931	1 065 245			
Harmattan Elkton	1 556 332	1 387 199	**Ontario**	462 233	3 730 449
Joarcam	57 082	50 809			
Kaybob South	3 866 971	3 451 792	**Saskatchewan**	308 862	406 223
Leduc-Woodbend	141 353	159 244			
Lloydminster	4 988	—			
Mitsue	17 373	1 579	Total Canada (14.696 psia)	13 455 079	15 604 393
Marten Hills	141	—			

Sources: Provincial government reports.
— Nil.

In the Beaufort Sea, exploration continued at a pace determined by weather and ice conditions. Dome Petroleum Limited kept their three drillships active by drilling new wells and having some existing wells reentered for the purpose of further testing. Four new wells were drilled by Dome during the year: Kopanoar D-14, Natsek E-56, Tarsiut A-25 and Kaglulik M-64, all of which will be reentered in 1979 for testing. It is also anticipated that four new wells will be drilled: Kenalooak O-94, Kilannak M-76, Nerlerk M-98 and Miterk.

In the Arctic islands, Panarctic Oils Ltd. was successful in discovering natural gas at its Drake F-76 well, which tested at 1.5 million m^3 of gas per day.

Saskatchewan. The total number of wells drilled increased by 84 per cent over 1977 to 974, with total depth attained of 719 611 m compared with 434 686 m in 1977. The number of gas discoveries declined to 40 from a high of 83 in the previous year.

Eastern Canada. In the east coast offshore, a total of seven exploratory wells were completed, with one being a natural gas discovery. A total of 26 242 m were drilled in 1978, compared with 7 742 m in the previous year. In the 1979 drilling season it is expected that 11 wells will be drilled in the Newfoundland-Labrador area and in the Scotian Shelf, two oil and gas discoveries made earlier will also be evaluated.

In Quebec, six exploratory wells drilled in the St. Lawrence Lowlands resulted in discovering neither oil nor gas. The total metreage drilled increased by 38 per cent over last year to 18 093 m.

Although the total number of wells drilled in Ontario decreased in 1978, the average depth per well increased. Of the 143 wells drilled, 11 were oil and 70 were gas, with the remainder being dry. A total depth of 108 919 m were drilled, with 61 302 m being in the exploratory category.

Reserves

At the end of 1978, the Canadian Petroleum Association (CPA) estimated Canada's proven reserves of marketable natural gas at 2 322 213 million m^3, compared with 2 230 842 million m^3 in 1977. Using the 1978 level of production of 66 000 million m^3, the life index (reserves-to-production ratio) had increased to 35.2 years. Gross additions to reserves amounted to 157 213 million m^3 and included 71 403 million m^3 attributed to extensions of existing fields, 57 108 million m^3 to an upward revision of field reserves and 28 702 million m^3 from new discoveries. Much of the gain was due to an increase in the amount of reserves in Alberta, although the Arctic islands contributed

Table 3. Canada, production of natural gas, 1977 and 1978[1]

	1977		1978[p]	
	(million cubic metres)	($ 000)	(million cubic metres)	($ 000)
Gross new production				
New Brunswick	2		2	
Quebec	. . .		. . .	
Ontario	239		312	
Saskatchewan	1 678		1 575	
Alberta	89 910		88 348	
British Columbia	11 795		10 556	
Northwest Territories and Yukon	49		70	
Total, Canada	103 673		100 863	
Waste and flared				
Saskatchewan	196		186	
Alberta	863		939	
British Columbia	104		116	
Northwest Territories and Yukon	40		59	
Total, Canada	1 203		1 300	
Reinjected				
Alberta	11 276		11 205	
British Columbia	47		32	
Northwest Territories and Yukon	—		—	
Total, Canada	11 323		11 237	
Net withdrawals				
New Brunswick	2	43	2	43
Quebec	. . .	. . .	. . .	. . .
Ontario	239	10 267	312	18 715
Saskatchewan	1 482	13 534	1 389	15 538
Alberta	77 771	3 110 319	76 203	3 590 518
British Columbia[2]	11 644	287 620	10 407	298 737
Northwest Territories and Yukon	9	287	10	370
Total, Canada	91 147	3 422 070	88 323	3 923 921
Processing shrinkage				
Saskatchewan	35		35	
Alberta	10 924		10 836	
British Columbia	1 120		973	
Total, Canada	12 079		11 844	
Net new supply, Canada	79 068		76 479	

Sources: Statistics Canada; Provincial government reports.
[1] 14.73 psia (101.878 kPa). [2] British Columbia total includes Pointed Mountain gas produced in Northwest Territories and Beaver River gas produced in the Yukon but processed in British Columbia.
[p] Preliminary; — Nil; . . . Insignificant.

Table 4. Canada, production, trade and total sales of natural gas, 1967-78

		Net Withdrawals	Imports	Exports	Sales in Canada
1967	000 cubic metres	41 690 777	1 497 740	14 310 223	19 779 162
	$ 000	197 983	19 914	123 664	454 722
1968	000 cubic metres	47 939 226	2 499 304	16 944 121	21 693 086
	$ 000	225 264	35 393	153 752	490 767
1969	000 cubic metres	56 027 884	1 068 886	18 974 434	23 885 042
	$ 000	262 332	16 025	176 188	537 187
1970	000 cubic metres	64 505 573	336 473	21 758 969	25 989 118
	$ 000	315 100	5 124	205 988	582 317
1971	000 cubic metres	70 791 941	453 535	25 581 486	28 365 477
	$ 000	342 549	7 021	250 719	641 898
1972	000 cubic metres	82 520 334	446 434	28 527 660	32 457 958
	$ 000	388 500	7 629	306 843	740 383
1973	000 cubic metres	88 367 585	416 410	29 203 534	34 826 520
	$ 000	451 853	7 793	350 745	797 856
1974	000 cubic metres	86 272 607	261 405	27 214 927	37 231 875
	$ 000	723 766	5 777	493 640	980 395
1975	000 cubic metres	87 519 740	295 940	26 896 300	37 526 031
	$ 000	1 520 661	7 830	1 092 168	1 307 287
1976	000 cubic metres	87 683 816	253 674	27 026 195	38 834 918
	$ 000	2 649 218	8 818	1 616 490	1 895 543
1977	000 cubic metres	91 147 120	821	28 320 248	40 547 055
	$ 000	3 422 070	46	2 092 942	2 303 220
1978[p]	000 cubic metres	88 324 075	1 844	24 960 158	41 745 254
	$ 000	3 923 921	59	2 165 064	2 783 413

Source: Statistics Canada.
Figures in Tables 4 and 12 differ for imports and exports because of different reporting procedures and timing.
[p] Preliminary.

Table 5. Canada, liquids and sulphur recovered from natural gas, 1967-78

	Propane	Butane	Condensate Pentanes Plus	Sulphur
	(cubic metres)	(cubic metres)	(cubic metres)	(tonnes)[1]
1967	2 249 166	1 482 987	4 887 492	2 203 448
1968	2 520 818	1 656 959	5 278 723	3 090 925
1969	2 831 090	1 778 223	6 126 421	3 773 919
1970	3 382 352	2 099 228	7 019 513	4 309 041
1971	3 851 547	2 455 929	7 456 208	4 628 393
1972	4 696 619	3 093 703	9 671 111	6 723 409
1973	5 315 544	3 567 161	9 867 029	7 115 881
1974	5 268 092	3 519 638	9 413 046	6 950 327
1975	5 531 963	3 642 717	8 816 323	6 487 466
1976	5 410 000	3 583 000	7 872 000	6 422 000
1977	5 512 000	3 650 000	7 712 000	6 500 040
1978[p]	5 203 000	3 354 000	6 925 000	6 310 511

Source: Statistics Canada.
[1] The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.
[p] Preliminary.

substantially, primarily through revisions. Alberta, with 1 549 716 million m^3 of marketable gas reserves, accounted for 67 per cent of Canadian reserves, British Columbia 9 per cent and the Territories 22 per cent.

In a recent report *Canadian Natural Gas*, prepared by the National Energy Board (NEB), Canada's remaining reserves of marketable natural gas were estimated to be 1 872 468 million m^3 and production was estimated to be 71 000 million m^3, indicating that Canada had a 26.4 year life index of natural gas.

The reason for the difference in the reserves production figures between the two sources is that the NEB does not include the frontier region in its reserves estimate and the production figure is preliminary.

Natural gas processing

Gas-processing capacity increased in 1978 because of new plants coming on stream and expansion to existing facilities. Almost all of the new projects completed were in the small plant category.

Of the 50 projects completed, 37 were new plants and the remaining 13 were expansions or additions to existing facilities. Of the 13 plants, three were ethane facilities, six were gas compression installations and four were expansions to small plants.

In the "new plant" category, four were of significant size and expensive in terms of capital cost: Quasar Petroleum Ltd.'s Grizzly Valley plant in northeastern British Columbia at $5.3 million, with an output of 13.867 million m^3/d; Amoco Canada Petroleum Company Ltd.'s Josephine plant in northwestern Alberta at $5.0 million, with an output of 1.389 million m^3/d; Champlin Petroleum Company's facility at Steele, Alberta at $3.0 million, with an output of 0.547 million m^3/d; and Hudson Bay Oil and Gas Company Limited's Kaybob South plant in Alberta at $3.0 million, with an output of 0.423 million m^3/d.

It is estimated that over $250 million will be spent in 1979 for natural gas processing plants. Two facilities are expected to cost $75 million each: Westcoast Transmission Company Limited's Pine River gas plant, which will also be the first sulphur recovery plant in several years and the Pacific Petroleums Ltd. Empress ethane facility. Another plant in the "high-cost" category is Shell Canada Limited's facility in the South Rosevear area of Alberta, at a cost of $25 million.

Three medium-sized plants will be built in the Elmworth gas play region. Canadian Hunter is expected to pay $6 million for its Elmworth plant, Sulpetro Limited will spend $3 million for its Wapiti plant and Dome Petroleum will have a similar plant completed in the northern sector of the region.

Transportation

Only 6 600 kilometres (km) of natural gas pipeline were constructed in 1978. A number of newly discovered fields

Table 6. Wells drilled, by province, 1977 and 1978

	Oil		Gas		Dry[1]		Total	
	1977	1978	1977	1978	1977	1978	1977	1978
Western Canada								
Alberta	705	946	2 953	3 090	1 420	1 483	5 078	5 519
Saskatchewan	359	766	83	40	88	168	530	974
British Columbia	38	72	148	186	199	128	305	386
Manitoba	9	10	—	—	2	6	11	16
Yukon and Northwest Territories and Arctic islands	—	1	8	3	18	13	26	17
West coast offshore	—	—	—	—	—	—	—	—
Sub-total	1 111	1 795	3 192	3 319	1 647	1 798	5 950	6 912
Eastern Canada								
Ontario	9	11	93	70	63	62	165	143
Quebec	—	—	—	—	6	6	6	6
Atlantic provinces	—	—	—	—	—	—	—	—
East coast offshore	—	—	—	1	2	6	2	7
Hudson's Bay offshore	—	—	—	—	—	—	—	—
Sub-total	9	11	93	71	71	74	173	156
Total Canada	1 120	1 806	3 285	3 390	1 718	1 872	6 123	7 068

Source: Canadian Petroleum Association.
[1] Includes suspended and abandoned wells but excludes miscellaneous wells and service wells.
— Nil.

Table 7. Metres drilled in Canada for oil and gas by province, 1977 and 1978

	Exploratory		Development		All Wells	
	1977	1978	1977	1978	1977	1978
Alberta	2 315 420	2 791 943	2 889 527	3 215 794	5 204 947	6 007 737
Saskatchewan	200 504	341 694	234 182	377 917	434 686	719 611
British Columbia	227 422	256 645	262 902	279 296	490 342	535 841
Manitoba	8 749	7 059	610	6 366	9 359	13 425
Territories and Arctic islands	57 312	32 124	23 454	19 671	80 766	51 795
West coast offshore	—	—	—	—	—	—
Total western Canada	2 809 407	3 529 465	3 410 675	3 898 944	6 220 082	7 428 409
Ontario	34 040	61 302	55 408	47 617	89 448	108 919
Quebec	13 233	18 093	—	—	13 233	18 093
Atlantic provinces	—	—	—	—	—	—
East coast offshore	7 742	26 242	—	—	7 742	26 242
Total eastern Canada	55 015	105 637	55 408	47 617	110 423	153 254
Total Canada	2 864 422	3 635 102	3 466 083	3 946 561	6 330 505	7 581 663

Source: Canadian Petroleum Association.
— Nil.

were not connected due to a decline in the demand for natural gas.

Table 8. Canada, estimated year-end marketable reserves of natural gas, 1977 and 1978

	1977	1978
	(million cubic metres)	
Alberta	1 310 559	1 549 716
British Columbia	186 624	218 365
Saskatchewan	23 285	35 333
Eastern Canada	12 039	9 439
Northwest Territories	152 205	509 360
Total	1 684 712	2 322 213

Source: Canadian Petroleum Association.

The largest line constructed was by The Alberta Gas Trunk Line Company Limited in the Peace River area, with a diameter of 76 centimetres (cm) and a length of 354 km. This program primarily involved looping in order to accept increased throughput.

The longest sour gas line was completed for Aquitaine Company of Canada Ltd. in the Stolberg field of Alberta. This line connects the field with the Ram River gas-processing plant, a distance of 61 km. There are three separate lines in this project: sour gas, sweet fuel gas and condensate, with respective diameters of 41 cm, 10 cm and 8 cm.

There were two ethane-ethylene systems completed in Alberta in 1978. Dome Petroleum completed an ethane line of 226 km and a diameter of 15 cm from the Waterton gas plant to the Cochrane straddle plant. The Alberta Gas Ethylene Company Ltd. finished construction of a 30-cm diameter line from Joffre to South Edmonton, a distance of 141 km.

Ontario was able to record a surge in the various utilities' distribution systems with an increase in construction of 17 per cent or 4 900 km of new pipeline.

There are a number of major transportation projects under various stages of development to move large quantities of natural gas to market in the future. TransCanada PipeLines Limited (TCPL) recently submitted a proposal to supply Quebec and the Maritimes with domestic natural gas. Another company, Q & M Pipe Lines Ltd., has previously made a similar proposal. The Polar Gas Project has proposed to bring Arctic gas to Ontario via the Mackenzie Delta. Petro-Canada has been studying the feasibility of transporting, by tanker, liquified natural gas from the Arctic islands to eastern seaboard ports. Another project, the Alaska Highway natural gas pipeline, would transport Prudhoe Bay Alaska gas southeastward across the Yukon, British Columbia and Alberta to U.S. markets. Provision would also be made to link Mackenzie Delta gas to this transportation system by a pipeline along the Dempster Highway for delivery to Canadian markets. The total project would be one of the biggest engineering projects of all time. Canadian and U.S. interests are working together on this transportation project with the encouragement of the two governments.

Table 9. Canada, natural gas processing plant capacities by field, 1978

Main Gas Field Served	Raw Gas Capacity	Dry Gas Produced
	(million cubic metres/day)	
Alberta		
Acheson	0.281	0.170
Atmore	0.297	0.297
Bantry (3 plants)	0.774	0.754
Bashaw (2 plants)	0.422	0.418
Bassano	0.704	0.700
Big Bend (4 plants)	2.059	2.000
Bigoray (2 plants)	0.459	0.421
Bigstone	1.577	1.211
Black Butte	0.281	0.281
Black Diamond	0.338	0.310
Bonnie Glen (2 plants)	5.819	4.846
Boundary Lake South	0.592	0.583
Braeburn	0.158	0.144
Brazeau River	6.180	5.550
Brazeau South	1.897	1.690
Bruce	0.845	0.845
Burnt Timber	3.610	3.211
Cadomin	0.071	0.069
Calling Lake	0.423	0.423
Carbon (2 plants)	4.431	4.218
Caroline (2 plants)	1.886	1.377
Carson Creek	2.450	2.140
Carstairs	9.861	7.888
Cessford (7 plants)	5.308	5.241
Chigwell (2 plants)	0.297	0.278
Chip Lake	0.135	0.127
Choice	0.297	0.283
Connorsville	0.704	0.684
Corbett Creek	0.254	0.251
Countess (3 plants)	1.338	1.264
Crossfield (3 plants)	14.087	9.344
Davey	0.225	0.220
Dunvegan	6.762	6.649
Edson (4 plants)	11.129	10.119
Elnora	0.510	0.490
Enchant	0.657	0.646
Ferintosh	0.141	0.140
Ferrier (4 plants)	3.676	3.270
Ferrybank (3 plants)	0.980	0.946
Garrington (3 plants)	0.991	0.817
Ghost Pine	3.184	3.124
Gilby (12 plants)	5.157	4.739
Gilby North	0.789	0.733
Gold Creek	0.648	0.507
Golden Spike	0.197	0.197
Greencourt	0.902	0.873
Hanna (3 plants)	0.536	0.518
Harmattan-Elkton (3 plants)	14.735	8.931
Hercules	0.085	0.084
Holmberg	0.087	0.085
Homeglen-Rimbey	11.918	9.974
Hotchkiss	1.274	0.977
Hussar (3 plants)	3.076	2.383
Huxley	0.352	0.351
Innisfail	0.564	0.366
Joffre (3 plants)	0.404	0.349
Judy Creek (4 plants)	7.865	5.518
Jumping Pound	7.015	5.635
Kaybob (2 plants)	3.205	3.080
Kaybob South (7 plants)	24.620	17.541
Kessler	0.340	0.283
Killam (4 plants)	1.128	1.103
Lacombe	0.145	0.144
Lac La Biche	0.524	0.524
Leduc Woodbend (2 plants)	1.212	0.871
Leedale	0.113	0.110
Lone Pine Creek	3.071	2.395
Marten Hills	5.069	4.970
McLeod River	0.212	0.170
Medicine River	0.225	0.212
Mikwan North	0.394	0.390
Minnehik-Buck Lake	3.043	2.817
Mitsue	0.733	0.521
Morinville	0.564	0.535
Nevis (2 plants)	5.776	4.541
Nipisi	0.564	0.333
Niton	1.133	1.084
North Twining	0.321	0.299
Okotoks	0.981	0.479
Olds (2 plants)	2.435	1.742
Oyen (4 plants)	0.366	0.360
Paddle River	2.440	2.065
Parflesh	0.056	0.056
Peco (3 plants)	0.460	0.407
Pembina (17 plants)	4.890	4.070
Penhold	0.176	0.174
Phoenix	0.085	0.085
Pincher Creek	2.536	2.282

Table 9. (cont'd)

Main Gas Field Served	Raw Gas Capacity	Dry Gas Produced	Main Gas Field Served	Raw Gas Capacity	Dry Gas Produced
	(million cubic metres/day)			(million cubic metres/day)	
Alberta (cont'd)					
Princess (2 plants)	0.451	0.394	Whitecourt	1.831	1.730
Provost	6.265	5.468	Wildcat Hills	3.522	3.240
			Willesden Green		
Quirk Creek	2.536	1.944	(2 plants)	0.492	0.451
			Wilson Creek	0.611	0.564
Rainbow Lake (5 plants)	3.636	2.946	Wimborne (2 plants)	1.090	0.831
Redwater	0.648	0.338	Windfall, Pine Creek	10.453	3.832
Retlaw	0.671	0.572	Wintering Hills	0.620	0.422
Ricinus	2.353	1.901	Wood River	0.141	0.141
Rockyford	0.141	0.138	Worsley	1.606	1.465
Rosevear	0.958	0.789			
			Zama	0.713	0.545
Sedalia	0.480	0.473			
Sibbald	0.169	0.169	**Saskatchewan**		
Simonette	1.042	0.761	Cantuar	0.708	0.680
Sounding	0.282	0.274	Coleville, Smiley	1.698	1.670
Stanmore (2 plants)	1.352	1.323	Dollard	0.057	0.057
Stettler	0.113	0.111	Hatton	5.094	5.094
Strachan	7.748	6.443	Milton	0.113	0.113
Sturgeon Lake South	0.669	0.602	Smiley	0.113	0.085
Swalwell (2 plants)	0.789	0.753	Steelman	1.075	0.849
Swan Hills	0.451	0.324	Totnes	0.198	0.198
Sylvan Lake (6 plants)	3.853	3.575	West Gull Lake	0.046	0.042
Teepee Creek	0.487	0.445	**British Columbia**		
Three Hills	0.085	0.082	Beaver River	6.799	0.850
Three Hills Creek	0.845	0.809	Boundary Lake (2 plants)	0.821	0.764
Turner Valley	1.127	1.099	Clarke Lake	31.161	25.778
Twining (4 plants)	1.631	1.562	Fort St. John	14.164	12.889
Virginia Hills	0.423	0.282	**Ontario**		
Vulcan	1.564	1.226	Becher	0.028	0.028
			Corunna (2 plants)	0.142	0.142
Waskahigan	0.479	0.451	Port Alma	0.453	0.453
Waterton	13.326	8.875			
Wayne-Rosedale			**Northwest Territories**		
(3 plants)	1.803	1.658	Pointed Mountain	5.320	5.320

Sources: *Natural Gas Processing Plants in Canada* (Operators List 7) January 1979. Department of Energy, Mines and Resources, Ottawa; Survey of gas processing plants, 1979, *Oilweek*.

Markets and trade

The total sales of natural gas decreased by 3 per cent to an estimated 66 705 million m^3 in 1978. This decline occurred because of lower exports of gas to the United States. Exports of Canadian natural gas to the U.S. amounted to 24 960 million m^3 or approximately 68 million m^3/d, compared with 78 million m^3/d in 1977 when the National Energy Board had authorized increased exports because of an emergency situation in the northern states.

Gas sales to domestic consumers increased slightly from 111 million m^3/d in 1977 to 114 million m^3/d in 1978. The requirements by sector were as follows: residential, 26 million m^3/d; industrial, 65 million m^3/d; and commercial, 24 million m^3/d; with each sector averaging an increase in demand of 4 per cent. Revenues from the sales of gas in Canada were in excess of $2 783 million, up 20.8 per cent from those in the previous year.

Ontario remains the largest user of natural gas in Canada, consuming a total of 18 674 million m^3 (51 million m^3/d) or 45 per cent. Alberta, the second-largest consumer, accounted for 29 per cent of gas marketed in Canada. British Columbia, Manitoba and Quebec experienced an increase in gas sales, whereas a decline in sales

Table 10. Kilometres of gas pipelines in Canada, 1973-78

	1973	1974	1975	1976	1977	1978^p
Gathering						
New Brunswick	9.7	9.7	9.7	20.8	20.8	20.6
Quebec	1.6	1.6	1.6	2.1	—	—
Ontario	2 026.1	1 825.0	1 839.5	1 992.0	1 939.1	1 934.8
Saskatchewan	1 549.8	1 208.6	1 643.1	2 290.1	2 757.2	1 802.8
Alberta	7 740.9	9 025.2	10 050.4	12 848.4	13 822.3	13 736.0
British Columbia	1 649.6	1 736.5	1 907.1	2 069.8	2 120.3	2 575.5
Northwest Territories and Yukon	—	54.7	54.7	55.0	55.0	54.7
Total	12 977.7	13 861.3	15 506.1	19 278.2	20 715.2	20 124.4
Transmission						
New Brunswick	20.9	20.9	20.9	21.6	21.6	21.4
Quebec	238.2	238.2	238.2	237.7	265.0	254.8
Ontario	8 410.4	9 239.2	9 224.8	9 387.8	9 345.9	9 188.9
Manitoba	2 640.9	2 645.8	2 743.9	2 743.4	2 779.0	2 762.7
Saskatchewan	10 241.9	10 513.8	10 581.4	10 614.9	10 862.5	10 640.6
Alberta	13 005.1	12 853.8	13 930.5	15 596.0	17 075.4	17 636.4
British Columbia	4 879.5	4 894.0	5 042.1	5 087.5	5 177.1	5 218.7
Total	39 436.9	40 405.7	41 781.8	43 688.9	45 526.5	45 723.5
Distribution						
New Brunswick	51.5	51.5	51.5	146.1	146.1	145.2
Quebec	2 772.9	2 764.9	2 975.7	2 890.0	2 938.9	2 954.8
Ontario	26 385.2	27 395.9	28 033.2	28 715.7	29 378.8	34 276.8
Manitoba	2 850.1	2 937.1	2 655.4	2 738.8	2 815.1	2 859.5
Saskatchewan	4 362.9	4 615.6	4 789.4	4 966.3	5 078.8	5 257.1
Alberta	14 917.0	16 523.1	18 851.9	21 554.1	25 065.1	26 694.2
British Columbia	9 957.0	8 946.3	9 285.9	9 397.6	9 789.3	10 013.6
Total	61 296.5	63 234.4	66 643.0	70 409.5	75 212.1	82 201.2
Total Canada	113 711.1	117 501.4	123 930.9	133 376.6	141 453.8	148 049.1

Source: Statistics Canada.
^p Preliminary; — Nil.

was recorded for New Brunswick, Saskatchewan and Ontario. Nova Scotia, Prince Edward Island and Newfoundland do not have natural gas service. It is anticipated that natural gas will become available in the Atlantic region during the 1980s.

Export sales of natural gas to the United States amounted to 68 million m^3/d compared with 78 million m^3/d in 1977. The revenue from these sales was over $2 165 million, an increase of 3.4 per cent which resulted from an increase in the export price of natural gas in mid-1978.

The price of natural gas is based on a British Thermal Unit (BTU) and is given in dollars per million BTU's (MMBTU). In July, 1978 the average wellhead price of gas in Alberta was $1.53 per MMBTU, the city-gate price in Toronto was $1.85 per MMBTU and the export price was $ U.S. 2.16 per MMBTU. In December, 1978 the three respective prices were: $1.60, $2.00 and $ U.S. 2.16 per MMBTU.

Composition and uses of natural gas

Marketed natural gas consists chiefly of methane (CH_4) but small amounts of other combustible hydrocarbons such as ethane (C_2H_6) and propane (C_3H_8) may also be present. Methane is nonpoisonous and odourless, but a characteristic odour is usually introduced into marketed natural gas as a safety measure.

The heat value of natural gas averages about 1 000 Btu/ft.^{3} (37.43 kJ/m^3) of gas. Raw natural gas, as it exists

Table 11. Canada sales of natural gas by province, 1978[p]

	000 cubic metres	$ 000	Average $/000 cubic metres	Number of Customers Dec. 31/78
New Brunswick	2 298	257	111.84	532
Quebec	2 459 873	223 738	90.96	175 732
Ontario	18 673 500	1 523 492	81.59	1 135 917
Manitoba	1 818 512	138 805	76.33	168 481
Saskatchewan	2 790 581	156 601	56.12	210 112
Alberta	12 062 197	495 473	41.08	506 746
British Columbia	3 938 293	245 047	62.22	381 021
Total Canada	41 745 254	2 783 413	66.68	2 578 541
Previous totals				
1973	34 827 379	797 856	22.91	2 131 090
1974	37 231 875	980 395	26.33	2 219 549
1975	37 526 031	1 307 287	34.84	2 300 039
1976	38 834 918	1 895 543	48.81	2 399 824
1977	40 547 054	2 303 220	56.80	2 490 702

Source: Statistics Canada.
[p] Preliminary.

in nature, may vary widely in composition. Besides the usually-predominant methane, varying proportions of ethane, propane, butane and pentanes plus may be present. Water vapour is a normal constituent. Hydrogen sulphide is present in sour gas, which is an important source of sulphur. Other nonhydrocarbon gases that may be present, usually in small amounts, are carbon dioxide, nitrogen and helium.

The largest use of natural gas is as a fuel. Residentially, gas is extensively used in space and water heating and cooking, but is becoming common as a fuel for air conditioners, incinerators, dishwashers and laundry equipment. In industrial areas, natural gas has been a boon to such industries as automobile manufacturing, iron and steel complexes, metal-working firms, glass factories and food processors. Ethane, seldom removed from natural gas at the field processing plant in the past, has become a valuable petrochemical feedstock, and ethane recovery on a large scale is now taking place. Natural gas is a 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 fuel-cells and power-generator systems driven by gas turbines.

Canada continues to be one of the world's largest producers of elemental sulphur, a byproduct recovered in the processing of sour (hydrogen sulphide) gas from fields in western Canada.

Table 12. Canada, supply and demand of natural gas, 1977 and 1978

	1977		1978[p]	
	(million cubic metres)			
Supply				
Gross new production		103 673		100 862
Field waste and flared		−1 203		−1 301
Reinjected		−11 323		−11 237
Net withdrawals		91 147		88 324
Processing shrinkage		12 079		11 844
Net new supply		79 068		76 480
Removed from storage	4 046		3 996	
Placed in storage	−4 994		−4 550	
Net storage		−948		−554
Total net domestic supply		78 120		75 926

Table 12. (cont'd)

	1977		1978p	
	(million cubic metres)			
Imports				2
Total supply		78 120		75 928
Demand				
Exports		28 320		24 961
Domestic sales				
Residential	8 892		9 320	
Industrial	23 230		23 400	
Commercial	8 425		9 025	
Total		40 547		41 745
Field and pipeline use				
In production	6 517		6 577	
Pipeline	2 535		2 149	
Other	1 431		1 346	
Adjustment metreing differences	−845		−201	
Line pack changes	77		49	
Total field and pipeline use		9 715		9 920
Gas unaccounted for		−462		−148
Total demand		78 120		75 928
Total domestic demand		49 800		50 967
Average daily domestic demand		136		140

Sources: Statistics Canada; Provincial government reports.
p Preliminary.

Nepheline Syenite and Feldspar

G.H.K. PEARSE

Nepheline syenite is a white to whitish-grey, medium-grained igneous rock resembling granite in texture. It consists of nepheline, potash and soda feldspar, and accessory mafic minerals such as biotite, hornblende and magnetite. Although nepheline syenite is a rock type known to occur in many parts of Canada, its development for industrial application is limited to those deposits from which iron-bearing accessory minerals can readily be removed; its major uses are in the glass and ceramics industries.

The use of nepheline syenite as a raw material for glass, ceramic and the filler industries was first developed in Canada, which was the world's sole producer for many years. Canada's only competitor in the field, Norway, began nepheline syenite mining in 1971. Although the U.S.S.R. began mining nepheline syenite on the Kola Peninsula during the 1930s, the deposit was worked for its phosphate content. Byproduct nepheline from the Kola deposit became an important source of aluminum and is still being used for this purpose. Nepheline syenite is also quarried in the United States for use as aggregate, railway ballast, jettystone and roofing granules.

Canada's nepheline syenite industry began in 1932 with the staking of five claims on Blue Mountain, 40 kilometres (km) northeast of Peterborough. A long period of persistent efforts in technical and market research and in development was necessary before this unique industry became established. Today there are two mills in operation on Blue Mountain processing rock from several quarries.

Over the years nepheline syenite has become preferred to feldspar as a source of alumina and alkalis for glass manufacture. Its use results in more rapid melting of the batch at lower temperatures than with feldspar, thus reducing fuel consumption, lengthening the life of furnace refractories and improving the yield and quality. Other industrial uses for nepheline syenite include ceramic glazes, enamels, and fillers in paints, papers, plastics and foam rubber.

Feldspar is the name of a group of minerals consisting of aluminum silicates of potassium, sodium and calcium. Feldspar is used in glassmaking as a source of alumina and alkalis, in ceramic bodies and glazes, in cleaning compounds as a moderate abrasive and as a flux coating on welding rods. High-calcium feldspars, such as labradorite, and feldspar-rich rocks, such as anorthosite, find limited use as building stones and for other decorative purposes. Potash feldspar is an essential ingredient in the manufacture of high voltage porcelain insulators. Dental spar, which is used in the manufacture of artificial teeth, is a pure white potash feldspar, free of iron and mica.

Feldspar occurs in many rock types, but commercially viable deposits are mostly restricted to coarse-grained pegmatites from which the mineral is concentrated by flotation or, less commonly, by handcobbing. It is then ground to the desired size. Nearly all of the feldspar produced in Canada has come from pegmatites in the Precambrian rocks of southern Ontario and southwestern Quebec.

Canadian production and developments

Nepheline syenite production comes from two operations on Blue Mountain in Methuen Township, Peterborough County, Ontario. The deposit is pearshaped, approximately 8 km long, and up to 2.4 km wide. The iron content of the rock is distributed quite uniformly, but selective quarrying, blending of quarry material, and careful pit development are necessary to ensure a mill product capable of meeting consumer specifications. In general, the nepheline syenite zone is underlain by syenites and overlain by steeply dipping biotite schists. Nepheline syenite reserves are sufficient to satisfy demand for the foreseeable future.

Indusmin Limited, a subsidiary of Falconbridge Nickel Mines Limited, is the larger producer. Shipments in 1978 were reported to be a record 380 000 tonnes*, an increase of 4 per cent over those of 1977. Ore is currently being mined from five open pits. Rock is blasted from the pit face and loaded by electrically powered shovels into trucks for haulage to an adjacent mill at Nephton. The mill, which was built in 1956 and expanded over time to 1 200-tonne-per-day capacity, operates on three shifts a day, seven days a week, and produces several grades of nepheline syenite to meet a wide variety of markets. The various grades produced are based on combinations of different mesh sizes and iron content. Iron-bearing minerals are almost totally removed by electromagnetic methods. Finished products are transported by rail through Havelock, Ontario, 29 km

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, nepheline syenite production, exports and consumption, 1977 and 1978

	1977		1978^{p}	
	(tonnes)	($)	(tonnes)	($)
Production (shipments)	574 558	11 983 799	579 000	13 100 000
Exports				
United States	415 479	9 117 000	395 258	9 814 000
Italy	867	33 000	10 048	373 000
United Kingdom	11 942	300 000	10 823	309 000
Australia	2 206	84 000	1 896	100 000
France	1 067	45 000	599	27 000
West Germany	254	9 000	542	27 000
Colombia	—	—	250	17 000
Dominican Republic	—	—	462	14 000
Spain	501	20 000	324	14 000
Other countries	11 447	240 000	757	36 000
Total	443 763	9 848 000	420 959	10 731 000

	1976	1977^{e}
	(tonnes)	
Consumption[1] (available data)		
Glass and glass fibre	70 975	57 694
Mineral wool	18 503	10 489
Whiteware	7 664^{e}	12 184
Paints	2 978^{e}	2 601
Rubber products	1 608	1 291
Others[2]	1 513	1 755
Total	103 241	86 014

Source: Statistics Canada.
[1]Total breakdown by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa. [2]Includes porcelain enamel, paper and paper products, plastics and other minor uses.
^{p}Preliminary; ^{e}Estimated.

south of the mill, to domestic and export markets. The United States accounts for as much as 75 per cent of Indusmin's sales. Expansion to the mill is planned for late 1979.

IMC Chemical Group (Canada) Ltd., a wholly-owned subsidiary of International Minerals & Chemical Corporation, operates quarries and a plant about 6 km east of Indusmin's operation.

The mill was constructed in 1956 on a part of the deposit originally staked in 1932 by the Canadian Flint and Spar Company, Limited. Present capacity is 1 000 tonnes per day and shipments in 1978 were well over 200 000 tonnes. The mill operates three shifts daily, seven days a week, and produces a variety of products, based on mesh sizes and iron content, suitable for many industrial uses. Rock is mined from an open pit adjacent to the mill and a certain degree of blending from various parts of the pit is required to ensure an acceptable mill feed. Ore reserves are sufficient for many years.

IMC's production is railed to Havelock, Ontario for distribution to various markets with up to 90 per cent being exported to the United States. The company produces three grades of nepheline syenite for glass, enamel, fibre and other applications.

In 1978 total nepheline syenite shipments amounted to a record 579 000 tonnes valued at $13 100 000, a tonnage increase of 1.0 per cent from 1977 and a value increase of 10 per cent, reflecting price increases during the year.

During the 1950s and 1960s, shipments increased at the rate of 17 per cent a year and 8 per cent a year, respectively. This dramatic growth was largely because of recognition by glassmakers of the superior properties, consistent quality, long-term reliable supply and low cost of nepheline syenite, compared with feldspar. Deceleration in growth over the years has occurred as markets formerly held by feldspar are nearing the saturation point. During the first half of the present decade growth was stagnant because of several factors, including strikes in the consuming industries, shortages of rail cars, and, finally, decreasing demand.

As a result of substitution of nepheline syenite, output of feldspar declined steadily from 55 000 tonnes in 1947 to 5 000 tonnes in recent years. This competition led to closure of Canada's last feldspar producer, International Minerals & Chemical Corporation (Canada) Limited's Buckingham, Quebec mine in 1972. Several local producers of high-value dental spar had delivered small tonnages to the mill at Buckingham until the closure. In 1974, one operation shipped several tonnes to Sweden and an enquiry for several hundred tonnes, following assessment of a trial shipment, was received during 1975 from a North American manufacturer. Early in 1979, Johnson and Johnson Ltd. of Montreal undertook evaluation of dental spar deposits in the area. A decision is expected on development later in the year.

Tantalum Mining Corporation of Canada Limited mines tantalum and lithium at Bernic Lake, Manitoba from a pegmatite containing abundant feldspar. This company could recover a clean quartz-feldspar product, should market demand warrant.

Other domestic occurrences

Nepheline syenite is known to occur in many localities in Canada but, to date, only the Blue Mountain deposit has proven amenable to economic mining and milling to produce material suitable for the glass and ceramic markets. Other occurrences are either too high in iron content or too variable in chemical composition to allow large-scale, open-pit development.

Table 2. Canada, nepheline syenite production and exports, 1965, 1970 and 1975-78

	Production[1]	Exports
	(tonnes)	
1965	308 426	224 256
1970	454 110	351 940
1975	468 427	356 629[r]
1976	540 121	416 169[r]
1977	574 558	443 763
1978[p]	579 000	420 959

Source: Statistics Canada.
[1] Producers' shipments.
[p] Preliminary; [r] Revised.

An extensive body of nepheline syenite outcrops in the Bancroft area of Ontario. Small tonnages of this material were mined from 1937 to 1942, but the product proved unacceptable because of considerable variation in the nepheline content and an over-abundance of iron-bearing accessory minerals. Tontine Mining Limited (now Coldstream Mines Limited) discontinued exploration work in 1971 on a large nepheline syenite intrusive located near Port Coldwell, Ontario, after obtaining discouraging results from petrologic and metallurgical studies.

Nepheline syenite occurs in several localities in southern British Columbia, notably in the Ice River area, near Field, and in the Big Bend area on the Columbia River.

Nepheline is a common mineral constituent in the alkaline complexes of northern Ontario and southern Quebec, but none of these deposits is, as yet, of economic significance.

Feldspar is the major mineral constituent of pegmatite dykes, which are widely distributed in Canada. Any large deposit near potential markets warrants investigation. Feldspar accompanied by byproduct silica can also be produced from granitic rocks of suitable composition by flotation.

Markets

In 1978, 73 per cent of Canada's nepheline syenite output was exported. Sales to the United States decreased 5 per cent to 395 258 tonnes, and accounted for 93 per cent of exports. Offshore sales were 26 000 tonnes, sustaining the high level reached last year. The United Kingdom and Italy together imported 21 000 tonnes of the offshore total.

Domestic shipments increased 20 per cent to an estimated 158 000 tonnes in 1978. Of this, about 70 per cent was used in glass and glass fibre manufacture.

In the glass industry, 15 to 20 per cent by weight of the glass batch is nepheline syenite. Material with a size range of minus 30 mesh to plus 200 mesh and with an iron content of less than 0.1 per cent is required in the production of flintglass. An iron content as high as 0.6 per cent, expressed as Fe_2O_3, is allowable for the manufacture of coloured glass. A typical chemical analysis for high-quality nepheline syenite produced in Canada for glass manufacture is:

Silica SiO_2	–	60.00
Alumina Al_2O_3	–	23.60
Iron Fe_2O_3	–	0.07
Lime CaO	–	0.30
Magnesia MgO	–	0.10
Potash K_2O	–	5.30
Soda Na_2O	–	10.20
Loss-on-ignition	–	0.50

A growing market is developing for finely ground material in the whiteware industry. The finer grades used for ceramic applications are produced by reducing the basic minus 30 mesh material in pebble mills. In ceramics, nepheline syenite is used as both a body and a glaze ingredient. High-purity material in the minus 200 to plus 375 mesh size and with an iron content of 0.07 per cent Fe_2O_3, or less, is most frequently used. Products utilizing this material include bathroom fixtures, vitreous enamels for appliances, china, ovenware, electrical porcelain and ceramic artwares.

Very finely ground material is being used increasingly as a filler in plastics, foam rubber and paints. Fine-grinding down to 10 microns is accomplished in pebble and fluid-energy mills. The very fine grain size, high reflectance and low oil absorption are important physical characteristics which make nepheline syenite an excellent filler material in the above products, and in vinyl, and floor and wall tile.

A low-grade nepheline syenite is sold in bulk for use in the manufacture of fibre glass and for glazing on brick and

Table 3. Canada, estimated feldspar consumption, 1976 and 1977

	1976	1977
	(tonnes)	
Consumption[1]		
Whiteware	3 911	3 796
Other products[2]	142	475
Total	4 053	4 271

Source: Statistics Canada.
[1]Breakdown by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa. [2]Includes porcelain enamel, artificial abrasives and other minor uses.

tile. Some material with high iron content is used in the manufacture of mineral wool, and as an aggregate.

Substitution of alternative materials for feldspar in ceramic manufacture has been less severe than in the manufacture of glass. The principal reason is that raw material costs are low in the ceramic industry in relation to total manufacturing costs, and manufacturers adopt a new raw material only after cautious trial use. Further, while the higher alumina content of nepheline syenite has been a decisive factor in the replacement of feldspar in glass manufacture, a high alumina content is less critical in ceramic manufacture. In ceramics, potash feldspar is used to bind the ceramic mix into what the industry terms a "body", and in the manufacture of electric porcelain for high voltage purposes, this mineral is essential. The domestic market for feldspar appears to be firm at around 4 000 to 5 000 tonnes per year.

Table 4. Canada, feldspar production, trade and consumption, 1965, 1970 and 1975-78

	Production[1]	Exports	Consumption
		(tonnes)	
1965	9 892	3 398	7 564
1970	9 667	. .	6 840
1975	—	. .	5 630
1976	—	. .	4 053
1977	—	. .	4 271
1978[p]	—	. .	. .

Source: Statistics Canada.
[1]Producers' shipments.
[p]Preliminary; — Nil; . . Not available.

World review

The Norsk Nefelin Division of Christiania Spiegerwerk is western Europe's only producer of nepheline syenite. Operations at the plant, near Hammerfest in northern Norway, began in 1961 and increased steadily from an output of 23 000 tonnes in 1963 to 200 000 tonnes in 1973. The latest expansion, completed in 1973, raised capacity from 175 000 to 225 000 tonnes per year. The lenticular deposit is about 2 km long and at least 250 metres (m) deep. Unlike Canadian producers, Norsk Nefelin mines underground, drilling and blasting by conventional techniques. Nepheline syenite is supplied to the glass, ceramic and enamel industries in two main grades; glass grade is about 28 Tyler mesh, and ceramic grade is 200 Tyler mesh. The finer-mesh, ceramic-grade material is usually shipped in bags, whereas the coarser glass-grade is shipped in bulk to European markets. The company employs a modern fleet of "coasters" on long-term charter, and ships finished products to storage and distribution centres in major market areas. Exports declined from 218 100 tonnes in 1976 to 196 300 tonnes in 1977 and remained around this level in 1978.

Nepheline syenite is an important source of alumina for aluminum production in the U.S.S.R. Very large deposits occur near Kirovsk in the Kola Peninsula and also in the Lake Baikal region of Siberia. The Kola deposits were first mined in the 1930s for phosphate. Byproduct nepheline that contains 30 per cent Al_2O_3 is recovered for use in aluminum production. In the process used to extract alumina, limestone is added to the nepheline concentrates and the mix is sintered and treated with caustic soda to yield anhydrous alumina, soda, potash and cement. Elsewhere in the world, rising bauxite prices and concern about raw material supply have stimulated research into alternative domestic sources of alumina, such as nepheline and anorthosite.

Feldspar still retains a major share of its traditional markets outside North America, although Norwegian nepheline syenite has been making headway in these markets. World production of feldspar in 1977 is an estimated 2.7 million tonnes.

Table 5. World production of feldspar, 1977 and 1978

	1977	1978[e]
	(tonnes)	
United States	666 000	708 000
West Germany	431 000	426 000
Italy	221 000	218 000
France	195 000	191 000
Sweden	45 000	45 000
Japan	43 000	45 000
Norway	40 000	36 000
Other countries	1 121 000	1 125 000
Total	2 762 000	2 794 000

Source: U.S. Bureau of Mines, Mineral Commodity Summaries, January 1979.
[e]Estimated.

Outlook

The outlook for nepheline syenite continues to be moderately good, although the world economy has not recovered from the recession. Housing starts in Canada and the United States are down and a longer-term outlook on the basis of population growth suggests a slower than normal rate of housing construction. This industry, of course, is a major consumer of glass, sanitary-ware, paint, etc. Canadian shipments offshore, mainly to Europe have, in the last two years, returned to pre-1970 levels. This is believed to be because of undercapacity at Norsk Nefelin's plant. The scope for increasing Canadian sales to Europe and elsewhere is improving as energy prices rise, thereby increasing the attractiveness of using nepheline syenite over feldspar in glass.

Over the last several years, the market for micronized material used as a filler and extender in plastics, paint, rubber and paper has grown more rapidly than consumption for glassmaking, and further diversification and growth of these markets is expected. Norway does not produce these finely ground grades.

The phenomenal growth rate enjoyed by the nepheline syenite industry during the 1950s and early 1970s has moderated as markets formerly supplied by feldspar approach saturation. Since 1970, average growth has been 4 per cent. With the recovery of the glass industry and continued expansion of other uses, a growth rate of 5 per cent a year is anticipated for the medium-term. Energy conservation considerations in glass and ceramics manufacture should maintain this growth rate into the long-term.

With increasing requirements for electrical energy, the demand for feldspar, essential in high voltage porcelain, could elevate this raw material to a position of prime importance. Notwithstanding the present slackness in the economy, supply for this purpose remains tight. Rising prices and growing markets could provide an opportunity to develop a suitable Canadian deposit in the near future.

Prices

Nepheline syenite prices vary from about $Cdn. 7.00 per tonne for low-purity, crushed rock in bulk, to over $Cdn. 40.00 per tonne for high-purity products. The price of nepheline syenite used in the glass industry is around $Cdn. 20.00 per tonne fob plant. The largest export market is the United States, where entry is duty free.

United States feldspar prices in U.S. currency as quoted in "Engineering and Mining Journal", January 1979

(per short ton, fob mine or mill, carload lots, depending on grade)

North Carolina	($)
40 mesh, flotation	32.50
20 mesh, flotation	21.75
200 mesh, flotation	48.00
Georgia	
200 mesh	43.50-47.00
40 mesh, granular	31.00-32.50
Connecticut	
200 mesh	36.75
20 mesh, granular	27.50

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
29600-1	Feldspar, crude	free	free	free	free
29625-1	Feldspar, ground but not further manufactured	free	7½%	30%	free
29640-1	Ground feldspar for use in Canadian manufactures	free	free	30%	free

United States

Item No.		
522.31	Crude feldspar	free
522.41	Feldspar, crushed, ground or pulverized	3.5% ad valorem

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States, Annotated (1978), USITC Publication 843.

Nickel

M.J. GAUVIN

Canada's production of nickel in 1978 was 130 055 tonnes* valued at $652 million, compared with 232 512 tonnes valued at $1 212.6 million in 1977. World mine production, estimated at 610 855 tonnes for 1978, declined about 21 per cent from the 777 912 tonnes produced in 1977. The drop in Canadian and world production reflects the production cutbacks instituted by producers around the world and the effect of strikes, particularly in Canada. During 1978, Canada, normally the world's largest producer of nickel, accounted for only 21.3 per cent of the total, down 8.6 per cent from 1977. The U.S.S.R. with about 22.9 per cent of world production, Australia with about 13.6 per cent and New Caledonia with about 9.8 per cent, together with Canada were the world's largest producers. Consumption of nickel in the non-communist world was about 525 000 tonnes in 1977, some 13 per cent above the 1977 level.

The upturn in demand in 1978, coupled with production curtailments by most producers, reduced producer inventories from about 390 000 tonnes at the end of 1977 to a more manageable 275 000 tonnes at the end of 1978, or about 6 months supply at 1978 consumption rates.

Prices were weak during the year, discounting from list price was the standard procedure as producers competed to maintain or increase market share.

Canadian operations and developments

Four companies mined nickel ore in Canada during 1978 The largest producer was Inco Limited, which operated mines in Ontario and Manitoba. Falconbridge Nickel Mines Limited, the second-largest producer, treated ores from its mines located in Ontario. Inco and Falconbridge each have integrated mine-concentrator-smelter and refinery complexes where they process ore to the metal stage. The two other concentrate producers, Noranda Mines Limited and Union Minière Explorations and Mining Corporation Limited (UMEX), operated mines in Ontario.

Inco Limited is the world's largest producer of nickel. In 1978 it produced 121 110 tonnes of finished primary nickel products, compared with 189 150 tonnes in 1977 and 209 562 tonnes in 1976. Planned production cutbacks, begun in 1977, continued during the year and a strike at the company's Sudbury operations further reduced output. The strike began on September 16, 1978 and continued beyond the end of the year. In Ontario, the company operated nine mines, three concentrators, two smelters and a nickel refinery in the Sudbury district; a mine and concentrator at Shebandowan, northwestern Ontario and a nickel refinery and additive plant at Port Colborne. In Manitoba, Inco operated two mines, one concentrator and a smelter and refinery at Thompson. In Ontario, the Copper Cliff North and Crean Hill mines and the Levack concentrator were placed on standby in the first half of the year. In Manitoba, work at the Birchtree mine was concentrated mainly on development and the underground portions of the Pipe mine were placed on standby. In addition, the Totten and Murray mines in Ontario and the Soab in Manitoba were maintained on standby. The proven ore reserves of the company in Canada are 360 million tonnes of ore, containing 6.0 million tonnes of nickel and 3.8 million tonnes of copper.

Adverse market conditions coupled with increasing inventories of finished nickel products forced the company, starting in the last half of 1977, to institute a series of major production and employment cutbacks. In February 1978, 650 jobs were eliminated at Thompson, Manitoba and 2 800 were eliminated at Sudbury. In addition, production was suspended during the summer for six weeks at Sudbury and Port Colborne, for four weeks at the Shebandowan mine and for two weeks at Thompson. Operations at Shebandowan were also reduced from two shifts to one. The company's overseas operations were also scaled down.

Falconbridge Nickel Mines Limited operated four mines, two concentrators and one smelter in the Sudbury area of Ontario. Four mines, the East, North, Onaping and Lockerby, and the Fecunis concentrator are temporarily closed and on standby. Some development work was completed in the Fraser mine. The new smelting and acid plant facilities at Sudbury became operational in mid-1978, at a total cost of about $79 million.

The reduction of the work force and production at Falconbridge followed a similar pattern to that at Inco. In December 1977, the company announced a seven-week shutdown of all operations during the summer of 1978, and a further reduction of 750 jobs effective April 1, 1978. These

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, nickel production, trade and consumption, 1977 and 1978

	1977		1978ᵖ	
	(tonnes)	($)	(tonnes)	($)
Production[1]				
All forms				
Ontario	179 995	927 518 355	97 396	489 616 000
Manitoba	52 517	285 049 723	32 659	162 424 000
Total	232 512	1 212 568 078	130 055	652 040 000
Exports				
Nickel in ores, concentrates and matte[2]				
United Kingdom	41 113	213 512 000	16 987	86 735 000
Norway	35 126	139 552 000	22 091	75 976 000
Japan	4 303	19 008 000	—	—
United States	4	6 000	—	—
Total	80 546	372 078 000	39 078	162 711 000
Nickel in oxide				
United States	16 599	73 786 000	21 321	92 831 000
EEC	12 362	57 762 000	4 237	20 680 000
Other countries	6 044	26 672 000	2 234	10 550 000
Total	35 005	158 220 000	27 792	124 061 000
Nickel and nickel-alloy scrap				
United States	1 266	3 740 000	1 970	6 658 000
Italy	538	2 634 000	126	643 000
South Korea	70	326 000	116	533 000
Japan	73	249 000	49	89 000
Other countries	261	196 000	47	100 000
Total	2 208	7 145 000	2 308	8 023 000
Nickel anodes, cathodes, ingots, rods				
United States	50 153	239 051 000	74 244	337 106 000
EEC	17 622	83 758 000	18 786	85 883 000
Other countries	6 854	32 824 000	12 636	59 808 000
Total	74 629	355 633 000	105 666	482 797 000
Nickel and nickel alloy fabricated material, nes				
United States	12 165	70 427 000	11 975	66 694 000
South Africa	359	2 065 000	782	5 217 000
United Kingdom	814	3 928 000	984	4 606 000
Belgium-Luxembourg	6	31 000	254	1 180 000
Japan	97	502 000	192	996 000
Australia	135	658 000	149	685 000
Other countries	795	3 693 000	518	2 636 000
Total	14 371	81 304 000	14 854	82 014 000
Imports				
Nickel in ores, concentrates and scrap				
Australia	10 983	36 186 000	16 502	19 621 000
United Kingdom	10 223	6 052 000	9 968	6 333 000
United States	8 855	9 134 000	4 687	3 831 000
Japan	1 408	4 897 000	—	—
Other countries	1 346	1 448 000	722	1 167 000
Total	32 815	57 717 000	31 879	30 952 000

Table 1. (cont'd)

	1977		1978^p	
	(tonnes)	($)	(tonnes)	($)
Nickel anodes, cathodes, ingots, rods				
United States	258	1 161 000	1 113	3 890 000
Norway	2 089	10 706 000	246	1 285 000
Netherlands	—	—	60	282 000
West Germany	56	14 000	20	154 000
Other countries	3	29 000	4	34 000
Total	2 406	11 910 000	1 443	5 645 000
Nickel alloy ingots, blocks, rods and wire bars				
United States	549	2 912 000	519	3 311 000
Dominican Republic	—	—	2 000	3 282 000
Belgium-Luxembourg	26	108 000	29	126 000
Other countries	8	66 000	27	123 000
Total	583	3 086 000	2 575	6 842 000
Nickel and alloy plates, sheet, strip				
United States	2 091	15 967 000	2 254	16 455 000
West Germany	334	2 277 000	446	2 177 000
United Kingdom	11	52 000	31	132 000
Other countries	1	8 000	20	103 000
Total	2 437	18 304 000	2 751	18 867 000
Nickel and nickel alloy pipe and tubing				
United States	1 425	11 544 000	1 341	13 673 000
West Germany	354	5 481 000	177	3 278 000
Sweden	54	1 393 000	22	736 000
Other countries	—	—	6	35 000
Total	1 833	18 418 000	1 546	17 722 000
Nickel and alloy fabricated material, nes				
United States	446	4 622 000	388	3 328 000
Norway	4	34 000	163	856 000
United Kingdom	41	395 000	55	467 000
West Germany	198	172 000	30	259 000
Other countries	12	85 000	34	178 000
Total	701	5 308 000	670	5 088 000
Consumption[3]	9 033	..	..	..

Source: Statistics Canada.
[1] Refined nickel and nickel in oxides and salts produced, plus recoverable nickel in matte and concentrates exported. [2] For refining and reexport. [3] Consumption of nickel, all forms (refined metal and in oxides and salts) as reported by consumers.
[p] Preliminary; — Nil; .. Not available; nes Not elsewhere specified.

Table 2. Canada, nickel production, trade and consumption, 1960, 1965, 1970 and 1975-78

	Production[1]	Exports				Imports[2]	Consumption[3]
		In Matte etc.	In Oxide Sinter	Refined Metal	Total		
				(tonnes)			
1960	194 505	67 050	12 027	98 293	177 370	1 598	4 410
1965	235 126	74 686	37 154	122 649	234 489	11 042	8 096
1970	277 490	88 805	39 821	138 983	267 609	10 728	10 699
1975	242 180	84 391	38 527	91 164[r]	214 082	12 847	11 308
1976	240 825	72 688	47 958	87 935[r]	208 581	16 829	9 972
1977	232 512	80 546	35 005	74 629	190 180	2 406	9 033
1978[p]	130 055	39 078	27 792	105 666	172 536	1 443	. .

Source: Statistics Canada.
[1] Refined metal and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates exported. [2] Refined nickel, comprising anodes, cathodes, ingots, rods and shot. [3] Consumption of nickel, all forms (refined metal, and in oxides and salts), as reported by consumers.
[p] Preliminary; . . Not available; [r] Revised.

actions reduced production to about 50 per cent of capacity.

The collective agreement between the company and its employees at Sudbury expired during the year and a new three-year agreement was signed in November. It provided a 10 cent an hour wage increase and contains reopening clauses for monetary items in the second and third years of the agreement.

Major cutbacks were also effected at the company's Dominican Republic and Norway operations. The company's ore reserves at Sudbury were reported as 71 million tonnes of ore, containing 1.1 million tonnes of nickel and 554 000 tonnes of copper.

Sherritt Gordon Mines Limited produced about the same amount of refined nickel as in 1977. The refinery operated at 70 per cent of capacity. Sherritt signed a long-term agreement with Inco Metals Company to purchase nickel feed for the refinery, replacing feed from Australian mines no longer in operation.

The Langmuir nickel mine in Ontario, jointly owned by Inco and Noranda Mines Limited, ceased operations in March because of the depletion of economical ore reserves.

Union Minière Explorations and Mining Corporation Limited (UMEX) continued production at its Thierry deposit near Pickle Lake, Ontario, at a reduced rate of about 60 per cent of capacity. The Thierry ore reserves contain a minor amount of nickel which is recovered in the copper concentrate.

The syndicate of Teck Corporation, Metallgesellschaft Canada Limited and Domik Exploration Limited completed the feasibility study on their nickel-copper deposit in Montcalm Township, Ontario. Further development was deferred until nickel markets recover. The orebody contains indicated reserves, to a depth of 400 metres (m), of 4.5 million tonnes grading 1.41 per cent nickel and 0.66 per cent copper.

Uranerz Exploration and Mining Limited continued work on its uranium-nickel discoveries at Key Lake in northern Saskatchewan. One of the partners in the project, Inexco Mining Company, sold its one-third interest in the property to the provincial Crown corporation, Saskatchewan Mining Development Corporation (SMDC), who in turn sold part of this holding to the federal Crown corporation, Eldorado Resources Limited, a wholly-owned subsidiary of Eldorado Nuclear Limited. Ownership of the project now is Uranerz Exploration, the project manager-operator, with 33.33 per cent; Eldorado, with 16.66 per cent; and SMDC with 50 per cent. The companies expect to be producing nickel at a rate of 2 500 tonnes per year starting in 1983.

World developments

All major producers in the non-communist world were forced to institute cost and production cutbacks in 1978. These restraint measures coupled with improved demand and strike actions eased the burdensome level of producer inventories from about 375 000 tonnes at the end of 1977 to about 275 000 tonnes at the end of 1978. At year-end, the world industry operated at a capacity utilization rate of just above 60 per cent.

Several Australian mines (Scotia, Carr Boyd, Fisher and Windarra) were closed or placed on standby and the Greenvale mine of Freeport Minerals Company and Metals Exploration N.L. underwent its third financial reorganization in four years of operation. Western Mining Corporation Limited commissioned a new flash smelter at Kalgoorlie, Western Australia, with a capacity of 450 000 tonnes of concentrates per year. The smelter has been designed to treat a wide range of nickel concentrates. The $100 million Agnew mine in Western Australia, jointly owned by Selection Trust Limited, with 60 per cent interest, and M-I-M Holdings Ltd., with 40 per cent, was officially opened in early November. The mine, with sulphide reserves of 45 million tonnes grading 2.05 per cent nickel, will initially produce about 9 000 tonnes of nickel per year contained in concentrates. The concentrates will be toll-smelted by Western Mining Corporation Limited and the matte shipped to the AMAX refinery at Port Nickel,

Table 3. Producing Canadian nickel mines, 1978 and (1977)

Company and Location	Mill or Mine Capacity	Grade of Ore: Nickel	Grade of Ore: Copper	Ore Produced	Contained Nickel Produced	Remarks
	(tonnes ore/day)	(%)	(%)	(tonnes)	(tonnes)	
Ontario						
Falconbridge Nickel Mines Limited	12 790	..	..	2 071 124	32 360[1]	North and Lockerby mines and
Falconbridge, Strathcona,	(12 790)	(..)	(..)	(2 599 111)	(14 536)	Fecunis concentrator temporarily
East, North, Onaping and	2 720	(Falconbridge)				closed during the year and on
Lockerby mines,	7 710	(Strathcona)				standby.
Falconbridge	2 360	(Fecunis Lake)				
Inco Limited	69 300	..	..	7 748 515[3]	121 246[4]	Copper Cliff North, Crean Hill,
Coleman, Copper Cliff North,	(69 300)	(1.41)[2]	(0.98)[2]	(14 798 481)[3]	(141 667)[4]	Creighton No. 3 mines and Levack
Copper Cliff South, Crean Hill,	31 800	(Clarabelle)				concentrator on standby.
Creighton, Frood-Stobie, Garson,	21 800	(Frood-Stobie)				
Levack, Levack West, and	5 400	(Levack)				
Little Stobie mines	10 300	(Creighton)				
Sudbury						
Shebandowan Mine	2 270	..	..	See above[3]	See above[4]	
Shebandowan	(2 270)	(..)	(..)	(See above)[3]	(See above)[4]	
Noranda Mines Limited	635	1.39	..	65 427	637	Mine closed in March 1978.
Langmuir Township	(635)	(1.22)	(0.05)	201 999	2 443	
Union Minière Explorations and	3 600	0.13	1.29	921 663	185	Mine continued operating below
Mining Corporation Limited (UMEX)	(3 600)	(0.13)	(1.26)	(875 815)	(177)	capacity because of depressed
Thierry mine						copper markets.
Pickle Lake						
Manitoba						
Inco Limited	12 700	..	..	2 139 900	See above[4]	Development work only at the
Birchtree, Pipe, Thompson	(12 700)	(See above)[2]	(See above)[2]	(2 982 522)	(See above)[4]	Birchtree mine. The Soab and
and Soab mines						underground portion of the Pipe
Thompson						mine on standby.

Sources: Company annual reports and data provided by companies.
[1]Total nickel deliveries. [2]Includes Manitoba Division. [3]Includes Shebandowan. [4]Total nickel production.
.. Not available.

Table 4. Prospective Canadian nickel mines

Company and Location	Mill Capacity and Ore Grade	Year Production Expected	Destination of Nickel Concentrates	Remarks
	(%)			
Quebec				
Renzy Mines Limited,	900	. .	. .	Surface buildings destroyed by fire
Hainault Township	Ni (0.69)			in 1974, will have to be rebuilt.
	Cu (0.72)			
Ontario				
Falconbridge Nickel Mines	. .		Falconbridge	
Limited, Falconbridge	Ni (. .)			
East mine	Cu (. .)			Placed on standby, 1976.
Fraser mine				Development continuing at reduced rate.
Onaping mine				Placed on standby, 1976.
Onex mine				Development deferred.
Thayer Lindsley mine				Development deferred.
North mine				Placed on standby, 1978.
Lockerby mine				Placed on standby, 1978.
Inco Limited,	. .		Sudbury	
Sudbury	Ni (. .)			
	Cu (. .)			
Clarabelle mine		. .		Open-pit mining finished in 1974. Mining to be resumed upon development of ore extension.
Copper Cliff North mine		. .		Placed on standby, 1978.
Crean Hill mine		. .		Placed on standby, 1978.
Levack East mine		. .		Development deferred.
Murray mine		. .		Placed on standby, 1971.
Totten mine		. .		Development suspended, on standby.
Fecunis mine				Acquired in an exchange from Inco, on standby.
Great Lakes Nickel	66 million tonnes reserves			Development to bring property on
Limited,	Ni (0.20)		. .	at a rate of 2.25 million tonnes of
Pardee Township	Cu (0.40)	. .		ore per year have been suspended and the project put on standby, 1974.
Teck Corporation,	4.5 million tonnes reserves			Feasibility study completed.
Montcalm Township	Ni (1.4)		. .	Development decision deferred
	Cu (0.66)	. .		pending an improvement in nickel markets.
Manitoba				
Inco Limited,	. .		Thompson	
Thompson	Ni (. .)			
	Cu (. .)			
Birchtree mine		. .		Production suspended and placed on standby, 1977.
Pipe No. 2 mine		. .		Development suspended 1977, on standby.
Soab mine		. .		Placed on standby, 1971.

Table 4. (cont'd)

Company and Location	Mill Capacity and Ore Grade	Year Production Expected	Destination of Nickel Concentrates	Remarks
	(%)			
Saskatchewan				
Uranerz Exploration and Mining Limited Key Lake	Gaertner deposit Ni (2.67) U_3O_8 (2.84) Deilmann deposit Ni (1.21) U_3O_8 (2.11)	1983		Estimated capital cost is $200 million. Gaertner reserves are about 850 000 tonnes. Deilmann reserves are about 1 000 000 tonnes.

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
. . Not available.

Table 5. Prospective world nickel producers

Country Company Mine	Annual Capacity	Announced Date of Production	Destination of Concentrates	Remarks
	(tonnes)			
Brazil				
Cia Niquel Toncantins Niquelandia district	5 000	1980	Own smelter	Delayed from 1978.
Codemin Niquelandia district	5 000	1981	Own smelter	Anglo-American has minority interest in project.
Cia Vale do Rio Doce Piaui State	10 000	. .	Own smelter	Company plans to build a smelter near the ore deposit – 20 million tonnes grading 1.7 per cent nickel.
Colombia				
Cerro Matosa SA Cerro Matosa deposit	22 500	1982	Own smelter	A consortium of the state-owned Empressa Colombiana de Niquel. The Hanna Mining Company and Billiton NV started construction early in 1979.
Cuba				
Cuban Government Cuban deposits	30 000 60 000	1980 1985	Own smelter Own smelter	Three new plants, each of 30 000 tonnes capacity are to be brought into production by 1985.
Greece				
Société Minière et Métallurgique de Larymna S.A. (Larco) Larymna area	12 400	1980	Own smelter	Expansion from current level of 16 200 tonnes per year.

Table 5. (cont'd)

Country Company Mine	Annual Capacity	Announced Date of Production	Destination of Concentrates	Remarks
	(tonnes)			
Indonesia				
P.T. International Nickel Indonesia Soroako deposit Sulawesi Island	30 000	1979	Own smelter	The first stage was completed in late 1977, but technical problems may delay the second stage.
P.T. Pacific Nikkel Indonesia Gag Island Irian Barat	50 000	1985	Own smelter	U.S. Steel will be the operator.
New Caledonia				
SLN	20 000	1985	Own smelter	The Doniambo plant is being expanded from 70 000 tonnes.
AMAX and Bureau de Recherches Géologiques et Minières (BRGM) Tiebaghi deposit	30 000	1985	Own smelter	
Yugoslavia				
Feni-Ruduici Kavadarci	19 000	1984	Own smelter	Will produce ferronickel with 25 to 40 per cent nickel content. Cost of U.S.$187 million.
Projmetal Kasovo Mitrovica	28 500	1980	Goles smelter Rzanovo smelter	Two smelters being built at cost of U.S.$92 million to treat ore from Kasovo mine – 20 000 tonnes of output for export market.

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
. . Not available.

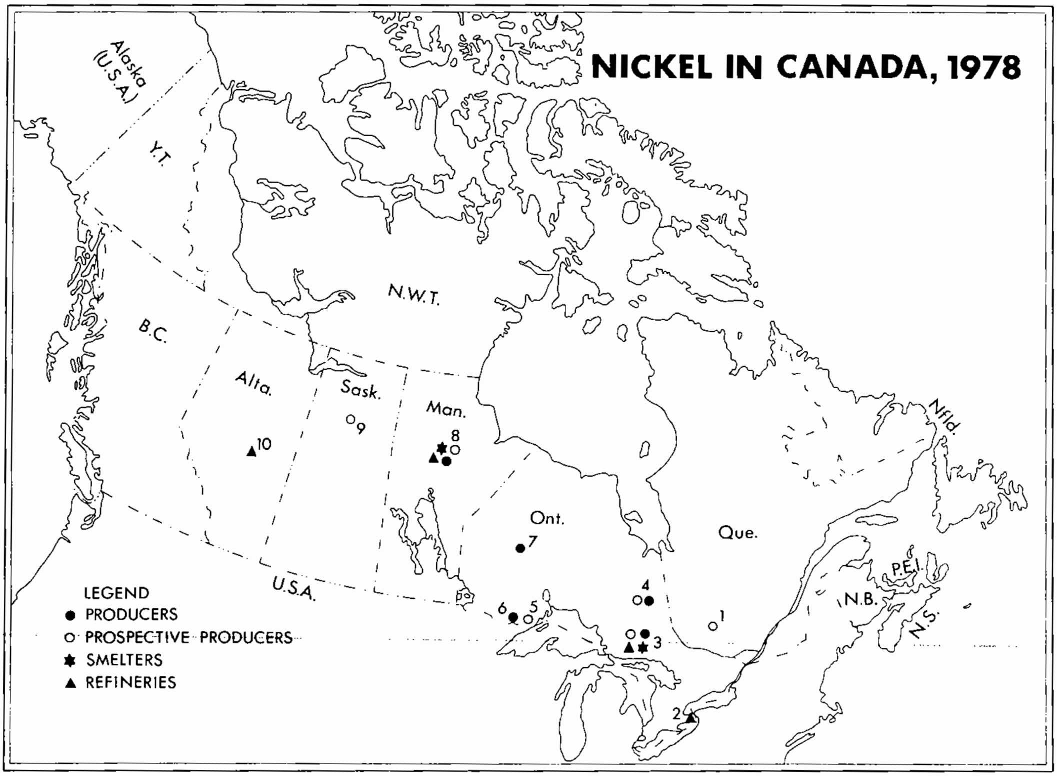
Louisiana. All output for the first ten years of production, up to 15 000 tonnes of nickel per year, has been sold to AMAX Inc. in the United States.

The two new overseas operations of Inco Limited in Indonesia and Guatemala both suffered technical problems in 1978. Start-up problems with Stage I of the P.T. International Nickel Indonesia project limited production to some 4 500 tonnes of nickel contained in matte. Construction of Stage II of the project was essentially completed by the end of the year. The 165-megawatt Larona hydroelectric plant was completed and dedicated in November. On completion of the second stage, annual capacity of the project will be about 45 000 tonnes of nickel contained in a 75 per cent nickel matte. The Guatemalan plant of Exploraciones y Explotaciones Mineras Izabal, S.A. (Exmibal) was shutdown for four months while modifications were made. About 1 800 tonnes of nickel contained in matte were produced. Construction of a fluid-bed roaster and acid plant at Inco's Clydach, Wales, nickel refinery was completed at year-end. The new plant will roast matte from the Guatemalan and Indonesian projects, preparing it for further refining or for sale as a sinter product.

Falconbridge overseas subsidiaries operated at about 50 per cent of capacity in 1978. The Kristiansand refinery in Norway was put on a four-day week and was shutdown for five weeks during the summer. The company's operation at Falconbridge Dominicana C por A was reduced to a single electric furnace line, bringing its operating rate down to 45 per cent of capacity for most of the year.

Société Métallurgique Le Nickel (SLN) reduced its operating rate at its Doniambo, New Caledonia plant to 60 per cent of capacity. A two-month strike reduced output further and production fell to 37 000 tonnes, compared with 52 000 tonnes in 1977. The company's ore shipments to Japan declined 33 per cent for the year as Japanese smelters cutback their ore purchases from New Caledonia. SLN has also slowed the expansion of its Doniambo plant, which was to have been expanded from 70 000 tonnes to 81 000 tonnes per year by 1980.

Société Métallurgique Le Nickel is an equal partner with AMAX Inc. of the United States in Penamax G.I.E., a French mining company that holds rights in New Caledonia



Producers, prospective producers and smelters, 1978
(numbers refer to locations on map above)

Producers

3. Falconbridge Nickel Mines Limited (Hardy open pit, Falconbridge, Strathcona, and Longvack South)
   Inco Limited (Coleman, Copper Cliff South, Creighton, Frood-Stobie, Garson, Levack, Levack West, Little Stobie and Victoria mines)
4. Noranda Mines Limited (Langmuir)
6. Inco Limited (Shebandowan mine)
7. Union Minière Explorations and Mining Corporation Limited (Thierry mine)
8. Inco Limited (Birchtree, Pipe and Thompson mines)

Prospective Producers

1. Renzy Mines Limited (Hainault Township)
3. Falconbridge Nickel Mines Limited (Lockerby, East, North, Onaping, Fraser, Onex and Thayer Lindsley mines)
   Inco Limited (Clarabelle, Levack East, Murray, Totten, Copper Cliff North and Crean Hill mines)
4. Teck Corporation (Montcalm Township)
5. Great Lakes Nickel Limited (Pardee Township)
8. Inco Limited (Soab mine, Birchtree, Pipe No. 2)
9. Uranerz Exploration and Mining Limited (Key Lake)

Smelters

3. Falconbridge Nickel Mines Limited (Falconbridge)
   Inco Limited (Sudbury)
8. Inco Limited (Thompson)

Refineries

2. Inco Limited (Port Colborne)
3. Inco Limited (Sudbury)
8. Inco Limited (Thompson)
10. Sherritt Gordon Mines Limited (Fort Saskatchewan)

Table 6. World production of nickel, 1977 and 1978

	1977	1978[e]
	(tonnes)	
U.S.S.R.	135 000	140 000
Canada[1]	232 512	130 055
Australia	85 700	82 900
New Caledonia	115 500	60 100
Cuba	37 000	36 000
Philippine Republic	36 800	28 500
South Africa	22 000	22 000
Greece	9 600	16 000
Botswana	11 800	15 800
Indonesia	16 100	15 600
Dominican Republic	24 900	13 300
United States	13 000	12 500
Rhodesia	13 000	12 000
Brazil	5 500	6 000
Other	19 500	20 100
Total	777 912	610 855

Sources: World Bureau of Metal Statistics, April, 1979; Statistics Canada.
[1] Production all forms.
[e] Estimated.

to mineralization estimated at more than 400 million tonnes of 1.37 per cent nickel ore. AMAX and Bureau de Recherches Géologique et Minières, a French Government agency, have agreed to investigate high-grade garnierite nickel deposits in New Caledonia. Feasibility studies are expected to take two to three years.

AMAX Inc. operates a nickel refinery at Port Nickel, Louisiana, with a capacity to produce 36 000 tonnes of nickel briquettes per year. In 1978, the refinery operated at 65 per cent of capacity. AMAX obtained about half its refinery feed from the Selebi-Pikwe project of Bamangwato Concessions Ltd. in Botswana.

Cerro Matosa SA, a consortium in Colombia of the state-owned Empressa Colombiana de Niquel Ltda, with 45 per cent interest; the Hanna Mining Company, with 20 per cent; and Billiton NV, a subsidiary of Royal Dutch Shell, with 35 per cent interest, will bring into production Cerro's northern Colombia laterite deposit in 1982, at a rate of 22 500 tonnes per year of nickel contained in a ferronickel grading 35 to 50 per cent nickel. Hanna will be the operator of the project and the first 20 million tonnes of ore to be mined will have an average nickel content of about 2.7 per cent.

Construction began on a new ferronickel plant at Kavadarci, Yugoslavia. The project's deposits are estimated at 100 million tonnes grading about 1.1 per cent nickel and 32 per cent iron. The project is expected to reach its full annual capacity of 19 000 tonnes of nickel contained in ferronickel by 1984.

New products played a significant role in the fight for market share in 1978 as Inco, SLN, AMAX, Falconbridge, Marinduque Mining and Industrial Corporation and Western Mining have all introduced, or plan to introduce, new product forms. Some nickel companies helped develop new material-handling processes. The new products and handling processes were designed to meet needs in the argon-oxygen-decarburization (AOD) steelmaking process.

Law of the Sea (LOS)

Two sessions of the third United Nations Conference on Law of the Sea were held during the year. Negotiations have been progressing on the form of the regime that would govern the exploration and exploitation of the mineral resources of the deep seabed, principally manganese nodules containing substantial quantities of nickel, copper, cobalt and manganese. Countries with land-based producers of nickel and a number of other countries felt that production from seabed resources should be phased-in to meet growing world consumption. During the spring session, which started in March, in Geneva, an ad-referendum agreement between the Canadian and United States delegations provided the basis for a compromise between producer and consumer interests regarding the phasing-in of seabed mining. Although all producing and consuming countries are not in agreement with the formula, it would allow seabed mining to compete for all the tonnage of world nickel consumption represented by the calculated growth in world nickel consumption for the five years prior to first commercial production, plus 60 per cent of the growth thereafter for 20 years. Negotiations continued on other

Table 7. Actual and projected world capacity[1] to produce finished nickel products, 1974-81

	1974	1975	1976	1977	1978	1979	1980	1981
				(tonnes)				
Europe	134.5	134.5	137.5	137.5	149.0	149.0	157.5	175.5
Africa	32.0	37.0	37.0	37.0	43.0	43.0	43.0	43.0
North America	366.3	366.3	366.3	366.3	342.7	342.7	342.7	347.7
South America	2.7	2.7	2.5	2.5	2.5	2.5	12.5	12.5
Asia	155.2	164.9	172.5	171.8	171.8	182.3	182.3	182.3
Oceania	84.0	94.0	104.0	104.0	104.0	109.0	116.0	136.0
Total	774.7	799.4	819.8	819.1	813.0	828.5	854.0	897.0

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Does not include communist countries, except Yugoslavia and Cuba.

Table 8. United States nickel prices in United States dollars per pound, 1978

	Jan. 1	Jan. 4	May 30	June 22	July 6	Sept. 1	Nov. 16	Dec. 31
AMAX, briquettes	2.06	2.12	2.12	2.12	2.12	2.12	2.12	2.12
Falconbridge, electrolytic	2.08	2.13	2.13	2.08	2.08	2.08	2.08	2.08
Inco, pellets[1]	..	2.10	2.08	2.08	2.08	2.00	1.93	1.93
Falconbridge, ferronickel[2]	2.00	2.10	2.10	2.00	1.90	2.00	1.83	1.83
Hanna, ferronickel[2]	2.34	2.08	2.08	2.08	1.88	1.88	1.88	1.88

Sources: *Metals Week*; *American Metal Market*; Reports by consumers.
[1] Consumer quotations. [2] Per pound of contained nickel.
. . Not available.

important aspects of seabed exploitation such as the terms of contracts, financial arrangements, transfer of technology and the decision-making powers of the Authority.

Uses

Nickel uses have not changed appreciably from the traditional pattern. Resistance to corrosion, high strength over a wide temperature range, pleasing appearance and suitability as an alloying agent are the chief advantages in almost all the uses of nickel.

Stainless steel is the largest single outlet for nickel, followed by nickel plating and high-nickel alloys. Stainless steel use has increased in the field of rapid transit and railway car manufacture, in fertilizer and food processing machinery, in petroleum refining and in architectural applications. High-nickel alloys are used in chemical, marine, electronic, nuclear and aerospace applications.

New end-use markets that will contribute to nickel's consumption growth are nuclear generating plants, gas turbine engines for surface applications, cryogenic containers, pollution abatement equipment, barnacle-resisting, copper-nickel alloy hull-plating for boats and nickel-cadmium batteries for standby power application. Long life, zinc-nickel batteries are being developed to power electric automobiles.

Outlook

World producers are facing several tough operating years ahead. At the end of the year producer inventories, although much lower than a year earlier, were still almost double what is considered normal. Producers must maintain the restraints they adopted a year earlier before a balance can be restored and economic operating levels reestablished. With excess inventories, excess capacity and new capacity coming on stream, it will probably be the mid-1980s before it will be necessary for producers to operate at 85 per cent or more of capacity. As producers reduce inventories, nickel prices are expected to firm and rise to more profitable levels.

The demand for nickel is caught up in the adjustment process that all industrial economies have been going through. The expected slow growth in GNP in the western world will limit capital goods expenditures, a major consumer of nickel. The growth rate of nickel consumption is expected to remain well below its historial trend of 6.0 to 6.5 per cent.

Prices

Producers' attempts to stabilize the nickel-pricing system at the end of 1977 by announcing firm nonnegotiable prices carried over into the first quarter of 1978. However, the combination of weak demand and strong competition for market share worked against this move. During the year there was little or no relationship between listed prices (Inco stopped posting prices in July 1977) and sale prices. Intense competition lead to larger discounts as the year progressed and consumers reported that Class I nickel sold down to \$1.75 per pound. The last half of the year, and particularly the last quarter, was reported as being the period that saw the most intense price competition among producers. In the last two months of the year Sinter 75 was reported as being offered at \$1.78 and ferronickel offered in a range of \$1.78 to \$1.88.

Tariffs

Canada

Item No.		GSP[1]	British Preferential	Most Favoured Nation	General
32900-1	Nickel ores	free	free	free	free
33506-1	Nickelous oxide	10%	10%	15%	25%
35500-1	Nickel and alloys containing 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	free
35505-1	Rods containing 90% or more nickel, when imported by manufacturers of nickel electrode wire for spark plugs, for use exclusively in manufacture of such wire for spark plugs in their own factories	free	free	free	10%
35510-1	Metal alloy strip or tubing, not being steel strip or tubing, containing not less than 30% by weight of nickel and 12% by weight of chromium, for use in Canadian manufactures	free	free	free	20%
35515-1	Nickel and alloys containing 60% by weight or more of nickel, in powder form	free	free	free	free
35520-1	Nickel or nickel alloys, namely: matte, sludges, spent catalysts and scrap and concentrates other than ores	free	free	free	free
35800-1	Anodes of nickel	free	free	free	10%
37506-1	Ferronickel	free	free	5%	5%
44643-1	Articles of nickel or of which 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 in own factories	6½%	10%	10%	20%

United States

Item No.		On and after January 1, 1978
419.70	Nickel chloride	5%
419.72	Nickel oxide	free
419.74	Nickel sulfate	5%
419.76	Other nickel compounds	5%
423.90	Mixtures of two or more inorganic compounds in chief value of nickel oxide	free
426.58	Nickel salts: acetate	5%
426.62	Nickel salts: formate	5%
426.64	Nickel salts: other	5%
601.36	Nickel ore	free
603.60	Nickel matte	free

607.25	Ferronickel	free
620.03	Unwrought nickel	free
620.04	Nickel waste and scrap	free
620.08	Nickel plates and sheets, clad	12%
620.10	Other wrought nickel, not cold worked	5%
620.12	Other wrought nickel, cold worked	7%
620.16	Nickel, cut, pressed or stamped to nonrectangular shapes	9%
620.20	Nickel rods and wire, not cold worked	5%
620.22	Nickel rods and wire, cold worked	7%
620.26	Nickel angles, shapes and sections	9%
620.30	Nickel flakes	5¢ per lb.
620.32	Nickel powders	free
620.40	Pipes, tubes and blanks, not cold worked	3%
620.42	Pipes, tubes and blanks, cold worked	4%
620.46	Pipe and tube fittings	9%
620.47	If Canadian article and original motor vehicle equipment	free
620.50	Electroplating anodes, wrought or cast, of nickel	5%
642.06	Nickel wire strand	7%
657.50	Articles of nickel, not coated or plated with precious metal	9%

Sources: Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1978), ITC Publication 843.

[1]GSP – Generalized System of Preferences extended to all beneficiary developing countries; some GSP rates are subject to quotas or withdrawals.

Phosphate

G.S. BARRY

World fertilizer demand increased in 1978 for the third consecutive year and sales of phosphate rock showed a significant rise. Production and apparent consumption were almost at balance at about 120.0 million tonnes*. Export sales increased by 4 per cent to 51.5 million tonnes and sales within the United States, the world's largest producer, increased by 3.8 per cent to 34.7 million tonnes. About one quarter of United States (domestic) shipments of phosphate rock in 1978 was processed into phosphoric acid and fertilizer compounds for export.

Phosphate is a term applied to a rock, mineral, or salt containing one or more phosphorous compounds. About four fifths of the world's phosphate consumption is used for agriculture, largely as fertilizers. World demand for phosphate rock expanded at unprecedented rates from 1963 to 1967 to meet the needs of a rapidly developing phosphate fertilizer industry. The demand eased considerably between 1968 and 1971 because of overcapacity in the industry, resulting in decreased prices and because of a lessening in demand for fertilizer, arising from lower farm product prices. A worldwide food shortage that assumed serious proportions during 1970 and 1971 carried through to 1974. This shortage was accompanied by higher food prices and a sharp increase in the demand for fertilizers, including phosphates. The unprecedented explosion in prices during 1974 and 1975 resulted in a rapid drop in demand in spite of an increased need for fertilizer application to boost food production. Sales did not recover to the 1974 high level until 1977.

In Canada, imports of phosphate rock, which declined between 1975 and 1977, rose to 2 961 362 tonnes, or an increase of 25 per cent in 1978. The value of imports was $76 202 000. In terms of unit value, the price rose by 10 per cent from $23.49 per tonne in 1977 to $25.82 per tonne in 1978.

Phosphate rock

Phosphate rock contains one or more suitable phosphate minerals, usually calcium phosphate, in sufficient quantity for use either directly or after beneficiation in the manufacture of phosphate products. Sedimentary phosphate rock, or phosphorite, is the most widely used phosphate raw material; apatite, which is second in importance, occurs in many igneous and metamorphic rocks and can be represented by the formula $Ca_5(PO_4)_3$ (F,C1,OH). Other sources of phosphate include guano and a basic slag byproduct of some steelmills. Phosphate rock can be decomposed by three methods: acid treatment, thermal reduction, or thermal treatment without reduction. Canadian phosphate producers use the first two methods.

Phosphate rock is graded either on the basis of its P_2O_5 equivalent (phosphorus pentoxide) or its $Ca_3(PO_4)_2$ content (tricalcium phosphate of lime or bone phosphate of lime — TPL or BPL). For comparative purposes, 0.458 unit P_2O_5 equals 1.0 unit BPL, and 1 unit of P_2O_5 contains 43.6 per cent phosphorus.

Occurrences in Canada

Although there are numerous occurrences of low-grade phosphate rock in Canada, there is no commercial production. Large quantities of rock are imported, mostly from the United States, for use in the manufacture of agricultural and industrial products sold in the domestic and export markets.

Known Canadian deposits are limited and fall into three main categories: apatite deposits within Precambrian metamorphic rocks in eastern Ontario and southwestern Quebec; apatite deposits in some carbonate-alkaline complexes (carbonatites) in Ontario and Quebec; and Late Paleozoic—Early Mesozoic sedimentary phosphate rock deposits in the southern Rocky Mountains.

The Precambrian metamorphic apatite deposits of Ontario and Quebec occur in pyroxenites as small, irregular, scattered pockets and veins with phlogopite mica and pink calcite. Most of the outcrops are in the Rideau Lakes region of eastern Ontario and the Lievre River area of southwestern Quebec, where many deposits were worked extensively between 1869 and 1900, before low-cost Florida rock entered world markets.

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, phosphate rock imports, 1977 and 1978 and consumption, 1976 and 1977

	1977		1978[p]	
	(tonnes)	($)	(tonnes)	($)
Imports				
United States	2 333 029	54 457 000	2 952 721	76 202 000
Netherlands Antilles	2 398	232 000	2 617	193 000
Morocco	26 203	780 000	6 000	72 000
Israel	—	—	24	1 000
Total	2 361 630	55 469 000	2 961 362	76 468 000
	1976		1977[p]	
Consumption[1] (available data)				
Fertilizer, and stock and poultry feed	1 420 013		1 522 018[e]	
Other [2]	162 848		149 381	
Total	1 582 861		1 671 399	

Source: Statistics Canada.
[1]Breakdown by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa. [2] Includes chemicals, refractory and food processing uses.
[p] Preliminary; — Nil; [e] Estimated.

Carbonatites usually occur as roughly circular plugs intruding older metamorphic rock. In August 1975, International Minerals & Chemical Corporation (Canada) Limited (IMCC) discovered a phosphate deposit in a carbonatite complex in Cargill Township, Ontario. Part of the complex was described in 1967 by the Ontario Department of Mines as being cut by very coarse white calcite veins containing up to 20 per cent apatite.

In 1976 IMCC completed the first-phase feasibility study. The study, based on 190 drillholes, reported reserves of 56 700 000 tonnes grading 20 per cent P_2O_5. Since that year, the property was kept in good standing pending conditions that will make the deposit economic sometime in the late 1980s or early 1990s. Another important apatite-bearing carbonatite is the Nemegos deposit, 24 kilometres (km) southeast of Chapleau, Ontario, held by Multi-Minerals Limited. In 1978 the company reported some 40 million tonnes of mineralized rock of which 5 000 000 tonnes in No. 6 zone averaged 70 per cent titaniferous magnetite and 22 per cent apatite and was suitable for open-pit mining. Apatite also occurs in the Oka deposit 32 km northwest of Montreal; the deposit was mined until 1976 for columbium (niobium) by St. Lawrence Columbium and Metals Corporation.

Sedimentary phosphate beds are fairly common in the Rocky Mountains. Most of the exposures occur along the Alberta-British Columbia border between the International Boundary and Banff. Beds at the base of the Fernie Shale have received considerable attention during recent years.

Canadian phosphate industry

Elemental phosphorus. Elemental phosphorus is produced in Canada by the thermal reduction method, which involves the smelting of phosphate rock with carbon (coke) and a siliceous flux. Coproducts of the process are ferrophosphorus, carbon monoxide and calcium silicate slag. About 9 tonnes of phosphate rock grading 66 to 68 per cent BPL are required to manufacture 1 tonne of phosphorus. Although elemental phosphorus can be used

Table 2. Canada, phosphate rock imports and consumption, 1960, 1965, 1970 and 1975-78

	Imports	Consumption[1]
	(tonnes)	
1960	854 566	809 113
1965	1 537 947	1 457 769
1970	2 240 792	1 720 524
1975	3 282 257	2 095 368
1976	2 241 086	1 582 861
1977	2 361 630	1 671 399[p]
1978[p]	2 961 362	. .

Source: Statistics Canada.
[1] Consumption as reported by industry users.
[p] Preliminary; . . Not available.

for making fertilizers, it is generally used in the manufacture of chemicals, insecticides, detergents and other industrial compounds. There are two plants producing elemental phosphorus in Canada, one in Newfoundland and one in Quebec. Erco Industries Limited commissioned its reconstructed No. 2 furnace at Long Harbour, Newfoundland in mid-1978, restoring its effective capacity to 72 500 tonnes per year. Due to market conditions, Canadian elemental phosphorus plants operated at 60 to 70 per cent capacity during 1978.

Phosphate fertilizers. Phosphate fertilizers are normally produced by decomposing phosphate rock with a strong mineral acid. In Canada only the two most common acidulents, sulphuric acid and phosphoric acid, are used in commercial practice; the former is by far the most common.

Table 3. Western world production of phosphate rock, 1976-78

	1976	1977	1978^p
		(000 tonnes)	
United States	44 670	46 448	49 733
Morocco	15 285	17 027	19 278
Tunisia	3 294	3 614	3 712
Togo	2 068	2 857	2 827
South Africa	1 631	2 403	2 622
Jordan	1 702	1 777	2 223
Nauru	754	1 146	1 999
Senegal	1 580	1 630	1 762
Israel	741	1 232	1 759
Christmas Island	1 037	1 260	1 386
Algeria	820	1 001	1 136
Brazil	465	608	1 094
Total	74 047	81 003	89 531

Sources: British Sulphur Corporation Limited; *Phosphorus and Potassium*.
^{p} Preliminary.

When phosphate rock is treated with sulphuric acid, either single superphosphate or phosphoric acid (correctly named orthophosphoric acid, H_3PO_4) is produced. To produce single superphosphate, the rock is treated with sufficient acid to convert the tricalcium phosphate into water-soluble monocalcium phosphate; the coproduct of the reaction, calcium sulphate, remains in the mixture. Normal raw material requirements to produce 1 tonne of superphosphate, grading 20 per cent P_2O_5 equivalent, are 0.64 tonnes of phosphate rock (70 to 72 per cent BPL) and 0.47 tonnes of sulphuric acid (100 per cent basis).

To produce phosphoric acid, larger quantities of sulphuric acid are added to maintain a fluid slurry that facilitates removal of calcium sulphate by filtering. Filtered acid containing 30 to 32 per cent P_2O_5 equivalent may be used, either directly in the manufacture of phosphate

Table 4. Canada, phosphate fertilizer production, years ended June 20, 1960, 1965, 1970 and 1975-78

	tonnes P_2O_5 equivalent
1960	181 047
1965	339 431
1970	450 308
1975	713 380^r
1976	786 708
1977	692 988
1978[1]	. .

Source: Statistics Canada.
[1] Data no longer available as source publication has been discontinued.
^{r} Revised; . . Not available.

fertilizers, or concentrated by evaporation to as high as 54 per cent P_2O_5 equivalent prior to further use or sale as "merchant acid". Further concentration is less common but may be pursued to produce viscous liquids known as superphosphoric acids.

Typical raw material requirements per 1 tonne P_2O_5 equivalent produced are 3.1 tonnes of phosphate rock (74 to 75 per cent BPL) and 2.6 tonnes of sulphuric acid (100 per cent basis). Also, for every tonne P_2O_5 equivalent produced, about 4.5 tonnes of waste calcium sulphate are generated.

Most of the acid is then neutralized with ammonia to form ammonium phosphate fertilizers. Common grades are 16-20-0 (16 per cent N, 20 per cent P_2O_5 equivalent, and 0 per cent K_2O equivalent), 11-48-0 and 18-46-0. At some plants, phosphoric acid is used to acidulate phosphate rock, in which case the end product is triple superphosphate, normally grading 46 per cent P_2O_5 equivalent.

There are eight phosphoric acid plants in Canada with a combined annual productive capacity of 970 000 tonnes P_2O_5 equivalent. The balance of Canada's P_2O_5 productive capacity, amounting to 18 900 tonnes annually, is produced at two plants capable of producing single and/or triple superphosphate.

Late in 1978, Earth Sciences Inc. (ESI) began construction of a processing plant near Calgary, Alberta, designed to recover uranium oxide from phosphoric acid, which is produced from phosphate rock imported from the United States. Completion is scheduled for 1980. Approximately 45 000 kilograms (kg) of uranium oxide a year will be recovered, using ESI technology, from acid produced by Western Co-operative Fertilizers Limited (WCFL). The two plants are 700 metres (m) apart and the phosphoric acid will be cycled through the ESI plant, then returned to WCFL after the uranium oxide has been extracted.

World developments

Western world phosphate rock producers had a good year, with exports up 7 per cent from 42 728 000 tonnes in 1977

Table 5. Canada, phosphorus and phosphate fertilizer plants, 1978

Company	Plant Location	Annual Capacity[1]	Principal End Products	Basis for H_2SO_4 Supply for Fertilizer Plants
		(tonnes)		
Elemental phosphorus				
Erco Industries Limited	Varennes, Que.	18 000	el ph	
	Long Harbour, Nfld.	72 500	el ph	
Total elemental phosphorus		90 500		
Phosphate fertilizer		(P_2O_5eq.)		
Canada Wire and Cable Limited[2]	Belledune, N.B.	136 000	am ph	SO_2 smelter gas
Canadian Industries Limited	Courtright, Ont.	87 000	am ph	SO_2 pyrrhotite, Copper Cliff
Cominco Ltd.	Kimberley, B.C.	114 000	am ph	SO_2 smelter gas
	Trail, B.C.	76 000	am ph	SO_2 smelter gas
International Minerals & Chemical Corporation (Canada) Limited	Port Maitland, Ont.[3]	118 000	H_3PO_4,ss ts, ca ph	sulphur, SO_2 smelter gas
Green Valley Fertilizer & Chemical Co. Ltd.	North Surrey, B.C.	900	ss	SO_2 smelter gas Trail
Esso Chemical Canada	Redwater, Alta.	218 000	am ph	sulphur
Sherritt Gordon Mines Limited	Fort Saskatchewan, Alta.	48 000	am ph	sulphur
Simplot Chemical Company Ltd.	Brandon, Man.	na	am ph	imports H_3PO_4
Western Co-operative Fertilizers Limited	Calgary, Alta.	100 000	am ph	sulphur
	Medicine Hat, Alta.	73 000		
Total, phosphate fertilizer		970 000		

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1]Revised from company information 1978. [2]Noranda Mines Limited acquired full ownership of Belledune Fertilizer Limited, effective April 1, 1972, name changed to Canada Wire and Cable Limited, June 5, 1972. [3]Operates at less than annual capacity because of environmental restrictions.
el ph Elemental phosphorus; P_2O_5 eq. Phosphorus pentoxide equivalent; am ph Ammonium phosphates; ss Single superphosphate; ts Triple superphosphate; ca ph Food supplement calcium phosphate; na Not applicable, H_3PO_4 is made elsewhere.

to 45 564 000 tonnes in 1978. In addition some 6 million tonnes in trade was ascribed to Eastern European countries.

Morocco. L'Office Cherifien des Phosphates (OCP) sold 17.7 million tonnes of phosphate rock from Morocco and West Sahara in 1978, with the fourth quarter exports at a high of 5.1 million tonnes. Of the above total, some 440 000 tonnes came from stockpiles at FosBuCraa although actual mining was not resumed in West Sahara. For Morocco, 1978 exports were the second highest ever recorded, the peak having been reached in 1974. Of particular significance was a major improvement of the European market to which Morocco exported 11.0 million tonnes in 1978 compared with 9.6 million tonnes in 1977. Through expansion and new operations at four sites, Morocco plans to expand phosphate production to about 20 million tonnes in 1980 and to over 25 million tonnes by 1985.

Morocco's Phosphore I, a 495 000-tonne-per-year P_2O_5 phosphoric acid plant commissioned in 1975, is working well and construction is to begin on a fourth unit of 165 000 tonnes per year capacity, due on stream in 1980-81. Morocco's Phosphore II, which will have a capacity of 495 000 tonnes per year P_2O_5, is also on schedule and will come on stream in 1980. With increasing evidence that sulphur and sulphuric acid will be in very tight supply in the 1980s, Morocco's main problem in full capacity utilization may be the supply of acid.

Table 6. Canada, trade in selected phosphate products, 1977 and 1978

	1977		1978ᵖ	
	(tonnes)	($)	(tonnes)	($)
Imports				
Calcium phosphate				
United States	16 233	4 910 000	17 193	5 818 000
Fertilizers:				
Normal superphosphate, 22% or less P_2O_5				
United States	371	50 000	3 999	513 000
Triple superphosphate, over 22% P_2O_5				
United States	23 074	2 230 000	46 185	5 589 000
Phosphatic fertilizers, nes				
United States	176 588	24 836 000	231 738	39 323 000
Portugal	—	—	3 125	815 000
Israel	162	82 000	513	313 000
Belgium-Luxembourg	249	105 000	664	292 000
France	—	—	36	16 000
Netherlands	1	1 000	—	—
Total	177 000	25 024 000	236 076	40 759 000
Chemicals:				
Potassium phosphates				
United States	1 102	771 000	1 254	1 046 000
West Germany	5	4 000	9	8 000
France	18	12 000	—	—
Total	1 125	787 000	1 263	1 054 000
Sodium phosphate, tribasic				
United States	404	186 000	1 191	234 000
West Germany	—	—	60	29 000
Netherlands	10	2 000	53	21 000
Belgium-Luxembourg	—	—	34	8 000
France	—	—	23	7 000
Taiwan	—	—	5	2 000
Total	414	188 000	1 366	301 000
Exports				
Nitrogen phosphate fertilizers, nes				
United States	391 050	47 934 000	350 479	49 975 000
Pakistan	32 676	4 615 000	111 415	19 924 000
Thailand	84 741	8 796 000	10 291	1 227 000
New Zealand	3 500	575 000	550	57 000
United Kingdom	—	—	49	14 000
Paraguay	113	13 000	21	3 000
Nicaragua	177	29 000	—	—
Total	512 257	61 962 000	472 805	71 200 000

Source: Statistics Canada.
ᵖ Preliminary; nes Not elsewhere specified; — Nil.

United States. The United States exported 13 684 000 tonnes of phosphate rock in 1978, slightly less than in 1977. Exports to Western Europe decreased from 5.2 to 4.5 million tonnes; there was also a decrease from 1.2 to 0.9 million tonnes to Latin America, exports to the rest of the world increased from 7.6 to 8.6 million tonnes. Major progress was made during 1978 in obtaining environment clearance for mine development in a number of localities in Florida, Idaho and North Carolina. Beker Industries Corp. will bring into production a new mine at Soda Spring, Idaho by 1981 with a capacity of 3.3 million tonnes; CF Industries Inc. will begin production, at 1.8 million tonnes per year, at Hardee, Florida; and Phillips Petroleum Company announced that it plans to break ground on a new 3.6-million-tonne-per-year mine in Desoto County in 1980, scheduled for production by 1982. Two other projects in Florida will probably add another 5 million tonnes to annual capacity in the early 1980s. All of these developments will result in production of phosphate rock in the United States rising to the 60-million-tonne-per-year level by 1985.

Table 7. Canada, phosphate fertilizer consumption and trade, years ended June 30, 1960, 1965, 1970 and 1975-78

	Consumption	Imports[1]	Exports[2]
	(tonnes P_2O_5 equivalent)		
1960	139 020	40 860	89 193
1965	266 493	60 422	88 185
1970	280 683	10 245	198 221
1975	501 765	29 976	180 561
1976	502 657	95 310	202 527
1977	503 181	67 522	210 579
1978[3]	. .	. .	. .

Source: Statistics Canada.
[1]Excludes nutrient content of mixtures and of orthosphoric acid. [2]Shipped for export by producers. Includes nutrient quantity of all fertilizer material and mixes. [3]Data no longer available as source publication has been discontinued.
. . Not available.

U.S.S.R. The Soviet Union produces slightly over 24 million tonnes of phosphate rock annually. Production was steady for the last few years and there are no immediate prospects for an increase. Thus the country's exports, mainly to other COMECON countries, are declining. Exports to the West, particularly of the high-grade (86 per cent TPL) rock from the Kola Peninsula, are on a decline. It is difficult to replace this product since only Togo, Senegal and the Christmas Islands have rock approaching this grade (79 to 81 per cent TPL). West European importers are buying phosphoric acid as an alternative. Another source of high-grade phosphate, the BuCraa mine of Western Sahara, is not expected to be back in production before 1980. Some forecasters predict a further decline of 50 per cent in exports of Kola rock over the next two years.

The government of the U.S.S.R. and Occidental Petroleum Corporation put into force an agreement, signed in 1974, under which Occidental is to supply the U.S.S.R. with 1.0 million tonnes per year of 70 per cent P_2O_5 superphosphoric acid for 20 years, starting in 1980. A test shipment of 10 000 tonnes was made in 1978 and about half a million tonnes may be shipped in 1979. On a reciprocal basis the U.S.S.R. will supply Occidental with ammonia, urea, and up to 1 million tonnes of muriate of potash. There are some serious doubts whether production and transport facilities will be ready on time at both ends to meet specified tonnage deadlines.

Togo. This country produced 2.9 million tonnes of phosphate in 1978. Exports of this high-grade material (79 to 81 per cent TPL) found a ready market as it was sought as a replacement to the scarce Kola rock from the U.S.S.R. Production will be expanded to about 3.5 million tonnes per year by 1980.

Jordan. This country produced about 2.3 million tonnes of rock and exported 2.16 million tonnes. Recent modernization and new equipment permitted the increase. Expansion at the El Hasa deposit will allow production to reach 3.0 to 3.5 million tonnes by 1979-80. A new mine and rail link is also being developed at Wadi-El-Abaid that will have an annual capacity of 1.5 million tonnes when completed in the early 1980s.

Mexico. Rofomex plans to start construction on a $200 million, 5-million-tonne-per-year phosphate mine near San Juan, Baja California in the early 1980s.

Israel. Production of about 1.5 million tonnes per year will be increased to about 2.0 million with the commissioning this year of the new Nahal Zin mine. Loading facilities at the port of Ashdod are also being expanded.

Table 8. Phosphate prices — January 1979

Phosrock[1] (fob Tampa per tonne)		OCP[2] (fas per tonne)	
% TPL	$U.S./tonne	% TPL	$U.S./tonne
66	31.00	68/69	35.25 Safi
66/68	33.00	74/75	42.00 Safi
68/70	35.00	70/71	38.00 Casablanca
70/72	37.00	72/73	40.00 Casablanca
73/75	40.00	75/76	42.00 Casablanca
		76/77	43.00 Casablanca

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1]These prices do not include the charge for a severance tax in Florida. [2]Office Cherifien des Phosphates.

Australia. Queensland Phosphate Ltd., a wholly-owned subsidiary of BH South Ltd., started production from the Duchess deposit in 1976. For two years the company experienced troubles with the quality of its phosphate rock and was not able to convince Australian fertilizer manufacturers to perform plant modifications that would allow them to use their product in favour of imports. Finally, after considerable financial losses the company closed the mine in July 1978.

Others. Besides those listed above, a number of other countries have fairly good opportunities to expand production or commence new mining operations in the 1980s. The most important are Brazil, Egypt, Iraq, Peru, Saudi Arabia, Senegal, Tunisia and Turkey. Other smaller prospective producers are listed in the accompanying table.

Trade and prices

Canada imports all of its phosphate rock requirements but exports fertilizers, mainly to the United States. Shipments are also made under the foreign aid program, mainly to countries in southwest Asia. Imports of phosphate rock increased by 26.6 per cent to 2 961 362 tonnes in 1978. Phosphate fertilizer production was 692 988 tonnes P_2O_5 in 1977. In 1978 production was higher, however Statistics Canada no longer compiles these statistics. Imports of phosphate fertilizers increased 43 per cent to 286 260 tonnes, but exports decreased by 8 per cent to 472 805 tonnes.

Table 9. Phosphate, major new projects and expansion programmes

Company	Location	Design Production (ore, unless otherwise stated)	Completion Date	Capital (million)	Type of Operation[1]	Remarks
Bolivia						
ENAF	Unsited	Phosphate			Cn	Davy Powergas feasibility study for plant (possibly Oruro)
Brazil						
Goias Fertilizantes	Catalao, Ouvido, Goias	620 000 tonnes concentrate	1982	$110	P	40% owned by Metago, a state of Goias enterprise. Concentrate: 35% P_2O_5
Fosfatos do Goias (Brazimet/Agrico)	Catalao, Goias	2.2 million tonnes per year phosphate rock 500 000 tonnes concentrate	1979	$38	P	Mine/fertilizer plant project under development. Concentrate 38% P_2O_5
Fosfertil	Patos, Minas Gerais	1 million tonnes concentrate	1981-83	$200	P	Development based on measured reserves of 238 million tonnes. Concentrate: 35% P_2O_5
Mineracao Vale Do Paranaiba SA	Tapira, Minas Gerais	900 000 tonnes per year phosphate, with Ti, Cb	1979	$200	P/Cn	Officially opened Jan. 25, 1979. Will reach full capacity, Nov. 1979. Ti, Cb byproduct recovery intended later. Concentrate: 36% P_2O_5
Industrias Luchsinger Madorin	Anitapolis, Santa Caterina	1 million tonnes per year	1983	$170	P/Cn	Reserves of 300 million tonnes
Central African Empire						
Soc. de l'Uranium Centrafrican	Bakouma	500-700 tonnes per year U_3O_8 concentrate; phosphate byproduct	1981	$8	P	Mine development considered by government/CEA/Cie. Francaise de Minerais de Uranium

Table 9. (cont'd)

Company	Location	Design Production (ore, unless otherwise stated)	Completion Date	Capital (million)	Type of Operation[1]	Remarks
Egypt						
Abu Zaabal Co.	Mahamid West	500 000 tonnes per year phosphate rock concentrate	1980-81		P	Expansion from 100 000 tonnes per year with Austrian assistance
El Nasr Co.	Sebaiya	560 000 tonnes per year phosphate rock concentrate	1982		P	Expansion from 180 000 tonnes per year
Govt.	Abu Tartur	7 million tonnes per year phosphate rock concentrate	1985		U	Preparatory studies continuing
Red Sea Phosphate Co.	Quseir, Safaga	400 000 tonnes per year	1982		U/P	Expansion from 150 000 tonnes per year
Finland						
Kemira Oy	Siilinjarvi	Phosphate rock	1979	$39.2	P/Cn	Construction and pilot operations underway
Rautaruukki Oy	Sokli, Lapland	Phosphate rock				Pilot plant to test feasibility study due complete third quarter 1978. Based on reserves of over 100 million tonnes
India						
Pyrites, Phosphates Chemicals (Gov't)	Mussorie, UP	80 000 tonnes per year phosphate rock			P/Cn	Tenders called for supply and installation of crushing/ grinding plant based on low grade reserves already being mined
Rajasthan State Mines & Minerals	Jhamar Kotra Rajasthan	Phosphate rock			Cn	Seeking finance to establish beneficiation plant based on local reserves
Iraq						
General Phosphate Co.	Akashat	3.4 million tonnes per year phosphate rock	1981		P/Cn	Mines (Sybetra contract for) plus beneficiation plant complex, Smidth also to supply equipment
Israel						
Negev Phosphates	Nahal Zin	2 million tonnes per year phosphate rock	1979	$1 200	P/Cn	Cost covers expansion of present operation and construction of bulk loading facility at Ashdod

Table 9. (cont'd)

Company	Location	Design Production (ore, unless otherwise stated)	Completion Date	Capital (million)	Type of Operation[1]	Remarks
Jordan						
Jordan Phosphate Mining Co. (JPMC)	Ruseifa/El Hasa	3.5 million tonnes per year phosphate concentrate	1979		P/Cn	Small expansion at Ruseifa and larger at El Hasa to raise effective capacity from 2 million tonnes per year
JPMC	Jebel-El-Abiuth	1.5 million tonnes per year phosphate concentrate	1979-81		P/Cn	Three units of 500 000 tonnes per year to be commissioned in 1979, 1980 and 1981
JPMC	Shidiya	2.0-3.0 million tonnes per year phosphate rock				Negotiations with U.S.S.R. (early 1979). Financing to be repaid by rock exports to U.S.S.R.
Mexico						
Rofomex	San Juan Baja California	5 million tonnes per year phosphate	1980s	$184		Mine/Concentrator venture
Morocco						
OCP	Ben Guerir	1.8 million tonnes per year phosphate rock	1980-84	$100	P	Mine/plant; at 600 000 tonnes per year in 1980 rising to 1.8 million tonnes per year by 1984
OCP	Khouribga	3.9 million tonnes per year phosphate rock	1981-82		P	Pit mining of Recette IV, coming onstream at 2.6 million tonnes per year in 1981 and rising to 3.9 million during 1982
OCP	Sidi Hajjaj	3-5 million tonnes per year phosphate rock	1985		P	Expanding to 8 million tonnes by 1990
OCP	Youssoufia	7 million tonnes per year phosphate rock	1980		U	Expanding from current 5 million tonnes per year
Pakistan						
PMDC	Hazara	Phosphate rock			P	PD-NCB conducting 2-1/2 year, 1.6 million study of mine viability
Panama						
Cerro Colorado Mining Dev. Corp. (Codemin/Texasgulf)	Cerro Colorado Chiriqui	27 million tonnes per year Cu ore 182 000 tonnes per year blister 226 000 tonnes per year P_2O_5 in phosphoric acid				Feasibility studies complete. Canadian (CEDC) loan of $Cdn. 1 million

Table 9. (cont'd)

Company	Location	Design Production (ore, unless otherwise stated)	Com-pletion Date	Capital (million)	Type of Operation[1]	Remarks
Peru						
Minero Peru	Bayovar	2 million tonnes per year phosphate rock		\$300	P/Cn	Feasibility studies by joint venture of Minero Peru and Spain's INI
Saudi Arabia						
Petromin	Thaniyat	Phosphate		\$250		Exploration drilling and feasibility studies by Granges continuing
Senegal						
Cie, Senegalaise de Phosphates de Taiba	Taiba	Phosphates			P	Finance for expansion from 1.5 million tonnes per year
Irasenco (Gov't/ Brazil/Iran)	Tobene	2 million tonnes per year phosphate rock	1980	\$200	P	Mines (2) development planned plus \$100 million for port expansion at Dakar: Iranian finance in exchange for ore
Sweden						
LKAB	Kiruna	100 000 tonnes per year apatite concentrate	1980	SKr43	Cn	Unit to separate apatite from iron ore will supply apatite to Norsk Hydro fertilizer plants in Norway
Togo						
Cotomib	Kpémé	4.0 million tonnes per year phosphate rock	1980		Cn	A slurry dressing plant and a fifth line is to be added to the beneficiation plant — which treats ore from Hahoetoe and Kpogamé, increasing output from present level of 2.5 million tonnes per year plus
Tunisia						
Cie, des Phosphates de Gafsa	Gafsa	7 million tonnes per year phosphate concentrate	1981		P/U/Cn	Washing capacity at Melaoui Moulares and Redeyf to be expanded and mine capacity at Kef es Schfair, M'rata and Redeyf to be raised, enabling output to build up from present 3.5 million tonnes per year concentrate
Turkey						
Etibank	Mazidag	Phosphate rock			P/Cn	Feasibility studies for new mine/plant

Table 9. (cont'd)

Company	Location	Design Production (ore, unless otherwise stated)	Completion Date	Capital (million)	Type of Operation[1]	Remarks
United States						
Beker/Western Fertilizers	Soda Springs, Idaho	3.6 million short tons per year phosphate rock			P/Cn	U.S. Dept. Interior clearance for mine development; EPA clearance to begin mine construction late 1979 for production in 1981
J.R. Simplot & Co.	North Trail Canyon, Idaho				P	Approval by the U.S. Dept. of Interior received (Nov. 1978)
C.F. Industries Inc.	Hardee Co., Florida	2 million short tons per year phosphate rock	1979-80	$200	P/Cn	New mine/fertilizer complex (Stuart Tract) construction underway
W.R. Grace and Company	Nr. Bradenton, Florida	2.5 million short tons per year phosphate rock	1981	$80	P	Water permits received for proposed Four Corners mine but still awaiting other permits
W.R. Grace and Company	Hardee Co., Florida	3 million short tons per year phosphate rock	1981		P	Plans submitted for new mine
Noranda Mines Limited	Desoto Co., Florida	phosphate rock			P	Drilling at Pine Level project indicates reserves of 35 million tonnes recoverable phosphate rock. Environmental studies continue
NC Phosphate	Aurora, N. Carolina	4 million short tons per year phosphate rock	1979	$250	P	Agrico/Kennecott Joint Venture at Canvas Creek has received environmental approvals
Phillips Petroleum Company	Desoto/Manatee Cos., Florida	phosphate rock 4 million short tons per year	1982	$200	P/Cn	Plans to break ground on a mine in early 1980. Partnership with AMAX Inc.

Source: *Mining Magazine*, January 1979, with update by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] P Placer; U Underground; Cn Concentrator.

Phosphate rock prices advanced by about 10 per cent during 1978. At year-end, Phosrock, a company that represents most United States exports outside of North America, raised list prices fob Tampa by $3.00 per tonne for all grades except 75 per cent TPL, which increased $5.00 per tonne. Morocco's OCP prices were quoted about $1.00 higher fas ports.

Outlook

The outlook for 1979 and the beginning of 1980 is for stable markets and good prices for phosphate rock producers. Some countries however may experience difficulties in obtaining sulphur or sulphuric acid needed to produce phosphatic fertilizers. The proliferation of new mining ventures, however, combined with the prospect of increased supply problems for acid in the early 1980s may lead to a substantial surplus of phosphate rock unless some timely production cutbacks are implemented. The large potential surplus is also demonstrated by recent projections of new capacity. The summation of projects listed by the *Mining Magazine* suggests that some 28 to 30 million tonnes of new capacity will be put in place by 1985 and another 40 million tonnes could be listed as ''potential developments'' over the next 10 years.

There is considerable speculation on the expected long-term growth rate in demand, with expectations ranging from 3 to 5 per cent a year. The lower level would certainly indicate that an oversupply is eminent in the early 1980s. Furthermore, any serious concern about the long-term security of supplies appears to have little foundation at present.

Platinum Metals

J.J. HOGAN

The platinum group metals consist of platinum, palladium, rhodium, iridium, ruthenium and osmium, with platinum and palladium being by far the more abundant and important. The metals are usually found in basic and ultrabasic rocks in association with nickel and copper sulphides and in placer deposits, although production from placers is now of minor importance. The major sources of platinum metals are ores treated principally for these metals, mainly in the Republic of South Africa, and byproduct production from the treatment of nickel-copper ores. A small amount of platinum is recovered from the refining of copper ores.

The major producers, ranked in decreasing order of production volume, are the Republic of South Africa, the U.S.S.R. and Canada. Minor producers are Colombia, the United States, Japan, Australia and the Philippines.

Canadian production of platinum group metals in 1978 was estimated at 8 678 kilograms (kg)* valued at $55 672 000, compared with 14 475 kg in 1977, valued at $61 988 406. The amount produced fell by 40 per cent largely because of action taken by Canadian nickel producers to lower nickel output in an effort to correct a worldwide oversupply of nickel, and because of a labour strike at Inco Limited that began in September and was still in effect at the end of the year. The value of production decreased by only 10.2 per cent partly because of the exchange rate differential between the Canadian dollar and its United States counterpart, but mainly because of a substantial increase in the price of platinum in 1978 and moderate increases in the price of palladium and rhodium.

World primary production of platinum group metals in 1978 was estimated by the United States Bureau of Mines (USBM) at 19 906 kg, about the same as in 1977. The Republic of South Africa and the U.S.S.R. were the leading world producers of platinum metals in 1978, and production from these two countries in 1978 was about equal. They accounted for 93 per cent of the world's total output in 1978, and Canada, the third-largest producer, accounted for about 6 per cent.

*31.103 5 grams are equivalent to one troy ounce.

There was a sharp turnabout in the platinum metals market in 1978. The market situation of low industrial demand and adequate supplies in 1977, which had forced platinum producers to reduce output, became one of tight supply in 1978. There were a number of factors responsible: marked reduction in sales by the U.S.S.R., increased demand by the automotive industry in the United States and Japan, increased requirements by other industrial applications in the United States, increased demand by the Japanese jewellery industry and a higher level of speculative demand. These factors, along with world monetary problems, forced the price up sharply. Production was increased by South African producers in the latter part of 1978 to previous levels.

Japan and the United States were the leading consumers of platinum metals in the non-communist world in 1978. J. Aron Commodities Corporation, a bullion dealer in New York, estimated the United States consumption of platinum and palladium to be 61 429 kg and Japanese consumption to be 61 274 kg. The overall non-communist world consumption of these metals was estimated to be 166 248 kg. Over the years, Japan has been the world's major consumer of platinum. The Japanese jewellery industry has been the largest user of the metal and in 1978 consumed about 25 000 kg, approximately 70 per cent of the country's total platinum consumption.

The USBM estimated the platinum group metals sold to industry in the United States in 1978 to be 68 622 kg, compared with 51 193 kg in 1977. The percentages by weight of platinum group metals sold to U.S. consuming industries were: platinum, 54.8; palladium, 38.9; rhodium, 2.8; ruthenium, 2.6; iridium, 0.8 and osmium less than 0.1.

The major users of platinum metals in the United States in 1978 were the automotive, electrical and chemical industries, which together accounted for 72.2 per cent of the total. Other substantial consumers were the dental and medical professions and the petroleum and glass industries. A relatively small amount of platinum metals is used in the United States for jewellery and decorative purposes, amounting to only 2.2 per cent of U.S. consumption in 1978. The automotive industry was the largest consumer of platinum metals, mainly for use in catalytic converters.

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The major producers, ranked in decreasing order of production volume, are the Republic of South Africa, the U.S.S.R. and Canada. Minor producers are Colombia, the United States, Japan, Australia and the Philippines.

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Preliminary estimates show sales of platinum and palladium in the U.S. automotive industry to be approximately 18 544 kg and 6 184 kg respectively, up sharply from 1977 sales of 11 021 kg and 3 888 kg. The USBM reports stocks of platinum group metals held by refiners, importers and dealers in the United States, including metals in depositories of the New York Mercantile Exchange, but not platinum metals contained in the United States government stockpile, to be 27 993 kg at the end of 1978, compared with 31 502 kg held at the end of 1977.

Table 1. Platinum metals, Canadian production and trade, 1977 and 1978

	1977		1978p	
	(grams)	($)	(grams)	($)
Production[1]				
Platinum, palladium, rhodium, ruthenium, iridium	14 474 687	61 988 406	8 678 000	55 672 000
Exports				
Platinum metals in ores and concentrates				
United Kingdom	12 390 816	48 373 000	10 557 112	55 062 000
Platinum metals, refined				
United States	1 023 087	4 112 000	573 610	2 141 000
United Kingdom	27 651	91 000	273 089	1 455 000
France	—	—	31 103	87 000
Other countries	68 490	197 000	33 094	58 000
Total	1 119 228	4 400 000	910 896	3 741 000
Platinum metals in scrap				
United States	948 096	3 212 000	1 230 360	8 518 000
United Kingdom	2 830	16 000	94 026	413 000
West Germany	43 545	69 000	—	—
Total	994 471	3 297 000	1 324 386	8 931 000
Re-export[2]				
Platinum metals, refined and semiprocessed	1 039 540	3 180 000	169 234	334 000
Imports				
Platinum lumps, ingots, powder and sponge				
United States	272 809	1 514 000	202 079	1 920 000
United Kingdom	44 571	217 000	50 668	680 000
Total	317 380	1 731 000	252 747	2 600 000
Other platinum group metals				
United States	677 496	1 816 000	1 317 419	1 496 000
United Kingdom	5 008	62 000	74 244	298 000
South Africa	90 636	183 000	102 641	249 000
Total	773 140	2 061 000	1 494 304	2 043 000
Total platinum and platinum group metals				
United States	950 305	3 330 000	1 519 498	3 416 000
United Kingdom	49 579	279 000	124 912	978 000
South Africa	90 636	183 000	102 641	249 000
Total	1 090 520	3 792 000	1 747 051	4 643 000

Table 1. (cont'd)

	1977		1978p	
	(grams)	($)	(grams)	($)
Platinum crucibles[3]				
United States	701 788	5 627 000	662 784	6 817 000
Platinum metals, fabricated materials, not elsewhere specified				
United Kingdom	391 220	2 447 000	519 521	3 807 000
United States	250 974	1 299 000	228 424	1 259 000
Other countries	41 896	91 000	—	—
Total	684 090	3 837 000	747 945	5 066 000

Source: Statistics Canada.
[1] Platinum metal, content of concentrates, residues and matte shipped for export. [2] Platinum metals, refined and semiprocessed, imported and re-exported in the same form as when imported. [3] Includes spinners and bushings.
p Preliminary; — Nil.

Canadian operations and developments

The platinum group metals produced in Canada were recovered as a byproduct from the treatment of nickel-copper sulphide ores. The two major Canadian producers of platinum metals are Inco Limited, by far the larger, and Falconbridge Nickel Mines Limited, both having their major operations in the Sudbury district of Ontario. Inco also recovers platinum metals from its mine in the Shebandowan district of northwestern Ontario and from its mines in the Thompson region of Manitoba. The Langmuir Mine, a small nickel-copper mine near Timmins, Ontario, owned 51 per cent by Noranda Mines Limited and 49 per cent by Inco, closed in 1978. Inco ships the residue from the refining of nickel and copper ores that contain platinum group metals to its refinery at Acton, England for the extraction and refining of platinum metals. Falconbridge Nickel ships a nickel-copper matte that contains platinum metals to its refinery in Kristiansand, Norway. The sludge collected from this operation is shipped elsewhere for recovery of the platinum group metals. The platinum group metals recovered from Canadian ores consists of about 46 per cent platinum, 40 per cent palladium and 14 per cent other platinum metals.

The copper ore deposit of Union Miniere Explorations and Mining Corporation Limited (Umex), near Pickle Lake, Ontario contains platinum metals and some nickel. These metals are contained in copper concentrates produced at the 3 600-tonne-a-day concentrator. The concentrate is shipped to Noranada, Quebec for recovery of the contained metals.

There was little activity during 1978 at the Lac des Isles platinum metals prospect of Boston Bay Mines Limited in northwestern Ontario. Exploratory work carried out on the property to date has outlined two zones of platinum metals mineralization reported to contain about 35 000 tonnes per vertical foot, grading 5.75 g of platinum group metals per tonne, 0.2 per cent copper-nickel and 0.62 g of gold per tonne. Preliminary work has indicated a high palladium to platinum ratio.

Foreign developments

Republic of South Africa. The Republic of South Africa is a major world producer of platinum group metals. It is the only country among the major producers that mines platinum metal-bearing ores primarily for the recovery of these metals. The deposits, which occur in the Merensky Reef of the Bushveld Complex near Rustenberg, also contain some gold, nickel and copper. The platinum group metals recovered from ore deposits in the Merensky Reef are estimated to be in the following proportion: platinum, 61 per cent; palladium, 25 per cent; and other platinum group metals, 14 per cent. Small amounts of osmium and iridium are recovered as a byproduct from the treatment of Witwatersrand gold ores.

The fortunes of the South African producers of platinum group metals improved greatly in 1978. An increase in industrial usage, a decline in the U.S.S.R. sales to world markets and an increase in speculative buying were the main reasons producers restored production to mid-1977 levels in late 1978. There was a plentiful supply of labour throughout 1978. The price of platinum moved sharply upwards and enabled the companies to show a much improved financial position.

Rustenberg Platinum Holdings Limited, the largest producer of platinum group metals in the non-communist world, operated three major mines, a smelter and two refineries in the Transvaal district of the Republic of South Africa, and a refinery in the United Kingdom. One mine is located in the Rustenberg section and the other two in the Union section, of the Transvaal. In October 1977, Rustenberg acquired the property of Atok Platinum Mines (Proprietary) Limited, near Pieterburg. This company operates a mine with a capacity of 1 200 kg of platinum metals per year. Two of Rustenberg's mines are partially within the new Republic of Bophuthatswana and to comply with the constitution of Bophuthatswana, Rustenberg Holdings will have to make adjustments to its employment procedures.

Table 2. Canada, platinum metals, production and trade, 1960, 1965, 1970 and 1975-78

	Production[1]		Exports: Domestic[2]		Exports: Re-export[3]		Imports[4]	
	(grams)	($)	(grams)	($)	(grams)	($)	(grams)	($)
1960	15 041 766	28 873 508	12 542 166	16 068 728	6 207 103	8 404 563	. .	12 951 420
1965	14 404 860	36 109 799	17 138 700	30 103 254	10 013 764	11 389 395	7 265 865	13 461 546
1970	15 005 188	43 556 597	15 327 731	44 174 000	634 480	2 365 735	1 889 381	3 123 000
1975	12 417 099	56 493 077	15 530 930	50 244 000	538 899	2 928 000	1 896 410	6 061 000
1976	12 964 582	50 143 112	13 726 089	45 319 000	383 972	1 618 233	1 325 318	3 570 000
1977	14 474 687	61 988 406	13 510 044	52 773 000	1 039 540	3 180 000	1 090 520	3 792 000
1978[p]	8 678 000	55 672 000	11 468 008	58 803 000	169 234	334 000	1 747 051	4 643 000

Source: Statistics Canada.
[1] Platinum metals, content of concentrates, residues and matte shipped for export. [2] Platinum metals in ores and concentrates and platinum metals, refined. [3] Platinum metals, refined and semiprocessed, imported and re-exported after undergoing no change or alteration. [4] Imports, mainly from United States and United Kingdom, of refined and semiprocessed platinum metals, derived from Canadian concentrates and residues, a large part of which is re-exported.
[p] Preliminary; . . Not available.

The refining of copper, nickel and platinum metals is carried out in the Republic of South Africa and in the United Kingdom by Matthey Rustenberg Refiners (Proprietary) Limited, a company owned jointly by Rustenberg and Johnson, Matthey & Co. Limited. The latter company is the marketing agent for Rustenberg's products.

Efforts by Rustenberg to improve productivity have resulted in better labour and plant efficiencies, improved mining techniques and a reduced rate of increase of operating costs. An increasing amount of ore is being mined by mechanized means. The development of a longwall system of mining is progressing satisfactorily. Major changes in labour application and in the operation of the refining process at the nickel-copper refinery resulted in a substantial savings in operating costs. Despite cost improvements, a feasibility study is underway regarding the possible erection of a new nickel-copper refinery. In 1978 Rustenberg was able to renegotiate the price of platinum in its sales contract with Engelhard Minerals & Chemicals Corporation, an agent for a United States automobile company.

Late in 1977 Rustenberg announced that it would cut production by between 10 and 20 per cent, because of weak market conditions and the generally low price of platinum which affected the company's financial position. There was a significant improvement in the market during 1978 and Rustenberg rescinded earlier reductions in production. At year-end the company was operating at a yearly production rate of 31 100 kg of platinum metal. To meet an expected increase in demand, especially by the United States automotive industry, the annual production rate will be increased to 37 324 kg in 1979. Further expansion would entail large capital expenditures and Rustenberg would require assurance that expenditures can be recovered before undertaking major expansion programs.

All production from the Rustenberg operations has come from the Merensky Reef of the Bushveld Complex. A second reef that contains chrome associated with the platinum group metals, and known as the Upper Group No. 2 Reef (UG2), occurs beneath the Merensky Reef. Rustenberg continued its research and exploration program to evaluate the mining costs and to develop a process to economically recover both chromium and platinum metals.

Impala Platinum Holdings Limited, the second-largest platinum metals producer in the non-communist world, operates a mine-concentrator-smelter complex in the Republic of Bophuthatswana and a refinery in the Republic of South Africa. Both of these operations are near Rustenberg. In 1977 Impala cut back its rate of production owing to poor market conditions, but with improved demand in 1978 output was increased to an annual rate of about 24 900 kg, slightly below capacity.

Western Platinum Limited, jointly owned by Lonrho Limited, Falconbridge Nickel Mines Limited and Superior Oil Company, operated a mine-concentrator-smelter-refinery complex in the Transvaal district of South Africa. The complex has an annual rated capacity of 4 666 kg of platinum metals. Production of these metals for the fiscal year ending September 30, 1978 was 3 515 kg, compared with 4 075 kg in 1977. Western Platinum uses the NIM process, developed by the National Institute of Metallurgy, for the recovery of platinum metals. The NIM process reduces treatment time for recovery of platinum metals from about four months to 20 days, sharply reduces labour requirements compared to other processes and lowers capital expenditures because of smaller space requirements.

U.S.S.R. In the U.S.S.R. platinum metals are derived mainly as a byproduct from nickel-copper ores mined in the Norilsk region of northwestern Siberia and the Kola Peninsula of northwestern Russia. Some platinum metals are recovered from placer deposits in the southern Urals, once the major source of U.S.S.R. output. The USBM estimated the U.S.S.R. production of platinum group metals to be 93 300 kg for 1978, compared with 90 200 kg in 1977. The U.S.S.R. is carrying out a major expansion program, part of which has been completed, to develop

Table 3. World mine production of platinum group metals, 1976-78

	1976	1977[p]	1978[e]
		(grams)	
U.S.S.R.[e]	87 090 000	90 200 000	93 310 000
Republic of South Africa[e]	83 979 000	91 755 000	91 755 000
Canada	12 964 582	14 474 687	8 678 000
Colombia	809 000	809 000[e]	778 000
United States	190 229	172 469	156 000
Other countries	920 818	1 099 290	933 000
Total	185 953 629	198 510 446	195 610 000

Sources: U.S. Bureau of Mines, *Mineral Trade Notes*, Vol 75, No. 8, August 1978; U.S. Bureau of Mines, Mineral Commodity Summaries, January 1979 for 1978; Statistics Canada.
[e] Estimated; [p] Preliminary.

nickel-copper deposits in the Norilsk region. The overall program should be completed by 1984. This expansion should result in substantial increases in the production of platinum and palladium. Platinum group metals output of the U.S.S.R. and the platinum metals content of the deposits now being mined and developed are treated as confidential data by the U.S.S.R. and, it is therefore not possible to determine the magnitude of increased output from this expansion program. In the past the U.S.S.R. ores contained a higher proportion of palladium than of platinum. The platinum metals recovered from the ores mined have been estimated to contain about 60 per cent palladium, 30 per cent platinum and 10 per cent other platinum metals.

Colombia. Mine production of platinum metals in Colombia in 1978 was estimated by the USBM to be 778 kg. The platinum metals are recovered as a coproduct from gold-platinum metals placer operations in the Chaco and Narimo districts of Colombia.

United States. Mine production of platinum metals in the United States was derived as a byproduct of copper refining, and amounted to only 150 kg in 1978. The United States also recovered a substantial quantity of platinum metals from secondary sources.

Platinum group metals are found in the rocks of the Stillwater complex, Sweetgrass County, in southwestern Montana. According to the USBM, exploration and evaluation of this occurrence continued in 1978.

Recycling

Recycling of platinum metals, especially platinum, is an important factor in the supply of these metals to the market. It is estimated that over 80 per cent of the platinum metals consumed by industry is recycled, a major portion being toll-refined. This is important to those industries that use platinum metals in their processes, such as those requiring catalysts, as recycling reduces the effect that the high cost of platinum metals have on the cost of the goods produced. In the United States, one of the few countries that reports detailed statistical data for platinum metals, an estimated 6 220 kg of these metals were recovered from secondary sources. Toll-refined platinum metals amounted to more than 31 000 kg in 1978.

Uses

The main applications for platinum group metals are in the automotive, electrical, chemical, glass, petroleum and jewellery industries and for dental and medical uses. The industrial use of these metals is based on special properties, the principal ones being: catalytic activity, resistance to both corrosion and oxidation at elevated temperatures, good electrical conductivity characteristics, high melting point, high strength, ductility and aesthetic qualities. Platinum and palladium have wide industrial applications, especially as catalysts. The others — iridium, rhodium, ruthenium and osmium — are used mainly as an alloying element with platinum and palladium, but small amounts of these metals are used individually in special applications.

The jewellery industry is the major world consumer of platinum metals, mainly because of the large Japanese demand for platinum jewellery. In Japan the jewellery trade consumed about 25 000 kg of platinum in 1978, approximately 69 per cent of the countries total. The use of platinum for jewellery in the United States and Europe has been small because of the preference in these countries for gold jewellery, due largely to the lower price of gold relative to that of platinum. The consumption of platinum for jewellery in the United States during 1978 was estimated to be 933 kg, less than 3 per cent of the country's total consumption and in western European countries 840 kg, approximately 7 per cent of the total consumption in those countries. It is apparent that there is potential for increased use of platinum in the jewellery trade in the U.S. and western Europe. To develop this market the major producers of the Republic of South Africa have launched an aggressive campaign to promote greater use of platinum metals in jewellery fabrication. The sharp increase in the price of platinum in the latter part of 1978 could, however, lower the potential for increased consumption of platinum in the jewellery industry, especially in Japan.

The recent development in catalytic converters used for control of automotive exhaust emissions has created a major new use for platinum and palladium and was responsible for the recent expansion of production facilities in the Republic of South Africa. The Environmental Protection Agency (EPA) of the United States and the Japanese government have established automotive emission standards that can best be attained today by use of platinum and palladium as catalysts in the converters. In 1977, the United States Congress passed a bill amending the Clean Air Act. One of the amendments pertained to automotive exhaust emission standards. The existing standards were extended for a two-year period, but stricter standards were established for model-year 1980 and beyond.

Platinum-palladium converters in use today do not control nitrogen oxide emissions and to meet the standards established to control nitrogen oxides it appears that rhodium will be a third metal used in catalytic converters. The rhodium type converter developed to date consumes a relatively high amount of rhodium and could not be adopted universally because the available supply of the metal could not meet the potential demand. Research activities are centered on lowering the amount of rhodium in catalytic converters, the ideal situation being development of a converter that contains platinum and rhodium in the same ratio as occurs in the South African ores.

Sales of platinum and palladium to the United States automotive industry were up sharply in 1978 and amounted to 18 584 and 6 184 kg respectively. Some sales may have been inventory buildup. The more stringent standards established for automotive emission control for model-year 1980 and subsequent years will require increased metal loadings in catalytic converters, and depending on car sales, consumption is expected to increase in 1979.

Platinum catalysts are used in the petroleum refining industry for the production of high-octane gasoline. A platinum-rhenium catalyst has been found to be effective in this application and is becoming more important with the lowering and elimination of tetraethyl lead in gasoline. The petroleum industry in the United States consumed 3 854 kg of primary platinum metals in 1978, compared with 2 749 kg in 1977.

Platinum, when alloyed with other platinum group metals finds wide application as a catalyst in the chemical industry, an important application being in the production of nitric acid from ammonia and oxygen. Platinum metal catalysts are also used in the production of pharmaceutical products and in the food processing industry. Consumption of platinum group metals in the chemical industry in the United States was 10 134 kg in 1978, compared with 8 740 kg in 1977.

The electrical industry is also a major consumer of platinum. It is used in the electronic industry in printed circuits, alone and with other precious metals; in electrical furnaces, thermocouples and for electrical contacts in telephone equipment. At one time palladium was the only metal used in telephone equipment but today it has been largely replaced with a palladium-silver alloy containing 60 per cent palladium and 40 per cent silver. Consumption of platinum group metals in the United States was 12 612 kg in 1978, compared with 10 723 kg in 1977.

A platinum-rhodium alloy is used in bushings and spinnerets fabricated for use in the production of fibreglass and synthetic fibres. It is also used in the glass manufacturing industry. Much of the platinum metals used are recycled by the industry through toll-refining. Consumption of platinum group metals in the glass industry was 3 572 kg in 1978, compared with 2 339 kg in 1977.

Platinum metals are used in a number of other applications: for dental and medical uses, for laboratory equipment and for medical research, for fuel cells used for direct generation of electric current and for crucibles used for growing laser crystals and synthetic gems.

The U.S.S.R. is issuing a number of silver, gold and platinum coins to commemorate the 1980 Olympic Games to be held in Moscow. In the platinum coin program, a series of five coins will be issued, each with different designs, in proof and brilliant uncirculated qualities. The first issue, struck in 1978, contained 40 000 coins with a face value of 150 roubles. The specifications for the coin are: diameter 28.6 millimetres (mm); thickness, 1.5 mm; total weight, 15.55 grams (g) and contained platinum, 15.5 g (999.3 fine). This was the first platinum Olympic commemorative coin to be struck in the U.S.S.R. and the first platinum coin to be circulated since 1845. It is expected that 40 000 coins will be struck for each of the remaining four issues. The coins reportedly will be sold in the price range of $ Cdn. 495 per coin.

Although the actual consumption of platinum may be small, an important recent development is the use of a platinum-based drug to combat advanced stages of certain forms of cancer.

The successful development of the fuel cell could create a relatively large new market for platinum. A fuel cell uses a platinum catalyst to convert gaseous fuel directly into electrical energy. A prototype 4.8 megawatt fuel cell is being built by United Technologies Corp. for use at Consolidated Edison Co. of New York Inc.'s generating plant. It is expected to be in operation by 1980.

Prices

A combination of reduced production of platinum metals by the South African producers in the latter part of 1977, an increase in industrial demand and a substantial reduction in sales by the U.S.S.R. resulted in a sharp increase in the prices of platinum and rhodium and a moderate increase in the price of palladium in 1978.

The average producer and dealer price for platinum in 1978, as quoted by *Metals Week*, were $U.S. 7.63 per g ($U.S. 237.25 per ounce) and $U.S. 8.38 per g ($U.S. 260.77 per ounce), respectively. Corresponding figures for palladium were $U.S. 2.28 per g ($U.S. 70.87 per ounce) and $U.S. 2.03 per g ($U.S. 63.01 per ounce).

Platinum. At the beginning of 1978 the producer price of platinum was quoted by *Metals Week* at $U.S. 5.79 per g. There was a sharp price increase in the latter part of January to $U.S. 6.59 per g caused by an upsurge in buying by the Japanese and by a cut in sales by the U.S.S.R. to the non-communist world market. The platinum price moved up in stages to $U.S. 9.65 per g on November 27 and remained at this level for the balance of the year. The dealer price, which reached a high of $U.S. 11.90 per g on October 26, was generally above the producer price. Producer price increases were made to bring the two prices into closer balance. At year-end the dealer price was $U.S. 11.22 per g.

Palladium. The rise in the price of palladium in 1978 was not as spectacular as that of platinum, but closely followed the rise of gold and silver prices. The producer price, as quoted by *Metals Week*, increased by about 33 per cent during the year, from $U.S. 1.93 per g to $U.S. 2.49 per g. The opening dealer price for 1978 was $U.S. 1.68 per g and it remained near this level until the end of January, when the price was increased to $U.S. 1.90 per g. The price remained comparatively close to this figure until early in October when it increased to $U.S. 2.41 per g, recording a high for the year of $U.S. 2.54 per g in the latter part of October. An announcement by Carter administration in early November of the action to be taken by the United States to support the dollar caused the palladium price to decline sharply to $U.S. 2.12 per g. The price increased towards the end of the year to close at $U.S. 2.33 per g.

Rhodium. The producer price of rhodium at the beginning of 1978 was quoted by *Metals Week* at $U.S. 14.47 per g and increased to $U.S. 16.08 per g in the latter part of January, following the announcement that rhodium would be used in platinum-palladium catalytic converters as a catalyst to control nitrous gas emissions. Stocks of rhodium are not large and any news concerning potential usage can cause the price to move sharply upwards. Producers made two more price increases during the year. In the latter part of September the price was increased to $U.S. 17.68 per g and at year-end to 20.89 per g. A major reason for the sharp price increases was the uncertainty of adequate supply to meet the United States automotive industry's needs for rhodium in catalytic converters. The dealer price was generally slightly above the producer price but in the latter part of the year the price spread increased sharply. At the end of 1978 a substantial increase in the producer price resulted in the two prices being more in balance.

Iridium, ruthenium and osmium. The producer price of iridium, ruthenium and osmium remained unchanged in 1978 at $U.S. 9.65 per g; $U.S. 1.93 per g and $U.S. 4.82 per g, respectively. The dealer price of iridium fluctuated between a low of $U.S. 7.39 to a high of $U.S. 8.04 per g and closed at $U.S. 7.71 per g. The dealer price of ruthenium was stable during the year and varied between $U.S. 0.96 and $U.S. 1.16 per g, while the osmium dealer price remained unchanged at $U.S. 4.18 per g.

Outlook

In the short term the strong demand that developed for platinum in 1978 is expected to continue, and the metal will be in tight supply. Platinum has been mainly an industrial metal and large stocks have not been built up due to the close balance between supply and demand. J. Aron of New York estimated that in 1978 world stocks were reduced by 12 440 kg to 15 550 kg. To ensure an adequate supply to meet industrial requirements, South African producers have discontinued previous cutbacks and are taking steps to increase their output by another 7 to 15 per cent, near the capacity of their present plants. The U.S.S.R. has not made platinum available to the open market for over a year and has not released any information on the reason for this action. A potential supply of platinum from the U.S.S.R. overhangs the open market, but it is expected that if the U.S.S.R. returns to the market its sales will be carried out in a manner least disruptive to the price structure. The supply of palladium is adequate to meet present needs.

The price of platinum will remain at a relatively high level in the short term, because demand is strong. The structure of the platinum industry is such that high prices will not make significant amounts of extra metal readily available by producers, scrap dealers or speculators. The South African producers estimate that it would take three to four years and high capital costs to increase output above present capacity. The producers would require assurances that capital expenditures could be recovered before undertaking any major programs.

In the medium- to long-term outlook the platinum metals industry faces a number of uncertainties. It is not known to what extent the recycling of platinum metals in scrapped automotive catalytic converters will have on the overall supply. Some sources believe that by the mid-1980s roughly 9 300 kg to 13 900 kg could be recovered annually from converters, while others question whether the metals can be economically recovered. Advances and improvements in catalytic converter technology could reduce the platinum metals load factor. If the price of platinum becomes excessive there is the threat of substitution, as occurred with palladium in the telephone industry. A high price could reduce consumption in the jewellery trade in Japan. It could also adversely affect the results of the promotional program now underway to encourage increased sales of platinum jewellery in Europe and the United States. The U.S.S.R. is increasing its nickel output in Norilsk region, and when this program is completed in 1984 additional platinum group metals should be available. Platinum and other platinum metals have superior qualities, especially in many applications where a catalyst is required, this reduces the possibility of their replacement by substitutes.

The United States Federal Preparedness Agency has set its strategic stockpile goal for platinum at 42 246 kg, an increase of 27 693 kg over the present stockpile of 14 553 kg. The stockpile objective for palladium has been increased from the present level of 40 349 kg to 70 769 kg. If the objective is approved by the U.S. government it is expected that purchases of these metals for the stockpile would be made in a manner least disruptive to the market.

In the long term consumption of platinum metals should show a steady growth pattern. The large reserves of these metals contained in the Merensky Reef in the Republic of South Africa and in the Republic of Bophuthatswana can be developed to ensure supply and demand are in balance. Failure by producers to ensure ample supplies of the platinum metals would encourage accelerated action by consumers to find substitutes.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential [1]
36300-1	Platinum wire and platinum bars, strips, sheets or plates; platinum, palladium, iridium, osmium, ruthenium and rhodium, in lumps, ingots, powder, sponge or scrap	free	free	free	free
48900-1	Crucibles of platinum, rhodium and iridium and covers therefore	free	free	15%	free

United States

Item No.		Rate of Duty
601.39	Precious metals ores	free
605.02	Platinum metals, unwrought, not less than 90% platinum	free
		% ad valorem
605.03	Other platinum metals, unwrought	20
605.05	Alloys of platinum, semimanufactured, gold-plated	25
605.06	Alloys of platinum, semimanufactured, silver-plated	12
605.08	Other platinum metals, semimanufactured including alloys of platinum	20
644.60	Platinum leaf	20

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States, Annotated (1978) ITC Publication 843.
[1] General Preferential Tariff rate from July 1, 1974 to June 30, 1984.

Potash

G.S. BARRY

A strong surge in world demand for potash in 1978 resulted in modest gains in production and in a large decline of inventories. World production increased 3.3 per cent over 1977 to 26.2 million tonnes, with the largest increases recorded by European producers and the U.S.S.R.

Canadian mines operated at 81 per cent of capacity, producing 6 124 000 tonnes of potash (K_2O equivalent) or about 0.7 per cent more than in 1977. However, because of excellent sales, inventories decreased by 29.6 per cent.

The Potash Corporation of Saskatchewan completed its acquisition program in 1978, which gives it ownership of 39 per cent of the province's potash operating capacity. The general objective of achieving a 50 per cent share in the province's potash production capacity will be attained over the next five years through a major expansion program that was initiated in 1978.

The bulk of world potash production is in the form of potassium chloride (KCl), known in the industry as muriate of potash, and used in the production of fertilizer. All Canadian potash production is marketed as the chloride, with a potassium content of about 50 per cent (60 to 62 per cent K_2O equivalent). This product is marketed in the United States, in offshore countries and domestically. Canada's exports amount to 37 per cent of the international potash market.

Production and developments in Canada

Saskatchewan. There are ten potash mines in Canada, all in the province of Saskatchewan, with an installed capacity of 12 350 000 tonnes of potassium chloride (7 575 000 tonnes K_2O equivalent). In 1977 the industry operated at 80 per cent of capacity and in 1978, at 81 per cent of capacity, responding to increased demand from domestic and export markets. These were the highest levels of capacity utilization since the beginning of potash mining in Canada.

Canadian potash production, at 6.1 million tonnes K_2O equivalent, was 0.7 per cent higher than in 1977. In the same period however, shipments increased by 13.5 per cent to 6 474 778 tonnes, resulting in a 29.6 per cent decrease of inventories to 832 000 tonnes. The value of potash shipments totalled $493 million, an increase of 22 per cent over the 1977 value. The potash mines employed 3 640 people in 1978 with an additional 600 to 700 employed on new construction.

In order to exercise direct control over the potash industry in Saskatchewan, the provincial government decided in 1975 to nationalize part of the industry. The Potash Corporation of Saskatchewan (PCS) was established by Order-in-Council on February 4, 1975 and continued under the Potash Corporation of Saskatchewan Act of April 1, 1976. Two subsidiary companies were incorporated under the Companies Act of the Province of Saskatchewan: Potash Corporation of Saskatchewan Mining Limited (PCSML) – Cory Division, Rocanville Division, Lanigan Division and Esterhazy Division; and the Potash Corporation of Saskatchewan Sales Limited (PCSSL).

In October 1976, PCS purchased Durval Corporation of Canada's mine for $128.5 million and now operates the mine as the Cory Division. In April 1977, PCS purchased the mining operations of Hudson Bay Mining and Smelting Co., Limited for $144 million and operates the mine as the Rocanville Division. In November 1977, the operation of Alwinsal Potash of Canada Limited was purchased for $86.5 million and is operated as the Lanigan Division. In 1978, PCS acquired 60 per cent of the Allan potash mine from two of the three owners of APM Operators Ltd. The agreement, reached with United States Borax & Chemical Corporation and Swift Canadian Co., Limited, was for a total payment of $85.8 million. Negotiations to obtain the remaining 40 per cent ownership of the mine from Texasgulf Potash Company (TPC), a subsidiary of Texasgulf Inc., were unsuccessful and TPC elected to continue as a minority owner in partnership with PCS.

The Potash Corporation of Saskatchewan also reached agreement during 1978 with AMAX Potash Limited, a subsidiary of AMAX Inc., to purchase AMAX's potash reserves of 50 to 70 million tonnes for a total of $85 million. Processing of the reserves at a rate of 0.9 million tonnes per year is provided for by the transfer to PCS of a long-term service contract in force between AMAX and the International Minerals & Chemical Corporation (Canada) Limited (IMCC). In practice PCS is now purchasing potash from IMCC which is presently mined in the K1 and the K2 Esterhazy mines.

In total, the Potash Corporation of Saskatchewan acquired 38.5 per cent of the capacity of the Saskatchewan mines at a total cost of $530 million.

The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, potash production, shipments and trade, 1977 and 1978

	1977		1978^p	
	(tonnes)	($)	(tonnes)	($)
Production, potassium chloride				
Gross weight[1]	10 017 757	. .	9 956 222	. .
K_2O equivalent	6 088 587	. .	6 123 544	. .
Shipments				
K_2O equivalent	5 764 181	403 706 531	6 375 000	492 963 000
Imports, fertilizer potash				
Potassium chloride				
United States	30 441	2 145 000	1 742	228 000
Belgium-Luxembourg	—	—	8	15 000
United Kingdom	15	10 000	44	8 000
West Germany	—	—	1	. . .
Total	30 456	2 155 000	1 795	251 000
Potassium sulphate				
United States	11 429	1 229 000	19 819	2 598 000
Mexico	18	3 000	—	—
Total	11 447	1 232 000	19 819	2 598 000
Potash fertilizer, nes				
United States	63 731	3 789 000	53 818	3 790 000
Potash chemicals				
Potassium carbonate	759	325 000	1 212	608 000
Potassium hydroxide	4 933	1 395 000	5 252	1 612 000
Potassium nitrate	1 967	507 000	2 288	656 000
Potassium phosphate	1 124	787 000	1 263	1 054 000
Potassium bitartrate	122	104 000	. .	. .
Potassium silicates	675	250 000	884	384 000
Total potash chemicals	9 580	3 368 000	10 899	4 314 000
Exports, fertilizer potash				
Potassium chloride, muriate				
United States	7 263 846	366 084 000	6 901 202	363 073 000
Japan	615 795	30 741 000	672 935	34 170 000
Brazil	372 759	19 699 000	412 079	21 119 000
India	216 975	11 182 000	332 569	17 970 000
South Korea	197 882	10 444 000	260 335	13 544 000
Singapore	139 063	7 274 000	205 193	10 575 000
Australia	86 053	4 555 000	148 089	7 949 000
Denmark	44 999	2 350 000	92 678	4 624 000
Taiwan	48 997	2 501 000	62 549	3 880 000
South Africa	35 265	1 868 000	51 640	3 669 000
Other countries	184 453	10 571 000	248 182	13 145 000
Total	9 206 087	467 269 000	9 387 451	493 718 000

Sources: Statistics Canada; Potash Institute of North America, for K_2O production figures.
[1] Based on a conversion factor of K_2O x 1.64 for standard, special standard, granular and coarse grades, and K_2O x 1.60 for soluble and chemical grades.
^{p} Preliminary; — Nil; . . Not available; . . . Less than $1 000; nes Not elsewhere specified.

PCS has embarked on a major rehabilitation and expansion program of the existing mines. The so-called Phase I expansion program is now in full swing in three mines, with the objective of raising annual capacities of KCl product between 1978 and 1983 as follows: Cory Division, 1 090 000 to 1 360 000 tonnes; Rocanville Division, 1 090 000 to 1 270 000 tonnes (stage 1), 1 270 000 to 1 815 000 tonnes (stage 2); Lanigan Division, 910 000 to 1 360 000 tonnes.

On completion in 1983, PCS will have increased its total production capacity by 1 350 000 tonnes to a total of 6 350 000 tonnes. The total cost of Phase I expansion is estimated at $256 million (in 1978 constant Canadian dollars).

Furthermore, PCS is now finalizing plans for a Phase II expansion program to commence in 1980 and terminate within four to five years. The expansion would bring the capacity of each mine to its ultimate potential. To a large extent the maximum hoisting capacity of the existing shafts is the most critical factor. Capacity increases in the Phase II program would be as follows: Cory Division, 1 360 000 to 1 815 000 tonnes (KCl); Rocanville Division, none (ultimate achieved in Phase I); Lanigan Division, 1 360 000 to 3 175 000 tonnes; Allan Division, 1 360 000 to 1 590 000 tonnes.

The capital costs of the Phase II program would be in excess of $400 million.

Table 2. Canada, potash production and sales by grade[1] and destination, 1977 and 1978

	1978					1978	1977
	Standard[2]	Coarse	Granular	Soluble	Chemical	Total	Total
	(tonnes K_2O equivalent)						
Production	1 571 242	2 422 854	1 508 059	558 185	63 204	6 123 544	6 088 587
Sales							
Domestic	20 535	318 040	20 207	11 186	—	369 968	249 192
United States	637 099	2 018 628	1 382 913	459 026	—	4 497 666	4 197 734
Offshore							
Australia	11 343	40 732	33 250	363	—	85 688	46 966
Bangladesh	—	43 067	—	—	—	43 067	12 193
Brazil	61 173	138 514	74 531	199	—	274 417	240 311
Chile	—	—	—	20 266	—	20 266	—
China	38 751	—	—	—	—	38 751	30 344
Costa Rica	5 650	—	1 269	—	—	6 919	3 194
Denmark	56 080	—	—	—	—	56 080	27 334
Guatemala	—	—	—	—	—	—	1 162
India	241 385	—	—	4 462	—	245 847	136 023
Italy	—	—	—	10 088	—	10 088	19 785
Japan	230 882	63 903	1 448	73 780	—	370 013	385 505
Kenya	—	—	—	—	—	—	213
Korea	145 202	—	—	—	—	145 202	133 886
Malaysia	86 134	1 016	—	587	—	87 737	75 877
Mexico	12 758	—	—	—	—	12 758	—
Nepal	1 334	—	—	—	—	1 334	—
New Zealand	31 137	—	—	—	—	31 137	11 601
Nicaragua	—	—	3 180	—	—	3 180	1 907
Philippines	30 047	—	—	—	—	30 047	30 365
Romania	23	—	—	—	—	23	23
South Africa	13 649	28 122	—	—	—	41 771	21 500
Sri Lanka	46 686	—	—	—	—	46 686	13 614
Swaziland	—	2 431	—	—	—	2 431	—
Taiwan	38 688	—	—	—	—	38 688	29 816
United Kingdom	3 442	—	—	—	—	3 442	1 040
Vietnam	—	—	—	—	—	—	9 367
Offshore total	1 054 364	317 785	113 678	109 745	—	1 595 572	1 232 026
Total sales	1 711 998	2 654 453	1 516 798	579 957	—	6 463 206	5 678 952

Source: Potash Institute of North America.

[1] Common specifications are: standard, −28 to +65 mesh; special standard, −35 to +200 mesh; coarse, −8 to +28 mesh; −6 to +20 mesh; each grading a minimum of 60 per cent K_2O equivalent, soluble and chemical grade a minimum of 62 per cent K_2O equivalent. [2] Standard includes special standard, production of which was 261 988 tonnes K_2O equivalent in 1978, and 200 051 tonnes in 1977, and sales of chemical grade.

— Nil.

The Canadian potash deposits are the most extensive in the world. One of the recent United States Geological Survey publications, *Mineral Commodities Summaries – 1978*, places world reserves at 13.2 billion short tons, of which 10.0 billion tons are in Canada. Reserves estimated by Department of Energy, Mines and Resources are higher – 56 billion tonnes of recoverable K_2O equivalent in Saskatchewan and parts of Manitoba. Potash beds that can be mined by "conventional" methods, i.e., to a maximum depth of 1 070 metres (m), underlie approximately 29 000 square kilometres (km^2). After making various allowances, including a 30 per cent recovery factor, it was calculated that 360 000 tonnes of product (K_2O equivalent) per square kilometre can be recovered. Based on a single bed recovery, this would place reserves at 10.5 billion tonnes; however, since about one third of the area is underlain by two mineable beds this estimate of "conventional" reserves was raised to 14 billion tonnes. In addition, "solution mining" reserves (at depths of 1 070 to 2 500 m) are known to be much higher; conservatively at least three times the "conventional" reserves, thus 42 billion tonnes.

On October 3, 1978, the Supreme Court of Canada ruled that the prorationing scheme for potash production introduced by the Government of Saskatchewan in 1970 is *ultra vires* as it concerns trade, which falls under federal jurisdiction. The suit was originally launched by Central Canada Potash Co. Limited, which claimed that it was denied sales to established markets in the United States as a result of the imposition of this scheme. In preceding lower courts' decisions, the case was originally ruled in favour of Central Canada Potash Co. Limited and then reversed.

In the Supreme Court judgement it is stated that "it is, of course, true that production controls and conservation measures with respect to natural resources in a Province are, ordinarily, matters within provincial legislative authority. The situation may be different, however, where a Province establishes a marketing scheme with price fixing as its central feature. Indeed, it has been held that provincial legislative authority does not extend to the control or regulation of the marketing of provincial products, whether minerals or natural resources, in interprovincial or export trade."

It is interpreted that if Saskatchewan had introduced a program to control production without direct references to marketing or the establishment of floor prices, the court might have rendered a different decision.

A judgement in another case on the "reserve tax" was delivered by the Saskatchewan Court of the Queen's Bench on November 16, 1978. In this ruling the court upheld the provincial right to institute a "reserve tax" as a form of property tax. The court rejected the claim of five potash companies that the 1974 tax amounted to an indirect levy and ran counter to British North America Act regulations on trade and commerce. The five plaintiffs in the action are: Potash Company of America, International Minerals & Chemical Corporation (Canada) Limited; Cominco Ltd., PPG Industries Canada Ltd. and Texasgulf Potash Company.

In a parallel case, still pending, potash companies contend that the "reserve tax" contravened an earlier agreement that "royalties" will not be increased. Another case, not yet heard before the court, challenges the validity of the prorationing fee regulation.

New Brunswick. After four years of exploration the Potash Company of America (PCA) outlined a potash deposit of commercial importance near Sussex, 65 km from the all-weather port of Saint John. Potash was discovered in the Sussex area in 1971 by the New Brunswick Department of Natural Resources as a result of a jointly-funded, federal-provincial, grass-roots exploration drilling program. In January 1973 PCA was granted an exploration concession and commenced detailed drilling. In October 1977 the company was granted a mining lease and presented a detailed mining development program for provincial approval in January 1978. Work on the property began soon after and by the end of December shaft sinking had reached a depth of 100 m, with an objective of 760 m. Difficult near-surface water conditions necessitated much grouting and cementation. The completion of the shaft is targeted for October 1979 and will be followed by about four months of underground development work. By that time sufficient information on the deposit will have been obtained to finalize beneficiation plans and mining methods. At present, it is thought that the relatively steep and wide beds should be mined by cut-and-fill methods. The high-grade potash beds occur at depths between 300 and 600 m. Reserves are sufficient for at least 30 years of operation at a planned annual rate of 0.9 million tonnes of KCl. The total cost of the project is estimated at $106 million and initial production should start by the end of 1981. During the four-year construction period about 500 people will be employed. The permanent work force at the mine will be between 250 and 300. Initially, output will be approximately 630 000 tonnes per year.

During 1978 International Minerals & Chemicals Corporation (Canada) Limited (IMCC) completed its exploration drilling on another potash concession near Salt Springs, south of Sussex. The company determined that tonnage and grade are sufficient to permit exploitation at a rate similar to the PCA mine. At the time of writing (March 1979) IMCC announced that it has sold the property and

Table 3. Canada, potash production and trade, years ended June 30, 1960, 1965, 1970 and 1975-78

	Production	Imports[1]	Exports
	(tonnes K_2O equivalent)		
1960	...	77 855	...
1965	1 067 219	45 160	892 267
1970	3 565 837	24 512	3 309 758
1975	5 063 635	28 764	4 583 648
1976	4 833 296	16 445	4 314 150
1977	4 803 015	24 289	4 175 473
1978[p]	6 206 542	26 095	5 828 548

Source: Statistics Canada.
[1] Includes potassium chloride and potassium sulphate, except that contained in mixed fertilizers.
[p] Preliminary; ... Negligible.

mining rights to Denison Mines Limited. Denison plans to spend about $150 million to develop the mine for production by 1983.

Ontario. Pot-Cal Ltd. is starting up a prototype plant for production of potassium sulphate. The plant is near Parry Sound, Ontario and will have an initial capacity of about 10 000 tonnes per year. Shamrock Chemicals Limited has a plant near Port Stanley, Ontario and has been using new technology to produce potassium sulphate for the last six years. More recently the company has been unable to test the plant because of environmental considerations. Work is progressing and the company hopes to solve these problems soon.

Table 4. Canada, consumption of potash fertilizers, years ended June 30, 1960, 1965, 1970 and 1975-78

	In Materials	In Mixtures	Total
	(tonnes K_2O equivalent)		
1960	3 980	77 009	80 989
1965	16 569	106 269	122 838
1970	36 718	137 896	174 614
1975	62 945	143 868	206 813
1976	84 649	157 428	242 077
1977	76 591	157 641	234 232
1978[1]	..	..	..

Source: Statistics Canada.
[1] Data no longer available since Statistics Canada has discontinued this statistical survey.
.. Not available.

Marketing

Sales of Canadian potash in 1978 were 6 474 635 tonnes (K_2O equivalent) a 13.5 per cent increase over 1977. Offshore exports, at 1 595 564 tonnes, were 29.5 per cent higher. Domestic agriculture sales, at 349 680 tonnes, were 43.9 per cent higher. Canadian sales in the United States, at 4 509 105 tonnes, were only 6.7 per cent higher, mainly because of very unsettled spring weather conditions, which delayed planting and the application of fertilizers, and the worst ever shortage of rail cars during the same critical period. Lower spring sales were offset by very good sales from October to December. Particularly important for Canadian producers was the substantial fall in inventories, which at the beginning of the year stood at 1 182 752 tonnes but decreased to 831 629 tonnes by the end of December 1978. Inventories reached a peak of 1 292 000 tonnes at the end of February. Imports of sulphate of potash into eastern Canada were 19 819 tonnes in 1978.

Canpotex Limited represents all the Canadian potash producers for offshore sales except Potash Company of America and PPG Industries. Canpotex potash exports were up 31 per cent in 1978 after a strong year in 1977. January 1979 shipments are at record levels with indications that the coming year may be another record. Canpotex sells to offshore markets only, which are generally defined as all markets excluding Canada and the United States. During 1978, Canpotex sold to 23 different countries including first-time sales to Mexico, Nepal, Swaziland and New Guinea. Sales were at record levels to Australia, Bangladesh, Chile, Denmark, Indonesia, Malaysia, Philippines and South Africa. The largest markets are in Japan, Brazil, India and South Korea. Lately Canpotex made a 300 000-tonne sale to China for shipment between October 30, 1978 and June 30, 1979. Previously, the highest sale to China was 170 000 tonnes in 1974. China is expected to continue to import large quantities as the country will emphasize more intensive agricultural methods.

Some potash sales abroad are financed by the Canadian International Development Agency (CIDA). For fiscal year April 1, 1978 to March 31, 1979, CIDA loans were given for 63 000 tonnes to India; 62 152 tonnes to Bangladesh and 85 000 tonnes to Sri Lanka.

Prices

Potash prices fob Saskatchewan hit a low of 45 to 50 cents per short ton unit (all in U.S. dollars) for standard grade muriate of potash (60% K_2O) in August 1977. At the beginning of 1978 the price was around 50 to 55 cents, rising rapidly to the 65 to 75 cent level during the spring application period of February to May. During the slow summer period the price eased slightly to the 60 to 65 cent level reflecting the normal seasonal pattern. In the last quarter of 1978 the price increased moderately, to end the year at the 64 to 67 cent level. A very strong price uptrend commenced in February 1979. Coarse and granular grades started 1978 with a premium of 10 to 12 cents over the standard product but the difference rose to 15 to 17 cents by the end of the year. United States prices, fob Carlsbad, New Mexico, were usually at a premium of 5 to 10 cents over the Canadian price. The price of potassium sulphate (standard) was $U.S. 180 per tonne K_2O equivalent fob Carlsbad at year-end.

World review

The entire world output of potash is produced by 10 countries, of which six, the U.S.S.R., Canada, East Germany, West Germany, the United States and France account for 94 per cent of the total. Potash demand in 1978, estimated at 27.3 million tonnes, exceeded production by 1.1 million tonnes, creating a substantial fall in inventories.

United States. Production in 1978 was 2 068 733 tonnes (K_2O equivalent) up 0.1 per cent from last year. However, higher sales at 2 141 963 tonnes, up 3.0 per cent from last year, resulted in a reduction of inventories to 357 332 tonnes by the end of December, 17 per cent lower than in December 1977. Ten firms produce potash in three western

Table 5. Canada, potash sales by product and area, 1977 and 1978

		Agricultural					Industrial			
		Standard	Coarse	Granular	Soluble	Total	Standard	Soluble	Total	Total Sales
		(tonnes K_2O equivalent)								
Alberta	1977	496	1 678	6 403	523	9 100	6 552	2 717	9 269	18 369
	1978	823	719	10 493	762	12 797	9 267	1 950	11 217	24 014
British Columbia	1977	92	2 762	3 315	113	6 282	232	14	246	6 528
	1978	353	3 092	3 867	121	7 433	809	28	837	8 270
Manitoba	1977	—	2 213	2 627	14	4 854	24	13	37	4 891
	1978	655	4 353	4 300	25	9 333	45	215	260	9 593
New Brunswick	1977	24	6 413	55	2	6 494	—	—	—	6 494
	1978	—	10 170	28	—	10 198	—	—	—	10 198
Northwest Territories	1977	—	—	—	—	—	—	631	631	631
	1978	—	—	—	—	—	—	98	98	98
Nova Scotia	1977	—	4 818	—	—	4 818	—	—	—	4 818
	1978	—	5 595	—	—	5 595	—	—	—	5 595
Ontario	1977	950	131 849	1 152	515	134 466	963	4 183	5 146	139 612
	1978	6 237	199 474	791	848	207 350	1 350	6 392	7 742	215 092
Prince Edward Island	1977	—	9 333	—	—	9 333	—	—	—	9 333
	1978	—	11 633	—	—	11 633	—	—	—	11 633
Quebec	1977	1 605	55 968	—	—	57 573	45	—	45	57 618
	1978	841	82 322	57	150	83 370	125	7	132	83 502
Saskatchewan	1977	9	325	351	—	685	15	198	213	898
	1978	30	682	671	590	1 973	—	—	—	1 973
Totals	1977	3 176	215 359	13 903	1 167	233 605	7 831	7 756	15 587	249 192
	1978	8 939	318 040	20 207	2 496	349 682	11 596	8 690	20 286	369 968

Source: Potash Institute of North America.
— Nil.

states with New Mexico accounting for about 85 per cent of production. During the year, Duval Corporation closed a mine in Carlsbad and terminated the production of muriate of potash, but the company increased its production of potassium magnesium sulphate. In mid-1978 total capacity of the United States potash industry was reported at 2 570 000 tonnes (K_2O equivalent), a decrease of some 400 000 tonnes since 1970.

The Occidental Petroleum Corporation concluded a 20-year barter arrangement with the U.S.S.R. that will involve the import of potash and ammonia in exchange for superphosphoric acid. Initial potash shipments were received in 1977 and 1978 but some problems with the quality of the potash were reported. Large commercial shipments into the U.S. are expected to start in 1979. Israel increased potash sales in the United States during the year, and Jordan plans exports to the United States from its new mine after 1982. Additional imports of potash from East Germany are also expected.

United Kingdom. The country continued to import a large part of its potash requirements in 1978, as the Boulby mine still produced much below designed capacity levels. East Germany, West Germany and the U.S.S.R. were the largest suppliers. Trade with the East Bloc countries is on the increase. In 1978 Canada exported only 3 794 tonnes (K_2O) to the United Kingdom.

Considerable progress was made at the Cleveland Potash Ltd. Boulby mine with the introduction of continuous mining machines, with production expected to reach the break-even level of 0.5 million tonnes of product (KCl) in 1979. However, difficult mining conditions exist and a shutdown of this facility cannot be ruled out. In addition, planning continues on bringing the Whitby Potash and Yorkshire Potash deposits into production. Success in all these ventures could make the U.K. self sufficient in the late 1980s. The Whitby operation would use solution mining methods at a planned capacity of 450 000 tonnes per year KCl and 500 000 tonnes of salt (NaCl).

Table 6. World potash production, sales and inventories, 1976-78

	1976		1977		1978p	
	Production	Sales	Production	Sales	Production	Sales
	(000 tonnes K_2O equivalent)					
U.S.S.R.	8 310	8 310	8 347	8 347	8 700	8 700
Canada	4 096	5 186	6 082	5 679	6 124	6 475
East Germany	3 161	3 100	3 229	3 500	3 270	..
West Germany	2 036	2 148	2 341	2 362	2 470	..
United States	2 206	2 305	2 231	2 055	2 069	2 142
France	1 603	1 950	1 580	2 259	1 795	..
Israel	690	..	707	..	691	..
Spain	535	562	563	615	615	..
Italy	140	..	151	..	139	..
United Kingdom	45	..	81	..	150	..
Congo	254	236	81	167	—	—
Other countries	—	875	—	829	—	—
Total	23 976	24 672	25 393	25 813	26 222	17 317

Year-end producer inventories

	1976	1977p	1978
Canada	799	1 183	832
United States	445	431	357

Sources: Potash Institute of North America; *Phosphorus and Potassium* 1978.
p Preliminary; — Nil; .. Not available.

German Federal Republic. Production of potash was up 5.5 per cent in 1978 at 2 470 000 tonnes. With further mechanization and rationalization, West Germany is expected to be producing at a higher level in the mid-1980s than the peak of 2.62 million tonnes reached in 1974. Consumption was steady at 1.17 million tonnes (K_2O equivalent in all forms) and potash exports registered gains.

Spain. There was a steady improvement in potash production in Spain in 1978, to 615 000 tonnes (K_2O equivalent), 9.2 per cent higher than in 1977. Four mines are operating in complex, low grade deposits, which are difficult to mine and upgrade. Efforts are being made to raise production to 650 000 tonnes per year by 1980. Spain exports about half of its current output.

France. Production of potash in 1978 rose by 14 per cent to 1 795 000 tonnes K_2O equivalent despite the fact that the country experienced rotating strikes toward the end of the year. Further improvement to the 2.0-million-tonne-level is possible, but above this level production would be limited both by reserve considerations and by a ceiling on the amount of salt brine that can be expelled into the Rhine River.

Italy. Five mines in Sicily produced a total of 139 000 tonnes of potash (K_2O equivalent) in 1978. Some production of muriate of potash was recorded up to 1975 but from that time on all output has been in the form of kainite, which is concentrated to give a 52 per cent product of potassium sulphate. Production is being rationalized and modest expansion to about 170 000 tonnes per year is expected by the early 1980s. Italy imports about 250 000 tonnes of potash, with East Germany and U.S.S.R. being the main suppliers.

Brazil. The country imported over 1 million tonnes of potash in 1978 slightly above 1977 levels. Canada was able to improve its exports of coarse and granular products to Brazil significantly. The extensive deposits of potash which occur in the Sergipe Basin in east-central Brazil are considered to be the geological extension of the African Gabon-Congo basin, formed before the continents split apart. Although the deposits are complex and of rather low grade, a decision was made in 1978 to develop a mine for production in the mid-1980s. French technical and financial assistance was successfully negotiated.

India. The country is a large importer of potash, having no indigenous resources. There are however some geological indications that saline formations exist in the western part of the country and exploration programs for potash are being undertaken. India now imports about 0.5 million tonnes (K_2O equivalent) of potash, mainly from Eastern Europe, West Germany and Canada. India expects a very rapid growth in fertilizer application, with their requirement in nutrient content (K_2O) rising from 0.5 to 1.5 million tonnes by 1988.

People's Republic of China. Production of potash in China is now estimated to be slightly below 0.5 million tonnes per year. Annual imports vary widely from less than 50 000 tonnes to 300 000 tonnes. It is expected that China's growth in demand in the next decade will be equal to or surpass that of India, reaching at least 1.5 million tonnes (K_2O equivalent) in 1988.

Israel. Dead Sea Potash Works produced 691 000 tonnes (K_2O) in 1978 and exported just over 700 000 tonnes. These higher levels were achieved despite a strike in the fourth quarter. Since domestic consumption is just over 100 000 tonnes, there was a substantial decrease in inventories during the year. The company is continuing an expansion program which will result in a 25 per cent rise in capacity in the early 1980s. Compactors to produce more granular product (250 000 tonnes per year) will be installed during 1979.

Jordan. International financing arrangements were completed for Jordan's major project that was designed to produce, through evaporation, 1.0 million tonnes per year of potash from Dead Sea brine. Construction of solar ponds commenced late in 1978, with initial production targeted for 1982 and full production by 1985. Total estimated costs of \$428.8 million will be financed by a number of Arab funding organizations as well as the World Bank and the United States AID agency. Sales contracts were secured for most of the output, of which about one third will be marketed on the American continent. In addition to potash extraction, the company plans to construct a \$120 million plant to recover 50 000 tonnes per year of magnesium and 30 000 tonnes per year of bromine. Great Lakes Chemical Corporation will hold a 25 per cent interest and provide technological assistance.

German Democratic Republic. East Germany increased potash production and exports. Exports to non-communist countries, at 640 000 tonnes and to communist countries, at 1.46 million tonnes were higher for the fertilizer year 1977-78. Some 300 000 tonnes were shipped to Latin America. East Germany signed an agreement to supply Cuba's total requirements of potash (approximately 150 000 tonnes per year) for the next three to five years, partly displacing imports from the U.S.S.R. East Germany plans a modernization and expansion program that will result in an increase in productive capacity of up to 0.5 million tonnes in the early 1980s. Construction of a 250 000-tonne-per-year plant for the Zielitz potash will commence in 1979.

U.S.S.R. The country's production in 1978 is estimated at 8 700 000 tonnes. For the fertilizer year 1977-78, 2.54 million tonnes were exported of which 1.65 million tonnes went to Eastern Europe. A large expansion program is in progress that will result in a 40 to 50 per cent capacity increase by the mid-1980s, mainly through new mines and expansions at the Soligorsk centre in Byelorussia and

Table 7. Summary of world potash mines, 1978

Company or Operating Name	Mine Name and/or Plant Location	Initial Production	Processing Methods: Crystal-lization	Processing Methods: Flota-tion	Principal Products: K_2SO_4 and/or $K_2Mg_2(SO_4)_3$	Principal Products: KCl 40-50% K_2O	Principal Products: KCl 60% K_2O	Principal Products: KCl 62% K_2O	Annual Capacity (thousand tonnes K_2O equivalent)
North America									
Canada									
Potash Corporation of Saskatchewan Mining Ltd. (PCS):									
Cory Division	Saskatoon, Saskatchewan	1968	x	xx	–	–	xx	x	655
Rocanville Division	Rocanville, Saskatchewan	1970	x	xx	–	–	xx	x	655
Lanigan Division	Lanigan, Saskatchewan	1968	x	xx	–	–	xx	x	545
Allan Potash Mines Limited (PCS-60%; Texasgulf Inc.-40%)	Allan, Saskatchewan	1968	x	xx	–	–	xx	x	815
International Minerals & Chemical Corporation (Canada) Limited	K-1, Esterhazy, Saskatchewan	1962	x	xx	–	–	xx	x	
(PCS contracts up to 25%									2 285
of annual production)	K-2, Esterhazy, Saskatchewan	1967	x	xx	–	–	xx	x	
Central Canada Potash Co. Limited	Viscount, Saskatchewan	1969	x	xx	–	–	xx	x	815
Cominco Ltd.	Vanscoy, Saskatchewan	1969	x	xx	–	–	xx	x	545
PPG Industries Canada Ltd.	Belle Plaine, Saskatchewan	1964	x	–	–	–	–	xx	845
Potash Company of America	Saskatoon, Saskatchewan	1965	x	xx	–	–	xx	x	415
								Total Canada	7 575
United States									
Kerr McGee Chemical Corporation	Trona, California	1926	x	–	–	–	–	x	178
	Hobbs, New Mexico	1965	x	–	–	–	–	x	336
Mississippi Chemical Corporation	Carlsbad, New Mexico	1931	–	xx	–	–	x	–	180
Potash Company of America	Carlsbad, New Mexico	1935	x	xx	x	–	xx	x	490
International Minerals & Chemical Corporation	Carlsbad, New Mexico	1940	x	x	x	–	x	–	330

Table 7. (cont'd)

Company or Operating Name	Mine Name and/or Plant Location	Initial Production	Processing Methods: Crystal-lization	Processing Methods: Flota-tion	Principal Products: K_2SO_4 and/or $K_2Mg_2(SO_4)_3$	Principal Products: KCl 40-50% K_2O	Principal Products: KCl 60% K_2O	Principal Products: KCl 62% K_2O	Annual Capacity (thousand tonnes K_2O equivalent)
United States (cont'd)									
Duval Corporation	Carlsbad, New Mexico	1952	x	xx	x	–		–	100
Amax Chemical Corporation	Carlsbad, New Mexico	1952	–	x	–	–	x	–	450
National Potash Company	Carlsbad, New Mexico	1957	x	xx	–	–	x	–	200
Texasgulf Inc.	Moab, Utah	1965	x	–	–	–	x	–	136
Kaiser Aluminum & Chemical Corp.	Wendover, Utah	1938	x	xx	–	–	–	x	50
Great Salt Lake Minerals & Chemical Corporation	Ogden, Utah	1971	xx	x	x	–	–	–	120
						Total United States			2 570
(in addition Dorchem, Odessa, Texas started in 1978 production of K_2SO_4 from purchased raw materials at 27 000 t.p.a.)									
South America									
Chile									
Soc. Guimica y Minera de Chile, S.A.	Salar del Miraje, Antofagasta	1800s	x	–	KNO_3	–	–	–	23
Western Europe									
France									
Mines de Potasse d'Alsace S.A.	Amelie, Alsace	1911	x	–	–	–	x	–	650
	Marie-Louise, Alsace	1914	x	–	–	–	x	x	1 100
	Theodore, Alsace	1914	x	x	–	–	x	–	450
							Total France		2 200
Germany, West									
Kali und Salz A.G.	Wintershall, Hessen	1903	x	–	x	–	x	x	585
	Hattorf, Hessen	1910	x	–	x	x	x	–	420
	Neuhof-Ellers, Hessen	1956	–	x	–	x	x	–	310
	Bergmannssegen-Hugo, Niedersachsen	1900-10	x	–	–	x	x	–	250
	Salzdetfurth, Niedersachsen	1900	x	–	–	–	x	–	300
	Siegfried-Giesen, Niedersachsen	1906	x	–	–	x	–	–	250

	Sigmundshall, Niedersachsen	1900-10	x	x	–	–	x	x	365
	Niedersachsen-Riedel	1900-10	x	–	–	–	x	x	220
Kali Chemie A.G.	Friedrichsall, Niedersachsen	1930-40	–	x	–	x	x	–	220
						Total	West Germany		2 920
Italy									
Industria Sali	S. Cataldo/Palo,Caltanissetta	1960	x	x	x	–	–	–	45
Potassici e Affini	Pasquasia/Corvillo, Enna	1964	x	x	x	–	–	–	125
	Racalmuto, Agrigento	1970	x	x	x	–	–	–	50
EMSAMS	Realmonte, Agrigento	1977	x	x	x	–	–	–	15
							Total	Italy	235
Spain									
Minas de Potasa de Suria S.A.	Suria, Catalonia	1926	x	x	–	x	x	–	150
Union Espanola	Cardona, Catalonia	1930	–	x	–	x	x	–	141
Explosives S.A.	Llobregat, Catalonia	1948	–	–	–	x	x	–	199
Potasas de Navarra	Pamplona, Navarra	1963	x	x	–	x	x	x	290
							Total	Spain	780
United Kingdom									
Cleveland Potash Limited	Boulby	1973	x	x	–	–	x	x	600
Eastern Europe									
Germany, East									
V.E.B. Kombinat Kali:									
Kalibetrieb "Werra"	Unterbreizbach	1900-10	x	–	x	x	x	–	340
	Dorndorf	1900-10	x	–	x	x	x	–	306
	Merkers	1900-10	x	–	x	x	x	–	510
Kali-und Steinsaltz-betrieb "Saale"	Teutschenthal, Halle	1907	x	–	–	–	x	–	34
Kalibetrieb "Sudharz"	Rossleben, Halle	1905	–	x	x	x	–	–	306
	Sondershausen, Erfurt	1895	x	–	–	x	–	–	204
	Menteroda, Muhlhausen	1909	x	–	x	x	–	–	136
	Sollstedt, Erfurt	1905	x	–	–	x	x	x	170
	Bleichrode, Erfurt	1902	x	–	x	x	–	–	204
	Bischofferode, Erfurt	1915	x	–	x	x	–	–	136
Kalibetrieb Zielitz	Krs Wolmirstedt	1973	–	x	–	–	x	–	1 054
							Total	East Germany	3 400

Berezhniki-Solikamsk centre in the Urals. Some of this expected increase will result in substantially greater exports to the west. Occidental Petroleum Corporation of the U.S. signed a 20-year agreement to purchase 0.6 million tonnes of potash (K_2O equivalent) a year in a trade deal that also includes export of phosphoric acid to the U.S.S.R. and the import of ammonia. It is envisaged that shipping and storage problems will continue to be the main difficulties of the Russian delivery system. Some apprehension about quality control was also voiced.

Outlook

A wet spring in 1978 precluded normal fertilizer applications in much of the United States, but there are predictions of increased application in 1979. Part of this desire by consumers to restock ahead of the next spring season is already evident in higher than normal "disappearance" from inventories in the last quarter of 1978. Stocks should decline to near normal during 1979 and prices will be firm throughout the year. In spite of expected sales of U.S.S.R. potash on this continent, no clouds appear on the horizon for potash producers for the next two or three years. Indeed, higher imports from the U.S.S.R. are deemed necessary to supplement North American supply, and failure to meet forecast export levels, which is always a possibility given the U.S.S.R.'s production and transport bottlenecks, may add to the tightening market situation.

Transport of potash however is also a problem in North America, with a shortage of railway hopper cars in evidence every spring. These difficulties are expected to continue for a few years. Experiments with unit trains taking Saskatchewan potash to several major depot centres in the United States and eastern Canada are to be undertaken in 1979.

Rhenium

J.J. HOGAN

Rhenium was first isolated in 1925 and produced commercially in small quantities in 1930. Output increased with improvements in recovery technology and with the development of new uses. The only known commercial source for rhenium is molybdenum concentrates, which are recovered from the treatment of low-grade porphyry copper ores. The rhenium content of such ores is relatively low, being only a few parts per million (ppm), whereas the molybdenite concentrates produced from these ores have a rhenium content that varies from 300 to 2 000 ppm. Rhenium has been identified in certain molybdenum, manganese and uranium ores, but in concentrations too low to be of economic significance under present technology and price structure.

Canadian rhenium production comes from the copper-molybdenum ore of Utah Mines Ltd. (Island Copper mine) at Port Hardy, Vancouver Island, British Columbia. The ore occurs mainly in altered volcanic rocks and, in this respect, differs from the prophyry copper deposits that have been the major source of rhenium in the United States and Chile. Rhenium has also been identified in the prophyry copper ores of Lornex Mining Corporation Ltd. and Brenda Mines Ltd., near Kamloops, British Columbia.

The United States, the largest producer of rhenium metal and rhenium salts in the non-communist world, recovers rhenium mainly from molybdenum-bearing porphyry copper ores in the western states. The following companies have facilities for the recovery of rhenium: S.W. Shattuck Chemical Co., of Denver, Colorado, a division of Engelhard Minerals & Chemicals Corporation; M & R Refractory Metals, Inc. of Winslow, New Jersey; Molycorp Inc. of Washington, Pennsylvania and Cleveland Refractory Metals, Inc. (CRM) of Solon, Ohio, a division of Chase Brass & Copper Co. Incorporated (a subsidiary of Kennecott Copper Corporation). Not all of the plants operated in 1978.

Chile, a substantial producer of rhenium, recovers rhenium from byproduct molybdenite concentrates produced from its large porphyry copper deposits. In 1974, Chile began to export ammonium perrhenate (NH_4ReO_4) to the United States. Data published by the United States Bureau of Mines (USBM), indicated that the United States imported substantial quantities of NH_4ReO_4 in 1978. Rhenium is generally used in this form by industry, but it can be further processed to rhenium powder. Prior to 1974 rhenium exported from Chile was contained in molybdenite concentrates shipped for treatment to the United States and elsewhere. Other countries that have metallurgical plants for the recovery of rhenium are the U.S.S.R., Sweden, Belgium and the Federal Republic of Germany. With the exception of the U.S.S.R., these countries recover rhenium from molybdenite concentrates imported from producing countries. In 1978, the Federal Republic of Germany exported substantial quantities of NH_4ReO_4 to the United States as well as small quantities of unwrought rhenium metal.

Production

Rhenium is a recent addition to the metals produced from Canadian ores, with production first being recorded in 1972 by Utah Mines. This company reported that the rhenium content of the molybdenite concentrate produced in 1978 at its Island Copper mine varied from 900 to 1 350 ppm, and averaged about 1 198 ppm. This compares with an average of about 1 117 ppm in 1977. In 1978, shipments of molybdenite concentrates by Utah Mines to the United States totalled approximately 2 086 tonnes*, compared with shipments of approximately 2 283 tonnes in 1977. The rhenium contained in the concentrates shipped was treated at the smelter on a toll basis and the recovered rhenium was returned to the company as perrhenic acid for subsequent sale. With present technology, the recovery of rhenium contained in the molybdenite concentrates is low, and ranges from 50 to 60 per cent. Based on 1978 shipments and estimated grade and recovery, the rhenium recovered from Canadian ores in 1978 was about 1 270 kilograms (kg).

Statistical data on world output and the total value of rhenium are not available. In order to avoid disclosing company confidential data, rhenium production in the United States in 1978 has not been made available. The

*The term "tonne" refers to metric ton of 2 204.62 pounds avoirdupois.

USBM estimated output of rhenium by Chile in 1978 to be 2 268 kg. The U.S.S.R., also a large producer of the metal, recovers rhenium form its porphyry copper deposits and production in 1978 was estimated to be about 907 kg by the USBM.

Technology

Rhenium has become an important industrial metal because of its special properties. The metal is highly refractory, having a melting point of 3 100°C, exceeded only by that of tungsten, and maintains strength and ductility at high temperatures. Its density is 21 grams per cubic centimetre (g/cm^3), exceeded only by that of the platinum group metals. Rhenium has good corrosion resistance to halogen acids. Alloyed with tungsten or molybdenum, rhenium improves the ductility and tensile strength of these metals. Stable oxide film on rhenium does not appreciably increase electrical resistance and this property, plus good resistance to wear and arc corrosion, makes the metal ideally suited for electrical contacts.

Rhenium is recovered from flue gases emitted from the roasting of byproduct molybdenite concentrates. Under properly controlled temperature, rhenium volatilizes as rhenium heptoxide (Re_2O_7), a compound which is readily soluble in an aqueous solution and can be recovered by subjecting flue gases to wet scrubbing. The rhenium is extracted from this solution as NH_4ReO_4 by ion-exchange resins or by solvent extraction. Perrhenic acid ($HReO_4$) is also an important commercial product of rhenium. Rhenium metal (99.99 per cent pure) is produced by the reduction of NH_4ReO_4 with hydrogen to produce rhenium powder. The powdered form is pressed and sintered into bars which are cold-rolled to form different shapes. The cost of producing rhenium metals and salts is high. Recent research has been directed towards the development of a hydrometallurgical process to recover molybdenum and rhenium from molybdenite concentrates in order to attain a higher rate of recovery and lower cost of production.

Uses

The major use of rhenium is in petroleum-reforming catalysts used to produce high-octane gasoline without the addition of lead. About 90 per cent of rhenium consumed is used for this purpose. Other important applications include electronic devices, high temperature thermocouples, temperature controls, heating elements, metallic coatings, and research and development. It is also used to produce ductile, high-temperature, tungsten-based alloys used in the electronic field.

World statistics on consumption of rhenium are limited. The United States is the world's largest consumer of rhenium and rhenium salts. According to the USBM, the United States used an estimated 5 443 kg in 1978, compared with 3 251 kg in 1977.

Outlook

Rhenium has been used as an industrial metal for only a short period and has not developed a clearly defined economic structure. The uncertainty of supply is an adverse factor. The potential supply of the metal is virtually limited to the rhenium contained in byproduct molybdenite concentrates obtained from porphyry copper ores. Under present technology, the overall recovery of molybdenite from the processing of copper ores varies considerably but is relatively low. The recovery of rhenium from the treatment of molybdenite concentrates is about 60 per cent. Any improvement in the recovery rate in either of these areas would increase the supply of available rhenium.

Not all producers of molybdic oxide recover rhenium from the treatment of byproduct molybdenite concentrates, because of the capital costs involved in building a recovery plant. These molybdic oxide operations are a potential source of rhenium, but the recent sharp drop in the price of the metal is a deterrent to committing funds for a recovery plant.

In the short-term the major demand for rhenium will continue to be its use as a bimetallic platinum-rhenium catalyst in the petroleum reforming industry. Rhenium used for this purpose could increase as more stringent standards are introduced for automotive emissions and the use of tetraethyl lead in gasoline is further reduced. Substitutes are available and are being evaluated for catalytic applications and could replace rhenium. However, it is expected that rhenium consumption will remain near its present level with perhaps a small upward trend. As world production of rhenium metal and salts exceeds consumption, stocks will continue to increase. The USBM estimated that stocks of rhenium in the hands of consumers, producers and dealers at the end of 1977 were 9 072 kg, but did not report stocks at the end of 1978 to avoid disclosure of confidential data. Imports into the United States increased in 1978 and a portion of these imports were probably added to existing stocks.

Prices

According to *Metals Week*, the quoted United States prices at the beginning of the year for the rhenium content of perrhenic acid and for rhenium powder were $772 per kg ($350 per lb.) and $827 per kg ($375 per lb.), respectively. On April 4, 1978, the prices of these products were lowered to $705 per kg ($320 per lb.) and $760 per kg ($345 per lb.). On September 14, 1978, *Metals Week* suspended publishing a list price for these commodities. Reports indicate that there has been an improvement in the price in the early part of 1979.

Salt

G.S. BARRY

Although many mineral commodities are important to man's development, few can be classed as essential to his very existence as can common salt, a compound of sodium and chlorine. Sodium chloride (NaCl), halite in mineralogic terms, is widely distributed throughout the world, a fact that has influenced history and the location of industry. Salt occurs in solution in seawater, in some spring and lake waters, in many subsurface waters, and in solid form in surface and underground deposits. Although seawaters contain the largest reserve of salt and contribute substantial quantities of solar-evaporated salt to the world's annual output, underground bedded and dome deposits supply the largest part of the world's salt requirements.

Summary

In Canada, underground salt deposits have been found in all provinces except British Columbia. They have also been found in the District of Mackenzie, Northwest Territories, and in some of the Arctic islands. Bedded rock salt deposits in southwestern Ontario, Saskatchewan and Alberta, and dome deposits in Nova Scotia are the sources of most of Canada's salt output. In past years, salt has been recovered from brine springs and natural subsurface brines in Nova Scotia, New Brunswick, Ontario, Manitoba, Saskatchewan and Alberta. Salt springs are also common to certain parts of British Columbia.

Canadian production of rock salt, from three underground mines, increased by 4.6 per cent in 1978 to over 4.5 million tonnes*. Fine salt, produced by multi-stage vacuum pan evaporation at six plants, totalled 723 000 tonnes, while the production of salt in brine, generally for caustic soda, chlorine and sodium carbonate production, increased by 6.9 per cent to 1.1 million tonnes. Two potash refining operations in Saskatchewan supplied byproduct salt for the production of fine salt and for highway application during the year.

Imports of salt and salt brine were up by 18 per cent in 1978 to 1.33 million tonnes, with British Columbia, Ontario and Quebec being the main importers. Exports, principally to the United States, were up 38 per cent to 1.6 million tonnes.

During 1978, Seleine Inc., a subsidiary of Quebec Mining Exploration Company (SOQUEM), continued exploratory and mine development work on a salt deposit on the Magdalen Islands, and the Potash Company of America indicated that it will consider the feasibility of mining salt in conjunction with their potash mine now under development in New Brunswick.

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Recovery methods

Canadian producers employ three different techniques in the recovery of salt and/or brine from depth, the method employed depending upon the nature of the deposit and the type of salt in demand. Conventional underground mining methods are used to mine good-quality rock salt deposits that are relatively shallow and located in areas near large markets that do not specify a high-purity product, or located close to inexpensive, large-volume, bulk-transporting facilities.

Brining methods, too, are used to recover salt from subsurface deposits, usually from depths greater than acceptable mining depths. Brine can be evaporated to produce high-purity, fine, vacuum salt, or it can be used directly in the manufacture of chemicals. Salt is similarly recovered from natural subsurface brines.

The third technique is to recover salt as a coproduct of potash mining, a practice quite common in Europe. In Canada the only commercial application of this technique is at a solution-type potash mine, where production methods permit the recovery of a good-quality salt brine. The other potash producers generally regard the waste salt as unmarketable, although some shipments have been made for use in snow and ice control.

A fourth method (not used in Canada) is solar evaporation of sea or salty lake waters, a process commonly used in warm, arid climates.

Rock salt mining

Access to rock salt deposits for conventional mining is through vertical shafts, normally about 5 metres (m) in diameter, serving the mining zone at depths of 200 to 600 m. Mining is normally by the room-and-pillar method, the dimensions depending on the depth and thickness of the salt deposit. Rooms vary from 9 to 15 m in width and from 5.5 to 15 m in height, and pillars vary from about 20 to 60 metres square. Extraction ranges from 40 to 60 per cent. The mining operations consist of undercutting, drilling, blasting, loading and primary crushing. Underground haulage is generally by trucks and conveyor belts. Milling involves crushing, screening and sizing; at one mine the milling is done underground. The product, ranging in size from about 1 centimetre (cm) to a fine powder, normally

Table 1. Canada, salt production and trade, 1977 and 1978

	1977		1978p	
	(tonnes)	($)	(tonnes)	($)
Production				
By type				
Mined rock salt	4 338 488	. .	4 543 976	. .
Fine vacuum salt	667 998	. .	723 170	. .
Salt content of brines used or shipped	1 037 621	. .	1 106 895	. .
Total	6 044 107	. .	6 374 041	. .
Shipments				
By type				
Mined rock salt	4 320 305	53 085 170	4 625 322	. .
Fine vacuum salt	681 557	32 738 971	720 064	. .
Salt content of brines used or shipped	1 037 621	4 251 517	1 106 895	. .
Total	6 039 483	90 075 658	6 452 281	104 042 000
By province				
Ontario	4 586 491	57 141 078	4 865 588	66 495 000
Nova Scotia	852 147	17 432 324	923 290	19 234 000
Saskatchewan	255 412	8 152 915	297 467	9 258 000
Alberta	318 158	7 183 978	358 098	9 003 000
Manitoba	27 275	165 363	7 838	52 000
Total	6 039 483	90 075 658	6 452 281	104 042 000
Imports				
Salt and brine				
United States	801 262	8 634 000	980 651	18 701 000
Mexico	294 087	2 144 000	327 766	2 764 000
Spain	24 698	236 000	21 760	320 000
Switzerland	54	25 000	24	11 000
Other countries	6 124	123 000	264	7 000
Total	1 126 225	11 162 000	1 330 465	21 803 000
Salt and brine by province of landing				
Newfoundland	34 923	363 000	14 484	222 000
Nova Scotia	229	14 000	7 320	102 000
New Brunswick	333	22 000	–	–
Quebec	305 386	3 279 000	299 781	10 462 000
Ontario	342 782	3 182 000	508 525	5 153 000
Manitoba	222	18 000	373	23 000
Saskatchewan	1	. . .	36	3 000
Alberta	480	17 000	5	1 000
British Columbia	441 869	4 267 000	499 950	5 837 000
Total	1 126 225	11 162 000	1 330 474	21 803 000

Table 1. (cont'd)

	1977		1978p	
	(tonnes)	($)	(tonnes)	($)
Exports				
Salt and brine				
United States	1 158 208	8 666 000	1 603 454	12 498 000
Guyana	2 442	300 000	1 225	154 000
Leeward-Windward Islands	637	33 000	1 988	86 000
Nigeria	–	–	525	38 000
Barbados	401	23 000	462	26 000
St. Pierre-Miquelon	963	48 000	308	19 000
Other countries	512	53 000	577	66 000
Total	1 163 163	9 123 000	1 608 539	12 887 000

Source: Statistics Canada.
pPreliminary;. . Not available; - Nil; . . . Less than $1 000.

Table 2. Canada, salt shipments, 1960, 1965, 1970 and 1975-78

	Producers' Shipments					
	Mined Rock	Fine Vacuum	In Brine and Recovered in Chemical Operations	Total	Imports	Exports
			(tonnes)			($)
1960	1 200 075	393 299	1 413 871	3 007 245	174 125	3 461 366
1965	2 177 170	506 523	1 474 929	4 158 622	400 614	4 996 509
1970	3 272 520	552 704	1 036 285	4 861 509	560 659	7 430 000
1975	3 626 123	578 649	917 801	5 122 573	1 183 144	5 185 000
1976	4 354 684	676 191	963 144	5 994 019	1 523 407	9 558 000
1977	4 320 305	681 557	1 037 621	6 039 483	1 126 225	9 123 000
1978p	4 625 322	720 064	1 106 895	6 452 281	1 330 465	12 887 000

Source: Statistics Canada.
pPreliminary.

has a purity of 96 per cent NaCl or better. Most of the gypsum, anhydrite and limestone impurities are removed during crushing and screening. Small amounts of the coarser salt fractions are further beneficiated by use of electronic sorters.

Most of the rock salt mined in Canada is shipped in bulk by water, rail and road, much of it being used for snow and ice control.

Brining and vacuum-pan evaporation

Underground brining is accomplished by injecting water into a salt deposit to dissolve the salt, then pumping the resulting saturated salt solution to the surface. Water injection and brine recovery can be done through a single borehole with casing and tubing, or through a series of two or more cased wells. A brine field normally has from 2 to 20 wells, depending on the quantity of brine needed for the surface operation. Depths of the brine fields in Canada range from 335 to 1 980 m. Saturated salt brine contains 26 per cent NaCl, which equates to about 300 grams (g) of salt per litre (ℓ). At the surface the brine is either evaporated to produce fine vacuum salt, or used directly in the manufacture of chemicals.

Canadian producers use a vacuum-pan process to evaporate the brine and produce fine salt. The brine is purified to remove gypsum and other impurities and fed into a series of three or four large cylindrical steel vessels under

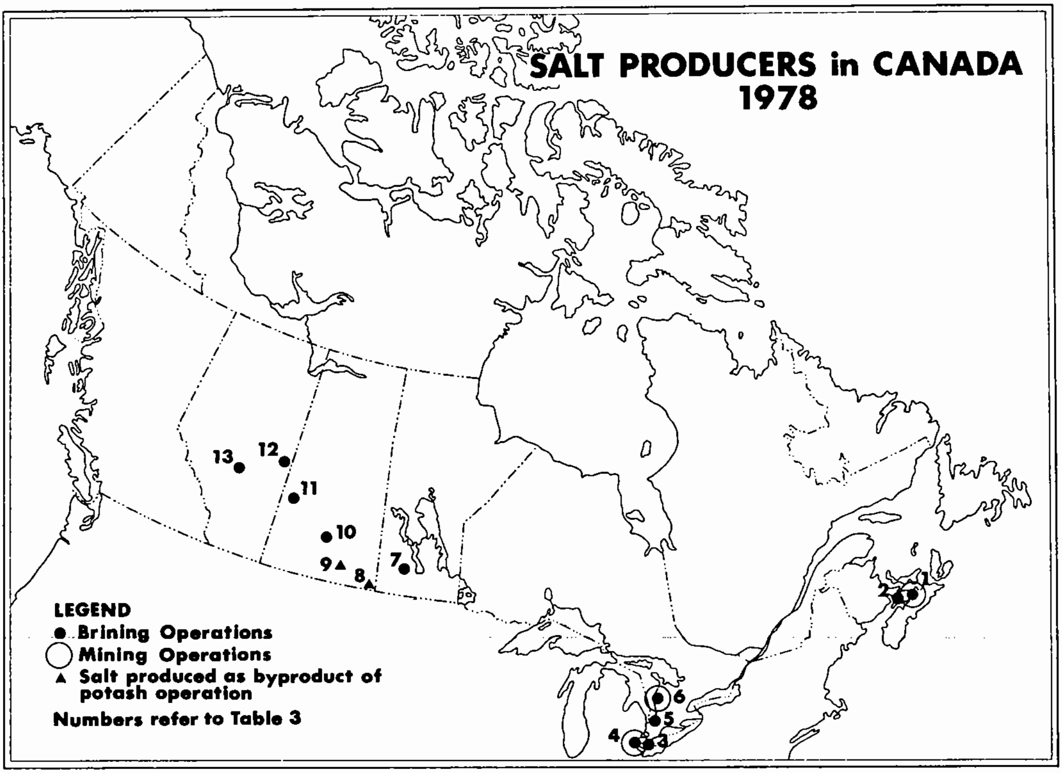


Table 3. Canada, summary of salt producing and brining operations, 1978

Company	Location	Initial Production	Remarks
	(numbers correspond to those on map above)		
Nova Scotia			
1. The Canadian Salt Company Limited	Pugwash	1959	Rock salt mining at a depth of 192 metres (m).
	Pugwash	1962	Dissolving rock salt fines for vacuum pan evaporation.
2. Domtar Inc.	Amherst	1947	Brining for vacuum pan evaporation.
Ontario			
3. Allied Chemical Canada, Ltd.	Amherstburg	1919	Brining to produce soda ash.
4. The Canadian Salt Company Limited	Ojibway	1955	Rock salt mining at a depth of 300 m.
	Windsor	1892	Brining, vacuum pan evaporation and fusion.

Table 3 (cont'd)

Company	Location	Initial Production	Remarks
5. Dow Chemical of Canada, Limited	Sarnia	1950	Brining to produce caustic soda and chlorine.
6. Domtar Inc.	Goderich	1959	Rock salt mining at a depth of 536 m.
	Goderich	1880	Brining for vacuum pan evaporation.
Prairie Provinces			
7. Hooker Chemical Canada Ltd.	Brandon, Man.	1968	Pumping natural brines to produce caustic soda and chlorine. Operation purchased from Dryden Chemicals Limited in 1974.
8. International Minerals & Chemical Corporation (Canada) Limited	Esterhazy, Sask.	1962	Byproduct salt from potash mine for use in snow and ice control.
9. The Canadian Salt Company Limited	Belle Plaine, Sask.	1969	Producing fine salt from byproduct brine from potash mine.
10. Northern Industrial Chemicals Ltd.	Saskatoon, Sask.	1968	Brining to produce caustic soda and chlorine.
11. Domtar Inc.	Unity, Sask.	1949	Brining, vacuum pan evaporation and fusion.
12. The Canadian Salt Company Limited	Lindbergh, Alta.	1968	Brining, vacuum pan evaporation and fusion.
13. Dow Chemical of Canada, Limited	Fort Sask. Alta.	1968	Brining to produce caustic soda and chlorine.

vacuum for triple- or quadruple-effect evaporation. The salt crystallizes and is removed as a slurry, washed, filtered and dried. Product purity is generally 99.5 per cent or better.

Final processing involves screening, the introduction of additives, compression into blocks, briquettes or tablets; or compaction, recrushing and packaging to prepare as many as 100 different salt products. In some cases, quantities are melted at a temperature of about 815°C and allowed to cool. This produces a fused salt, which is particularly suitable for use in water softeners.

Production and developments in Canada

Atlantic region. Salt deposits occur in isolated sub-basins of a large sedimentary basin that underlies the northern mainland of Nova Scotia and extends westward under the bordering areas of New Brunswick, northeastward under Cape Breton Island, Prince Edward Island, the Magdalen Islands and southwestern Newfoundland. The salt beds occur within the Mississippian Windsor Group and are generally folded and faulted. The deposits appear to be steeply dipping tabular bodies, domes and brecciated structures of rock salt.

The salt production in the Atlantic provinces in 1978 was from an underground mine at Pugwash, Nova Scotia and a brining operation near Amherst, Nova Scotia. At Pugwash, The Canadian Salt Company Limited, completed a major development program to achieve production from the new 250 m level through a newly rebuilt second shaft, increasing hoisting capacity to 3 000 tonnes per 8-hour shift.

Salt domes in both Richmond and Inverness counties in Nova Scotia have been explored by Domtar Inc., Chemicals Division, and The Dow Chemical Company for gas storage purposes, and early in 1978 Home Oil Company Limited sank two test holes in the McIntyre Lake region near the Strait of Canso to determine oil storage capability. It is apparent that additional drilling is required before the full potential of the area is determined. Home Oil, in partnership with Murphy Oil Company Ltd. and North Canadian Oils Limited, applied for a contract in September 1977 with the United States Government to store 100 million barrels of crude oil as part of that country's long-term strategic storage program. In early 1979 Gulf Canada Limited bought out the interest held by Murphy Oil and North Canadian Oils, becoming an equal partner with Home Oil. The marine terminal of Gulf's refinery is only 18 kilometres (km) away from the salt domes. No decision has yet been made by the United States Department of Energy on this facility or on the competing storage proposed in the abandoned iron ore mine on Bell Island, Newfoundland. It is estimated that creating a cavern for storage would cost about $2 a barrel, or about $200 million for the 100 million barrels of proposed storage.

In New Brunswick, Potash Company of America (PCA) has a major potash mine under construction at Plumweseep, near Sussex, 60 km east of Saint John. The company announced that it is also considering the feasibility of producing common salt from a section of the mine which contains beds of high purity. Initial production of potash is scheduled for the fall of 1981 and it may be one or two years later before salt will be produced. There are other saline deposits in the area and International Minerals & Chemicals (Canada) Limited (IMCC) currently has a deposit of potash that may be brought into production in the 1980s. In early 1979, IMCC was negotiating to sell the property to another corporation.

Quebec. Quebec Mining Exploration Company (SOQUEM) continued its rock salt mine development program on Grosse-Ile (Dauphin deposit) on the Magdalen Islands during 1978. Surface installations were completed for an underground program of development and a shaft having a diameter of 4.3 m was sunk to a depth of 203 m. At that elevation some 1000 m of horizontal drifting and extensive drilling was undertaken to determine the structure, extent and quality of the salt deposit. A decision to proceed to production could be made during the first half of 1979. Some $12 million have been spent on exploration and development to date. Additional capital costs of $30 to 40 million would be required to bring the project to production at an annual capacity of 1.25 million tonnes. Current reserves are estimated at 480 million tonnes of rock salt grading between 85 and 100 per cent NaCl. There is still some uncertainty about the average grade to be mined, but it is reported to be around 94 per cent NaCl. Some sections in the deposit contain 98 per cent salt.

Environmental impact studies are also in progress; for some time now local groups have been apprehensive, particularly about effects of the salt tailings on the lobster industry that provides the economic underpinning of the islands. The Environmental Consultative Council of Quebec strongly recommended that intensive studies should be undertaken and has criticized the promoters of the project for not initiating such studies at an earlier date. Transportation studies include the feasibility of a deep-sea port suitable for domestic as well as foreign marketing. Lately a modified scheme being studied is the use of barges instead of cargo vessels to carry salt to the St. Lawrence ports or simply to deep water for transfer to ocean vessels. Although the economics of production have not yet been fully assessed, it may be presumed that some extraction will take place in the 1980s. A major determinant would be a decision by Quebec Department of Highways to sign a long-term contract for Magdalen Islands salt. The department uses about 800 000 tonnes out of the total 1.3 million tonnes of salt that is applied on Quebec's roads annually. Such a decision would materially affect sales of salt from The Windsor-Sarnia area of Ontario and the Pugwash mine in Nova Scotia.

The Magdalen Islands salt domes are so extensive that serious thought is being given to the utilization of the formations for storage of oil, gas and other products. Laduboro Oil Ltd. holds provincial permits to develop such a system of storage reservoirs and this opportunity continues to be under active consideration.

Table 4. World salt production, 1976-78

	1976	1977[p]	1978[e]
	(000 tonnes)		
United States	40 114	39 383	39 630
People's Republic of China[e]	30 000	30 000	30 000
U.S.S.R.[e]	14 000	15 500	15 690
West Germany	11 822	12 398	12 520
United Kingdom	8 006	8 001	8 070
France	6 416	6 486	6 530
Canada	5 994	6 039	6 220
Australia	4 700[e]	4 808	4 810
Mexico	4 591	4 536	4 720
Italy	4 013	4 199	4 170
Poland	3 818	3 874	3 990
India	3 068	1 757	1 810
Other countries	31 623	33 083	33 660
Total	168 165	170 064	171 820

Sources: U.S. Bureau of Mines, *Mineral Trade Notes*, Vol. 75, No. 12; U.S. Bureau of Mines, *Mineral Commodity Summaries*, January 1979; Statistics Canada.
[p]Preliminary; [e]Estimated.

Numerous drillholes on the Dauphin deposit encountered low values of potash (5 to 10% K_2O). During 1977, additional drilling on the southeastern part of the islands near Havre Aubert encountered very good grades and widths of potash; more drilling is required to determine whether there is any continuity of mineralization of economic importance in this region. Apparently, such drilling will not be scheduled at present. The Quebec government announced in January 1978 that it would study the possibility of establishing a multi-million dollar chemical plant to produce about 770 000 tonnes per year of soda ash (sodium carbonate) in the Gaspé region of Quebec. Surveyor, Nenninger and Chenevert Inc. of Montreal was awarded a contract ($290 000) by the Quebec industry department for a feasibility study. The proposal would use salt from the planned salt mine on Grosse-Ile in the Magdalen Islands, limestone from the Gaspé and coal from Nova Scotia. Cost estimates are in the $200 million range. As of the end of 1978, results of this study were not yet announced. The only soda ash producer in Canada liable to be affected is Allied Chemical Canada, Ltd. at Amherstburg, Ontario where brine and limestone are obtained locally. Production is about 400 000 tonnes per year. Soda ash is also produced from natural ore — trona — in Wyoming. Principal markets for soda ash are the glass manufacturing industry and the paper industry.

Ontario. Thick salt beds underlie much of southwestern Ontario, extending from Amherstburg northeastward to London and Kincardine, bordering on what is known geologically as the Michigan Basin. As many as six salt beds, occurring in the Upper Silurian Salina Formation at depths from 275 to 825 m, have been identified and traced from drilling records. Maximum bed thickness is 90 m, with aggregate thickness reaching as much as 215 m. The beds are relatively flat-lying and undisturbed, permitting easy mining.

During 1978 those beds were worked through two rock salt mines, one at Goderich and one at Ojibway, and through brining operations at Goderich, Sarnia, Windsor and Amherstburg. In early February 1979, Domtar Inc. announced a $25 million expansion program for their Goderich mine that will raise annual capacity by 55 per cent from 2.25 million tonnes to 3.5 million tonnes. The expansion project will take two and a half years to complete.

Prairie provinces. Salt beds underlie a broad belt of the Prairie Provinces extending from the extreme southwestern corner of Manitoba northwestward across Saskatchewan and into the north-central part of Alberta. Most of the salt deposits occur within the Prairie Evaporite Formation, which constitutes the upper part of the Middle Devonian-Elk Point Group, with thinner beds of salt occurring in Upper Devonian rocks. Depths range from 180 m at Fort McMurray, Alberta, to 900 m in eastern Alberta, central Saskatchewan and southwestern Manitoba, and to 1 830 m around Edmonton, Alberta, and in southern Saskatchewan. Cumulative

Table 5. Canada, available data on salt consumption, 1975-78

	1975	1976	1977	1978[e]
	(tonnes)			
Snow and ice control[1]	2 301 541	2 224 234	2 600 838	2 368 627
Industrial chemicals	1 531 323	1 964 406	946 920	1 584 400
Fishing industry	96 700[e]	97 400[e]	89 300[e]	100 000
Food processing				
Fruit and vegetable preparation	32 212[r]	20 547	19 760	26 400
Bakeries	15 012[r]	13 639	13 705	17 600
Fish products	17 080[r]	22 108	26 889	23 200
Dairy factories and process cheese	8 973	8 732	7 965	9 700
Biscuits	1 702	3 104	2 176	2 300
Poultry processors	168	74	49	100
Miscellaneous food preparation	21 531[r]	23 650	21 493	24 100
Grain mills[2]	50 473	47 012	53 646	62 100
Slaughtering and meat packing	40 106	37 905	43 741	48 900
Pulp and paper mills	31 322	37 691	40 000[3]	43 500[3]
Leather tanneries	9 074	11 416	9 951	11 600
Soap and cleaning compounds	2 525	3 181	3 000[e]	3 700
Textile dyeing and finishing	2 742	2 656	953	2 300
Breweries	370	550	236	500

Sources: Statistics Canada; Salt Institute; *Pulp and Paper Canada*.
[1]Fiscal year ending June 30. [2]Includes feed and farm stock salt in block and loose forms. [3]Not included in 1977 Statistics Canada survey. Figures are estimates as published in *Pulp and Paper Canada*.
[e]Estimated; [p]Preliminary; [r]Revised.

thicknesses reach a maximum of 400 m in east-central Alberta. The beds lie relatively flat and undisturbed. The same rock sequence contains a number of potash beds currently being exploited in Saskatchewan.

Brine for vacuum-pan evaporation is produced from these formations at two locations — Lindbergh, Alberta and Unity, Saskatchewan — while brine for the production of caustic soda and chlorine is obtained at Brandon, Manitoba; Saskatoon, Saskatchewan and Fort Saskatchewan, Alberta. In addition, byproduct brine from a potash solution mine at Belle Plaine, Saskatchewan is used in the production of fine vacuum-pan salt by The Canadian Salt Company Limited; and at Esterhazy, Saskatchewan, International Minerals & Chemical Corporation (Canada) Limited (IMCC) supplied a significant quantity of waste salt from potash mining for snow and ice control on highways.

British Columbia. Solar-evaporated salt from Mexico supplies the British Columbia caustic soda and chlorine manufacturing industry. Erco Industries Limited has a plant in North Vancouver; FMC Canada Ltd., at Squamish and Hooker Chemical Canada Ltd., at North Vancouver.

Canadian consumption and trade

Salt is marketed in at least 100 different forms, packages and containers, and its direct and indirect uses number in the thousands. The largest single market for salt in Canada is for snow and ice control in highways and city streets. By comparison with other uses, this market is new, having expanded in Canada from less than 100 000 tonnes in 1954 to an estimated 2.8 million tonnes in 1978.

The next-largest consumer of salt is the industrial chemical industry, particularly for the manufacture of caustic soda (sodium hydroxide) and chlorine. Salt for four caustic soda and chlorine plants is obtained from on-site brining and natural brines; others use mined rock salt or imported solar-evaporated salt. Other industrial chemicals that require significant quantities of salt in the manufacturing process include sodium carbonate (soda ash), sodium chlorate, sodium bicarbonate, sodium chlorite and sodium hypochlorite.

The pattern of Canada's salt trade has not changed considerably in the past few years. Because of its low unit value and availability in most key market areas, salt is seldom hauled long distances, except in the case of seaborne and intercoastal shipments where greater mileage entails little additional cost.

Outlook

Demand for industrial salt is expected to remain good for the foreseeable future. Application of salt for road de-icing and snow control however appears to have reached a plateau with some indications that usage on a road-kilometre basis may be even on the decrease. A number of municipalities are experimenting with higher sand to salt ratios. New road construction in North America is also experiencing a long-term decline. Thus, the overall growth in salt usage may be in the order of 2 per cent per year and it is not expected to exceed 3 per cent per year. The development of new capacity in Ontario through expansion at one underground mine and the possibility of a new mine being brought into production in Quebec may bring in a period of overcapacity that would have severe negative effects on the industry and may even lead to the closure of some operations. Prospects for significantly higher exports and lower imports may have a partial counterbalancing effect.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
92501-1	Common salt (including rock salt)	free	free	5¢/100 lb.	free
92501-2	Salt for use of the sea or gulf fisheries	free	free	free	free
92501-3	Table salt made by the admixture of other ingredients when containing not less than 90 per cent of pure salt	5%	5%	15%	3%
92501-4	Salt liquors and sea water	free	free	free	free

United States

Item No.		
420.92	Salt in brine	5% ad valorem
420.94	Salt in bulk	0.8¢ per 100 lb.
420.96	Salt, other	free

Sources: Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa, Canada; Tariff Schedules of the United States Annotated (1978), ITC Publication 843.

Sand and Gravel

D.H. STONEHOUSE

The Canadian industry

Production of sand and gravel in Canada has increased steadily if not spectacularly over the years, apace with population growth and tied closely to construction needs. Per capita consumption remained in the 11-tonne* range during 1978 despite slow construction activity in eastern and central Canada and moderate growth in western Canada, generally offsetting relatively good growth in Alberta. After a 5 per cent increase in sand and gravel output in 1977 to nearly 263 million tonnes, a nominal 1 per cent increase is indicated in 1978 preliminary figures.

The principal uses for sand and gravel are in highway construction and as concrete aggregate. Output of ready-mix concrete and of most concrete products was considerably reduced during 1978, as construction in real terms slowed. Housing starts were down to 227 667 from 245 724 in 1977. Although nonresidential construction showed strength, the net demand for aggregates was down. Individual home construction triggers the need for about 300 tonnes of aggregate per unit while apartment construction requires only about 50 tonnes, according to an Ontario Ministry of Natural Resources study.

The construction industry is often the first to be influenced by changes in the economic climate and, as suppliers of raw materials to such a volatile industry, the producers of sand and gravel and other aggregates must be capable of adjusting to periods of high and low activity thus created, as well as to surges in demand caused by regional and seasonal construction programs.

Sand and gravel deposits are widespread throughout Canada, and large producers have established "permanent" plants as close to major consuming centres as possible. Urban expansion has greatly increased demand for sand and gravel in support of major construction. Paradoxically, urban spread has not only tended to overrun operating pits and quarries, but has extended at times to areas containing mineral deposits, thereby precluding the use of these resources. Further complications have arisen in recent years as society has become increasingly aware of environmental problems and the need for planned land utilization. Municipal and regional zoning must be designed to determine and regulate the optimum utilization of land, but must not be designed to provide less than optimum resources utilization. Industry must locate its plants so as to minimize any adverse effects on the environment from their operations. Also, provision must be made for rehabilitation of pit and quarry sites in order to ensure the best sequential land use. The frequency with which small quarries and pits materialize to supply short-lived, local demands, leaving unsightly properties, has prompted action by municipal and provincial governments to control or to prohibit such activity.

Table 1. Canada, value of construction by province, 1977-79

	1977[1]	1978[2]	1979[3]
	(millions of dollars)		
Newfoundland	623.1	664.0	838.1
Prince Edward Island	119.0	144.8	150.7
Nova Scotia	914.5	1 015.8	1 066.8
New Brunswick	873.7	921.8	977.5
Quebec	8 589.9	8 736.2	9 199.2
Ontario	10 613.6	10 914.5	11 758.3
Manitoba	1 397.6	1 523.3	1 546.1
Saskatchewan	1 564.0	1 663.2	1 840.7
Alberta	6 124.8	7 387.8	8 316.2
British Columbia	4 492.7	4 976.4	5 372.2
Yukon and Northwest Territories	490.5	428.3	449.1
Canada	35 803.4	38 385.1	41 514.9

Source: Statistics Canada.
[1]Actual; [2]Preliminary; [3]Forecast.

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Ideally, the exploitation of sand, gravel and stone deposits should be done as part of the total land-use planning package, such that excavations are designed to conform with a master plan of development and even to create new land forms. Inventories indicating the potential available reserves of sand, gravel and stone should be prerequisite to legislation regulating land use. Surveys to locate such resources are being carried out in many provinces in order to optimize their use and to choose the best possible distribution routes to consuming centres. It should be observed that controls and zoning can reduce reserves of these resources significantly.

In addition to large aggregate operations usually associated with some other phase of the construction industry such as a ready-mix plant or an asphalt plant, there are many small, privately-owned producers serving small, localized markets. These are often operated on a seasonal or part-time basis. Many larger operations are short-term, intermittently serving as a supply arm of a heavy construction company, and provide material for a given project. Provincial departments of highways operate regional or divisional quarries to supply roadbed material for new and repair work. Exploitation by such a large number of widely diversified groups not only makes control difficult, it also provides great obstacles to the collection of accurate data concerning both production and consumption of sand, gravel and stone.

Although producers' shipments, as recorded by Statistics Canada (catalogue 26-215), reflect the total amounts of sand and gravel recovered by all producers regardless of statistical classification, only about 150 "establishments" are listed, showing a total employment of less than 2 000 persons. More detailed data from individual provincial government departments such as highways, municipal affairs, natural resources, lands and forests are required to reveal the total number of active pit and quarry operations.

Substitutes

Materials competitive with sand and gravel include crushed stone, slag and the lightweight aggregates, depending on the application considered. It has been estimated that total aggregate consumption in some Canadian urban centres could reach 18 tonnes per capita by 1980. Estimates have indicated that available sand and gravel supplies in some regions of Southern Ontario will be depleted by the 1990s. This could make outlying deposits not only attractive but necessary to the continued operation of the Canadian construction industry in certain areas. Transportation charges represent from 35 to 58 per cent of consumer costs for over 75 per cent of sand and gravel consumption in Southern Ontario, where 90 per cent is moved by truck, according to the Ontario Ministry of Natural Resources. Predicted shortages could also encourage development of underwater deposits.

Technology

Unconsolidated granular mineral material produced by the natural disintegration of rock under weathering and erosion processes is termed either "sand" or "gravel". The terms relate to grain size rather than to composition. Sand is defined very generally as that material passing a 9.51-mm sieve, almost all passing a No. 4 (4.76 mm) sieve, and almost all remaining on a No. 200 (74 micron) sieve. Gravel is that granular material remaining on a No. 4 seive — the cut-off between commercial sand and gravel. Material finer than 200-mesh is referred to as silt or clay, depending on the particle size.

Commercial sand and gravel deposits are generally classified into one of four categories according to origin or method of deposition. Deposits composed of sand and gravel that have been carried by rivers and streams are referred to as fluvial deposits. They exhibit limited size

Table 2. Canada, production (shipments) of sand and gravel by provinces, 1976-78

	1976		1977		1978^p	
	(000 tonnes)	($000)	(000 tonnes)	($000)	(000 tonnes)	($000)
Newfoundland	4 964	8 687	4 468	7 023	4 627	7 650
Prince Edward Island	789	1 684	865	1 864	885	1 901
Nova Scotia	8 408	15 727	9 012	18 214	9 067	18 491
New Brunswick	5 672	5 403	5 378	6 141	5 443	6 600
Quebec	77 156	68 852	74 423	69 586	71 776	64 398
Ontario	68 802	106 093	75 400	121 776	79 832	132 000
Manitoba	16 126	25 395	14 535	29 363	14 969	30 195
Saskatchewan	8 619	11 142	9 135	11 102	9 253	11 730
Alberta	24 520	43 659	23 900	45 658	24 313	46 900
British Columbia	34 103	47 772	45 789	54 154	45 813	55 550
Canada	249 159	334 414	262 905	364 881	265 978	375 415

Source: Statistics Canada.
^{p} Preliminary.

Table 3. Production (shipments) of sand and gravel by uses and by areas, 1976 and 1977

		Atlantic Provinces	Quebec	Ontario	Western Provinces	Canada
				(000 tonnes)		
Roads	1976	14 848	54 013	34 369	47 793	151 023
	1977	13 582	43 423	37 851	61 053	155 909
Concrete aggregate	1976	1 541	5 516	15 841	10 733	33 631
	1977	1 738	5 962	16 770	9 893	34 363
Asphalt aggregate	1976	2 356	4 048	5 072	6 334	17 810
	1977	2 793	3 963	6 493	7 227	20 476
Railroad ballast	1976	192	226	195	2 338	2 951
	1977	285	156	497	2 869	3 807
Mortar sand	1976	59	414	1 271	502	2 246
	1977	44	403	1 373	431	2 251
Backfill for mines	1976	107	7	928	24	1 066
	1977	155	16	989	189	1 349
Other fill	1976	577	5 650	9 530	12 198	27 955
	1977	965	6 368	9 620	8 494	25 447
Other uses	1976	153	7 282	1 596	3 446	12 477
	1977	161	14 132	1 807	3 203	19 303
Total sand and gravel	1976	19 833	77 156	68 802	83 368	249 159
	1977	19 723	74 423	75 400	93 359	262 905

Source: Statistics Canada, with breakdown by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.

Table 4. Canada, exports and imports of sand and gravel, 1976-78

	1976[r]		1977		1978[p]	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Exports						
Sand and gravel						
United States	377 598	551 000	273 600	431 000	269 057	502 000
Bermuda	—	—	—	—	122	13 000
Japan	—	—	19	3 000	17	3 000
France	43	3 000	126	10 000	18	1 000
Other countries	36	6 000	—	—	1	. . .
Total	377 677	560 000	273 745	444 000	269 215	519 000
Imports						
Sand and gravels, nes						
United States	2 083 937	3 809 000	1 645 336	4 642 000	1 809 204	5 515 000
Australia	—	—	—	—	54	12 000
West Germany	1 959	5 000	327	1 000	1 020	2 000
Hong Kong	26	. . .	—	—	—	—
Total	2 085 922	3 814 000	1 645 663	4 643 000	1 810 278	5 529 000

Source: Statistics Canada.
[r] Revised; [p] Preliminary; — Nil; . . . Less than $500; nes Not elsewhere specified.

gradation, and the distribution of size ranges and shapes can vary greatly, depending on whether the streams had been meandering, fast-flowing, narrow or shallow. Glacial deposits were distributed from massive ice sheets over large areas of Canada and the United States as well as in other countries. They consist of rock particles of various types, shapes and sizes and display little sorting or gradation. Marine and lake deposits are usually of hard, tough material, well-segregated and well-rounded. Unstratified mixtures of sand and gravel, covering the complete size range and occurring on the parent rock, are termed residual deposits. These are not usually of commercial importance because of the large amount of softer clays associated with the mass.

Table 5. Canada, production (shipments) of sand and gravel by uses, 1976 and 1977

	1976	1977
	(000 tonnes)	
Roads — construction, maintenance, ice control	151 023	155 909
Concrete aggregate	33 631	34 363
Asphalt aggregate	17 810	20 476
Railroad ballast	2 951	3 807
Mortar sand	2 246	2 251
Backfill for mines	1 066	1 349
Other fill	27 955	25 447
Other uses	12 477	19 303
Total sand and gravel	249 159	262 905
$000	334 414	364 881

Source: Statistics Canada, with breakdown by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.

Uses

The main uses for sand and gravel are: as fill, granular base and finish course material for highway construction, coarse and fine aggregates in concrete manufacture, coarse aggregate in asphalt production, and fine aggregate in mortar and concrete blocks. Specifications vary greatly, depending on the intended use, and many tests are required to determine the acceptability of aggregates for certain applications. Particle size distribution of aggregates, as assessed by grading tests or sieve analysis, affects the uniformity and workability of a concrete mix as well as the strength of the concrete, the density and strength of an asphalt mix, and the durability, strength and stability of the compacted mass when aggregates are used as fill or base-course material. Of importance also are tests to determine the presence of organic impurities or other deleterious material, the resistance of the aggregate to abrasion and to freeze-thaw cycles, the effects of thermal expansion, absorption, porosity, reactivity with associated materials and surface texture.

The use of sand and gravel as backfill in mines continues, along with increasing use of cement and mill tailings for this purpose. Abrasive sands, glass sand, foundry sands and filter sands are also produced.

Even the common products such as sand and gravel require a sales and distribution effort which depends upon forecast data supplied by monitoring relevant indicators. One such indicator is the number of regional housing starts which, in turn, can be projected to determine future needs for roads, driveways, shopping centres and schools. Heavy construction awards can be used to provide an estimate of the quantity of aggregate required for given projects over given periods of time.

Prices

There is no standard price for sand and gravel. In addition to supply-demand factors prices are determined regionally, or even locally, by production and transportation costs, by the degree of processing required for a given end use and by the quantity of material required for a particular project. Increased land values, reduction of reserves and added rehabilitation expenditures should result in higher prices.

Prices for graded, washed and crushed gravel and sand will show a slow but steady increase, based on greater property costs, more sophisticated operating techniques and equipment, pollution and environmental considerations, and higher labour and transportation costs.

Outlook

On average, total aggregate consumption will rise in line with population increases, housing requirements and construction in general. Sand and gravel consumption will continue in competition with crushed stone and, in some applications, with lightweight aggregates. New reserves must be located, assessed and made part of any community development planning or regional zoning, with optimum land and resource utilization in mind. In the search for new sources of sand and gravel some countries are turning to their seabeds. The use of huge pumps and specially equipped ships to draw gravel from the sea floor and deposit it in attendant barges is already common practice in Britain. Such methods of obtaining aggregates can have far-reaching environmental effects.

Table 6. Canada, sand and gravel production (shipments) and trade,1965,1970 and 1975-78

	Production	Imports	Exports
		(tonnes)	
1965	186 208 979	517 982	624 090
1970	183 846 431	456 077	1 125 083
1975	247 155 421	1 909 894	138 452
1976	249 158 891	2 085 922[r]	377 677[r]
1977	262 904 861	1 645 663	273 745
1978[p]	265 978 000	1 810 278	269 215

Source: Statistics Canada.
[r] Revised; [p] Preliminary.

Silica

G.H.K. PEARSE

Silica (SiO_2) occurs as the mineral, quartz, in a variety of rocks and unconsolidated sediments. Although it is one of the most abundant minerals, making up an estimated 12 per cent of the earth's crust, commercial sources of silica are presently restricted to uncommonly pure sands, sandstones, quartzites and vein quartz. Further, because of its low unit value, an economically viable deposit should normally be mineable by low-cost, open-pit methods and, ideally, be located close to consuming areas in order to minimize transportation costs.

The principal uses for silica are: as the chief constituent in glass, as metallurgical flux, in the manufacture of silicon carbide, as an ore of silicon and ferrosilicon, as foundry sand for metal castings, in sand blasting, and as filler materials in tile, asbestos cement pipe, concrete and bricks.

Production of silica in Canada in 1978 was 1.98 million tonnes*, down 18 per cent from 1977. The record 2.94 million tonnes shipped in 1970 remains unsurpassed.

About 40 per cent of silica produced in Canada is low-value lump and sand consumed as metallurgical flux. High-quality silica sand suitable for the manufacture of glass is produced by two companies in Canada. Indusmin Limited, the largest, operates beneficiation plants in southern Ontario and Quebec. Steel Brothers Canada Ltd. quarries high-grade silica sandstone on Black Island in Lake Winnipeg and processes the material at the company's plant at Selkirk, Manitoba.

Canada imports high-grade silica sand for use in glass manufacturing, and sand suitable for foundry castings, silex and crystallized quartz and silica brick. In 1978, imports, nearly all from the United States, totalled 1.24 million tonnes, 11 per cent greater than in 1977.

Principal producers and developments

Newfoundland. Newfoundland Enterprises Limited, a subsidiary of Armand Sicotte & Sons Limited, produces silica from a quarry at Villa Marie on the Avalon Peninsula. The silica is hauled by truck 19 kilometres (km) to Long Harbour where it is used as a flux in the manufacture of elemental phosphorus by Erco Industries Limited. This plant requires about 100 000 tonnes of silica annually.

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Quebec. Indusmin Limited produces a wide variety of silica products at its mill near Saint-Canut, Quebec. In addition to quarrying Potsdam sandstone adjacent to the Saint-Canut mill, the company quarries a friable Precambrian quartzite from a deposit near Saint-Donat. Material from the Saint-Donat quarry is trucked about 80 km to the Saint-Canut mill for processing. Products produced at Saint-Canut include silica sand suitable for glass and silicon carbide manufacture, foundry sand, and silica flour for use as a filler in tiles, asbestos cement pipe, concrete blocks and bricks. Production at Indusmin's operation in Quebec was 400 000 tonnes in 1978, down 8 per cent from 1977. Ore reserves at the two deposits are reported to be 15.3 million tonnes combined (annual report – 1978). The silica sand suitable for glass manufacture is marketed in Quebec, while much of the product suitable for use in the construction industry is sold in Ontario. The balance of Quebec's silica sand requirements for glass manufacture is imported from the United States.

Union Carbide Canada Mining Ltd., quarries quartzitic sandstone at Melocheville, Beauharnois County, for use in ferrosilicon manufacture at Beauharnois. Fines from this operation are used in foundry work, cement manufacture and as a metallurgical flux. Silice L.M. Ltée at Lac Bouchette, Roberval produces about 15 000 tonnes from vein quartz for Union Carbide's silicon plant at Chicoutimi.

S.K.W. Electro-Metallurgy Canada Ltd., operates a 52 000-tonne-per-year ferrosilicon plant at Bécancour, Quebec. The company obtains its raw material from a high-purity silica deposit 40 km north of Baie St. Paul near La Galette in Charlevoix County, operated by Baskatong Quartz Products Ltd. The silica is shipped by truck via Baie St. Paul to Bécancour. Production commenced in the fall of 1975.

Armand Sicotte & Sons Limited produces about 80 000 tonnes of silica for flux in phosphorus-making at Erco Industries Limited's plant at Varennes.

Montreal Silica Mines Ltd. began production during the summer of 1977 from unconsolidated Pleistocene sands near Ormstown, 50 km southwest of Montreal. The 50 000-tonne-per-year washing, screening and drying plant produces 50- 55- and 65-mesh foundry sand, 24- and 40-mesh sandblasting sand and a 70-mesh product for glass fibre manufacture. Much of the impurities are in the finer

Table 1. Canada, silica production and trade, 1977 and 1978

	1977		1978^p	
	(tonnes)	($)	(tonnes)	($)
Production, quartz and silica sand				
By province				
Quebec	721 990	9 153 332	684 000	8 948 000
Ontario	1 043 066	6 128 927	767 000	5 961 000
Manitoba	289 659	1 587 595	230 000	2 008 000
Alberta	. .	1 460 624	. .	1 755 000
Nova Scotia	. .	315 000	. .	320 000
Newfoundland	—	—	. .	230 000
Saskatchewan	122 471	209 300	118 000	210 000
British Columbia	19 073	205 589	19 000	206 000
New Brunswick	. .	250 000	. .	105 000
Total	2 316 680	19 310 367	1 983 000	19 743 000
By use				
Glass and fibreglass	425 166	6 611 610		
Flux	875 221	2 509 842		
Ferrosilicon	251 858	1 626 088		
Other uses[1]	764 435	8 562 827		
Total	2 316 680	19 310 367	1 983 000	19 743 000
Imports				
Silica sand				
United States	1 094 909	9 476 000	1 226 668	12 669 000
South Africa	—	—	9 986	763 000
Belgium and Luxembourg	6 198	39 000	5 559	43 000
West Germany	—	—	90	4 000
United Kingdom	54	3 000	87	3 000
France	25	8 000	—	—
Total	1 101 186	9 526 000	1 242 390	13 482 000
Silex and crystallized quartz				
United States	1 187	230 000	1 945	186 000
Brazil	1	3 000	10	9 000
France	30	11 000	—	—
Mexico	1	1 000	—	—
Total	1 219	245 000	1 955	195 000
Firebrick and similar shapes, silica				
United States	8 548	2 180 000	5 076	1 585 000
United Kingdom	295	157 000	1 672	165 000
France	91	68 000	162	130 000
Belgium and Luxembourg	9	3 000	35	15 000
West Germany	414	174 000	3	2 000
Other countries	672	467 000	—	—
Total	10 029	3 049 000	6 948	1 897 000
Exports				
Quartzite				
United States	56 296	246 000	67 767	332 000
United Kingdom	—	—	7	3 000
Barbados	1	. . .	—	—
Total	56 297	246 000	67 774	335 000

Source: Statistics Canada.
[1] Includes foundry use, sand blasting, silica brick, concrete products, chemical manufacture, building products and silicon carbide.
[p] Preliminary; — Nil; . . Not available; . . . Insignificant.

sizes, and screening results in a product purity of 93 to 96 per cent SiO_2.

Ontario. Indusmin Limited quarries a high-grade silica deposit on Badgeley Island in Georgian Bay. The deposit, containing reported reserves of 12.6 million tonnes, consists of very pure Precambrian Lorraine quartzite. A primary crushing plant at the deposit, some 190 km north of Midland across Georgian Bay, and a grinding and processing plant at Midland, came on stream during the first half of 1970. The Badgeley Island operation has a capacity of approximately 1 million tonnes per year of washed lump silica and fine material. The Midland plant capacity is about 500 000 tonnes per year of refined silica products. Primary products from the crushing plant on Badgeley Island are shipped directly to manufacturers of ferrosilicon and silicon metal, and to the Midland grinding plant for further processing. Products from the Midland plant go to the glass, ceramic, chemical and other industries in Ontario.

A substantial increase in lump silica shipments for the ferrosilicon market contributed to an overall 20 per cent increase in sales. A new product, 325-mesh flour, was introduced in 1978. In 1978, production was 421 000 tonnes (exclusive of metallurgical flux). Inco Limited and Falconbridge Nickel Mines Limited together use about 745 000 tonnes of silica for smelter flux.

Manitoba. Steel Brothers Canada Ltd., quarries friable sandstone of the Winnipeg Formation at Black Island in Lake Winnipeg. The sandstone is then barged to the company's processing plant at Selkirk where it is washed, sized and packaged for sale. The company provides silica sand for a large portion of the western Canadian market. Silica sand suitable for the manufacture of glass containers is shipped to Alberta. The majority of the remaining production is consumed in the Manitoba market, largely as foundry sand. The company formerly quarried quartzite and sand for Inco's smelter at Thompson, Manitoba, for use as metallurgical flux. Inco now manages these facilities. Manitoba's output declined about 22 per cent to an estimated 230 000 tonnes in 1978 as a result of slack demand for smelter flux. Higher value silica sales increased substantially, however.

Saskatchewan. Hudson Bay Mining and Smelting Co., Limited obtains silica for smelter flux from Pleistocene glacial sand deposits in Saskatchewan, adjacent to its operations at Flin Flon, Manitoba. Production in 1978 was 118 000 tonnes.

Alberta. Sil Silica Ltd., quarries Pleistocene dune sands at Bruderheim, 65 km northeast of Edmonton. A washing and flotation plant upgrades material running 93 per cent silica, 3 per cent alumina, 1 per cent clay and 0.75 per cent iron oxide, to products suitable for fibreglass manufacture, sand blasting and foundry use. Since operations started in 1971, capacity has tripled to more than 60 000 tonnes per year. Reserves are adequate for many years.

British Columbia. In August 1968, Pacific Silica Limited ceased production of silica for ferrosilicon and silicon carbide at its deposits near Oliver, British Columbia. Stucco dash and roof chips are being produced from existing stockpiles. Production in 1977 was 19 000 tonnes.

Uses and specifications

The principal uses of lump silica, silica sand and crushed quartzite, together with specifications by consuming industry, are as follows:

Lump silica. *Silica flux.* Massive quartz, quartzite, sandstone and unconsolidated sands are used for flux in smelting base-metal ores where iron and basic oxides are slagged as silicates. Because free silica is the active slagging agent, the free silica content should be as high as possible. Minor amounts of impurities such as iron and alumina are tolerable. Lump silica used as a flux is usually minus-one to plus 5/16 inch in size.

Silicon and silicon alloys. Lump quartz, quartzite and well-cemented sandstones are used in the manufacture of

Table 2. Canada, silica production and trade, 1965, 1970 and 1975-78

	Production	Imports		Exports	Consumption
Year	Quartz and Silica Sand	Silica Sand	Silex or Crystallized Quartz	Quartzite	Quartz and Silica Sand
			(tonnes)		
1965	2 207 802	757 300	4 630	101 181	2 863 498
1970	2 937 498	1 176 199	186	58 917	3 979 305
1975	2 491 715	1 044 160	1 550	39 977	3 510 818
1976	2 520 476	1 337 138	863	47 944	3 077 594
1977	2 316 680	1 101 186	1 219	56 297	3 037 701
1978[p]	1 983 000	1 242 390	1 955	67 774	. .

Source: Statistics Canada.
[p] Preliminary; . . Not available.

silicon, ferrosilicon and other silicon alloys. Lump silica 3/4 to 5 inches in size, obtained by crushing quartzite or indurated sandstone, is used in the manufacture of ferrosilicon. Chemical specifications are: silica, 98.0 per cent; alumina (Al_2O_3), less than 1.0 per cent; iron (Fe_2O_3) plus alumina, not over 1.5 per cent; lime and magnesia, each less than 0.2 per cent. Phosphorus and arsenic should be absent.

Premium quality material, essentially 100 per cent SiO_2 with a few parts per million allowable impurities is required for silicon used in making photovoltaic cells.

Silica brick. Quartz and quartzite crushed to minus 8 mesh are used in the manufacture of silica brick for high-temperature refractory furnaces. Chemical specifications for this use are: silica, 96 to 98 per cent; alumina, less than 0.1 per cent; combined iron and alumina, less than 1.5 per cent. Other impurities such as lime and magnesia should be low.

Aggregate. Crushed and sized quartz and quartzite are used as exposed aggregate in precast concrete panels for buildings, slabs, sidewalks and for other decorative landscape purposes.

Other uses. Lump quartz and quartzite are used as lining material in ball and tube mills and as lining and packing for acid towers. In some instances, naturally occurring quartzitic pebbles are used as grinding media in the crushing of various nonmetallic ores.

Silica sand. *Glass.* High-purity, natural-occurring sand or material produced by crushing quartzite or sandstone is used in the manufacture of glass. Minor amounts of certain elements are particularly objectionable because they act as powerful colourants. For example, chromium should not exceed six parts per million and cobalt not over two parts per million. Glass fibre optics technology, developing over the last few years, promises to become important in communications and could displace copper cable in several applications.

Silicon carbide. Silica sand used in the manufacture of silicon carbide should have a silica content of at least 99 per cent. Iron and alumina should be less than 0.1 per cent each; lime, magnesia and phosphorus should be absent. Sand should be plus 100 mesh, with the bulk of it plus 35 mesh.

Hydraulic fracturing. Sand is used in the hydraulic fracturing of oil-bearing strata to increase open-pore spaces, thus increasing the productivity of the oil well. Sand utilized for this purpose should be clean and dry, have a high compressive strength, be free of acid-consuming constituents and have a grain size between 20 and 35 mesh. Grains should be well-rounded to facilitate placement in the formation in order to provide maximum permeability.

Foundry sand. Naturally occurring sand or material produced by crushing friable sandstone is used in the foundry industry for moulding. For foundry purposes, the chemical composition of the sand is not as important as its physical properties. For the end-use, a highly refractory sand, having rounded grains with frosted or pitted surfaces, is preferred. Grain sizes vary between 20 and 200 mesh. Rounded grains are preferable to angular fragments because they allow maximum escape of gas during casting.

Sodium silicate. Sand for the manufacture of sodium silicate should contain more than 99 per cent silica, less than 0.25 per cent alumina, less than 0.05 per cent lime and magnesia combined, and less than 0.03 per cent iron (Fe_2O_3). All sand should be between 20 and 100 mesh.

Other minor uses. Coarsely ground, closely sized quartz, quartzite, sandstone and sand are used as abrasive grit in sandblasting and in the manufacture of sandpaper. Various grades of sand are used as filtering media in water-treatment plants; silica is also required in portland cement manufacture if there is insufficient silica in the limestone or in other raw material used in the process.

Silica flour. Silica flour, produced by fine-grinding quartzite, sandstone and lump quartz, is used in the ceramics industry for enamels, frits and pottery flint. For use in enamels, the silica flour must be over 97.5 per cent silica, with alumina (Al_2O_3) less than 0.5 per cent and iron (Fe_2O_3) less than 0.2 per cent. Silica flour is also used as an inert filler in rubber and asbestos cement products, as an extender in paints and as an abrasive agent in soaps and scouring pads. It is used increasingly in autoclave-cured concrete products such as building blocks and panels, approximately 45 kilograms (kg) of silica flour being used for every 100 kg of portland cement consumed.

Quartz crystal. Quartz crystal with desirable piezoelectric properties is used in radio-frequency control, radar and other electronic devices. Natural crystal for this purpose

Table 3. Canada, estimated consumption of silica by industries, 1976 and 1977

	1976	1977
	(tonnes)	
Smelter flux[1]	1 072 917	875 221
Glass manufacture (including glass fibre)	740 427	886 356
Foundry sand	577 455	549 089
Refractory brick	280 090	359 097
Artificial abrasives	143 895	129 056
Fertilizer, stock, poultry feed	12 830	2 146
Chemicals	19 966	18 358
Concrete products	12 064	8 440
Gypsum products	8 932	7 759
Other[2]	209 018	202 179
Total	3 077 594	3 037 701

Source: Statistics Canada for source data. Compiled by the Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Producers' shipments of quartz and silica for flux purposes.
[2] Includes asbestos products, ceramic products, soaps, frits and enamels, paper and paper products, roofing, silica brick and other minor uses.

must be perfectly transparent and free from all impurities and flaws. The individual crystals should weigh 100 grams or more and measure at least 5 centimetres (cm) in length and 2.5 cm or more in diameter. Much of the world's crystal requirement has been met in the past by natural crystal from Brazil; however, natural crystal is rapidly being replaced by excellent-quality, synthetic crystal grown in the laboratory from quartz "seed". Artificial quartz crystals are oriented for the cutter prior to delivery. The high degree of purity permits product yields at least four times that of natural quartz crystal.

There is no production of quartz crystal in Canada, and only a small demand exists. Domestic requirements are met mainly by imports, chiefly from the United States, with minor amounts from Brazil. Quartz Crystals Mines Limited, Toronto, produced minor amounts from an occurrence near Lyndhurst, Ontario, several years ago.

A quartz-crystal stockpile of 165.8 tonnes was sold by the Canadian Government during 1974.

Outlook

Silica output and consumption in Canada has been declining for eight years, reflecting a slowdown in metals production and hence silica flux requirement. However, glass requirements, especially glass fibre for thermal insulation, and other higher-value silica end-uses have advanced strongly. Because metallurgical flux constitutes more than half of silica production, a recovery in the base metal industries would be necessary to boost silica tonnages significantly, but it should be noted that silica flux is valued at 2 to 3 dollars per tonne.

Compared with 1970, total Canadian silica production is down 24 per cent in tonnage but has tripled in value by virtue of the change in product mix and price increases. Imports of high-quality grades during this period have declined slightly.

The outlook is for a continuation of the growth in output of higher-quality silica products through increases in domestic and United States demand and erosion of imports. Montreal Silica Mines Ltd.'s new facility, and expanded capacity under study at Indusmin's operations, are the most immediate developments that will give effect to this outlook. Interest in silica in eastern Ontario followed a recent in-depth evaluation by the Ontario Ministry of Natural Resources of several promising deposits. Activity in La Galette area northeast of Quebec City, the Magdalen Islands deposits and other occurrences south of Montreal may yield a producer in the coming years. Recovery in the nonferrous smelting industry and other elements of the economy will provide growth over the medium-term, and in the long-term the new fibre optics technology is likely to become an important consumer of silica, although significant improvements in mineral processing technology would be required for any of the current Canadian operations to meet the stringent raw material specifications.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
29500-1	Ganister and sand	free	free	free	free
29700-1	Silex or crystallized quartz, ground or unground	free	free	free	free

United States

Item No.		(¢ per long ton)
513.11	Sand containing 95% or more silica, and not more than 0.6% of oxide of iron	25
513.14	Sand, other	free
514.91	Quartzite, whether or not manufactured	free
523.11	Silica, not specially provided for	free

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978), USITC Publication 843.

Silicon, Ferrosilicon, Silicon Carbide and Fused Alumina

D.G. LAW-WEST

Silicon is the second most abundant chemical element in the earth's crust, and world resources of this metal are almost inexhaustible. Silica deposits (SiO_2) are the main commercial source of silicon. As the production of silicon metal, ferrosilicon and silicon carbide from silica ores requires large amounts of energy, production plants are usually situated in areas with an abundant supply of electrical power. In Canada, the ferrosilicon, silicon carbide and silicon metal producers operate plants in Quebec and southern Ontario.

Canada

The three major producers of ferrosilicon in Canada all operate plants located in Quebec. In 1978 Chromasco Limited operated its Beauharnois plant at full production capacity of 33 800 tonnes*. The bulk of Chromasco's output is consumed at its Haley, Ontario plant in the production of magnesium.

Union Carbide Canada Limited (UCC) is one of two domestic producers of both ferrosilicon and silicon metal, with plants in Quebec at Chicoutimi and Beauharnois. Only ferrosilicon is produced at Chicoutimi and during the year, capacity production of 28 000 tonnes was achieved. The Beauharnois plant, which produces both ferrosilicon and silicon metal, operated below capacity as a result of a strike which began late in November and was still in effect at the end of the year.

S.K.W. Electro-Metallurgy Canada Ltd. (S.K.W. Canada), which started its Becancour, Quebec plant in 1976, has an annual production capacity of 35 000 tonnes of ferrosilicon and 25 000 tonnes of silicon metal. S.K.W. Canada is owned 85 per cent by S.K.W.-Trostberg of West Germany and 15 per cent by A/S Ila Og Lilleby Smelterverker of Norway. The bulk of production is exported to the United States, West Germany and Japan. In 1978 the Treasury Department of the United States determined that S.K.W. Canada had sold silicon metal in the U.S. at less than fair value, but in 1979 the International Trade Commission found that this had not caused injury nor was it likely to cause injury to the U.S. industry.

The availability of energy enables Canada to produce and export bulk quantities of synthetic abrasives such as silicon carbide (SiC) and fused alumina (Al_2O_3). Producers of these abrasives are located in Quebec and Ontario, the Quebec-based companies are Canadian Carborundum Company, Limited (SiC) of Shawinigan, Norton Company (SiC), Electro Refractories & Abrasives Canada Ltd. (SiC) of Cap-de-la-Madeleine, and Unicorn Abrasives of Canada Ltd. (Al_2O_3) of Arvida. The Ontario-based companies are Canadian Carborundum Company (Al_2O_3), Norton Company (Al_2O_3 and SiC), and Usigena (Canada) Limited (Al_2O_3 and SiC), all of Niagara Falls, and The Exolon Company of Canada, Ltd. (Al_2O_3 and SiC) of Thorold. All Canadian production of synthetic abrasives is exported, principally to the United States where the bulk material is crushed, screened and classified. A small part of the refined material is reimported for production of bonded abrasives such as abrasive wheels and for production of coated abrasives such as sandpaper.

Uses

Silicon metal is used principally as an alloying agent for aluminum. It serves to increase fluidity, corrosion resistance and thermal and electrical conductivity, and to reduce specific density and thermal expansion. The alloys are used principally to make aluminum castings, which contain on the average around 6 per cent silicon. More than half of the cast aluminum tonnage is used in the transportation industry. Another important use of silicon metal is in the fabrication of silicones, which are used in oil production and for the manufacture of more than 200 products, including synthetic rubber, resins and electric motor insulation. Silicon metal is also used to some extent to make silicon bronze, aluminum alloys for coating of steel sheets, semiconductor electronic devices and silicon nitride (Si_3N_4).

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, exports and imports of ferrosilicon, silicon carbide and other ferroalloys[1], 1977 and 1978

	1977		1978[p]	
	(tonnes)	($)	(tonnes)	($)
Exports				
Ferrosilicon				
United States	31 895	11 337 000	48 296	21 196 000
Japan	1 207	771 000	5 542	3 691 000
West Germany	8 795	3 961 000	5 019	1 588 000
United Kingdom	2 605	730 000	721	239 000
Australia	—	—	122	106 000
Dominican Republic	190	117 000	174	104 000
Mexico	44	37 000	58	44 000
South Korea	—	—	37	40 000
Other countries	754	272 000	178	45 000
Total	45 490	17 225 000	60 147	27 053 000
Silicon carbide, crude and grains				
United States	80 473	26 362 000	104 412	32 688 000
Japan	4 876	1 920 000	2 298	878 000
Taiwan	—	—	402	157 000
Greece	214	83 000	240	94 000
United Kingdom	453	146 000	—	—
Total	86 016	28 511 000	107 352	33 817 000
Ferroalloys, nes				
United States	1 363	1 598 000	8 506	3 941 000
United Kingdom	308	47 000	1 212	256 000
Mexico	—	—	11	111 000
Taiwan	—	—	63	46 000
Poland	—	—	5	38 000
South Korea	—	—	81	32 000
Argentina	53	460 000	—	—
Other countries	74	16 000	—	—
Total	1 798	2 121 000	9 878	4 424 000
Imports				
Ferrosilicon				
United States	7 787	4 583 000	8 662	6 349 000
Sweden	193	162 000	663	585 000
Norway	418	302 000	650	548 000
France	428	285 000	478	366 000
West Germany	—	—	21	38 000
Venezuela	—	—	8	4 000
South Africa	230	186 000	—	—
Other countries	75	34 000	—	—
Total	9 131	5 552 000	10 482	7 890 000

Table 1. (cont'd)

	1977		1978[p]	
	(tonnes)	($)	(tonnes)	($)
Imports (cont'd)				
Silicomanganese including silico spiegel				
United States	2 693	1 569 000	6 309	2 902 000
Norway	1 139	431 000	5 779	2 412 000
South Africa	—	—	507	721 000
Brazil	—	—	1 745	673 000
Other countries	1 003	357 000	1 502	470 000
Total	4 835	2 357 000	15 842	7 178 000
Ferroalloys, nes				
Greece	9 237	11 449 000	10 005	10 725 000
Brazil	1 797	3 721 000	773	6 204 000
United States	3 108	3 582 000	2 803	4 102 000
Dominican Republic	637	1 082 000	2 253	3 085 000
France	1 199	1 395 000	1 372	1 769 000
United Kingdom	16	25 000	83	561 000
Chile	—	—	40	307 000
South Korea	—	—	10	108 000
Other countries	1 121	903 000	18	99 000
Total	17 115	22 157 000	17 357	26 960 000

Source: Statistics Canada.
[1] Other important ferroalloys are discussed in the manganese, nickel and titanium reviews for 1978.
[p] Preliminary; — Nil; nes Not elsewhere specified.

Table 2. Ferrosilicon production and trade, 1976

	Production	Imports	Exports
		(tonnes, gross weight)	
Austria	..	14 071	..
Belgium and Luxembourg	..	31 313	..
Brazil	45 252	..	..
Canada	..	10 424	34 673
France	236 532	..	84 797
West Germany	91 000	136 138	16 612
India	45 931	..	10 383
Italy	77 659	40 027	..
Japan	313 077	46 717	8 224
Norway	275 270	..	247 787
Republic of South Africa	115 220	..	..
Spain	56 529	..	16 483
Sweden	37 736	21 983	20 051
United Kingdom	—	111 718	1 224
United States	780 904	89 608	11 264
U.S.S.R.	300 000[e]	..	160 246
Yugoslavia	85 600	..	50 039

Sources: *Metal Bulletin*, Handbook 1978; for Canada, Statistics Canada; for U.S., Bureau of Mines *Minerals Yearbook*, Preprint 1976.
.. Not available; [e] Estimated.

Table 3. Canada, ferrosilicon production[1], 1965, 1970 and 1975-77

	Ferrous Industry[2]	Other Industries[3]	Total
		(tonnes)	
1965	53 585	13 523	67 108
1970	78 338	8 087	86 425
1975	41 443	15 922	57 580
1976	70 755	14 813	85 983
1977	. .	. .	99 880

Source: Statistics Canada.
[1]Producers' shipments. [2]Estimated by the Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa. [3]Principally abrasives industry.
. . Not available.

The iron and steel industry is the largest user of ferrosilicon as well as other silicon alloys such as silicocalcium, silicochrome and silicomanganese. Ferrosilicon is used principally to deoxidize molten steel. It is also used as a graphite promoter in carbon steels, to improve the electrical properties of electric steels and as a reducing agent in other alloys. Carbon steel contains, on the average, 0.755 kilograms (kg) of silicon per tonne of steel and consumes about one-third of the ferrosilicon production. Stainless steels and electric steels, which contain an average of 10 and 20 kg of silicon respectively per tonne of steel, and other types of steel consume the remaining two-thirds. Ferrosilicon is also used in the production of other metals produced by the silicothermic process, but only small tonnages are used for this purpose.

Outlook

The outlook for silicon metal and ferrosilicon is dependent on the growth and demand for aluminum and steel, respectively.

In the case of silicon metal approximately 65 per cent is consumed by the aluminum industry, which at the present time is expanding rapidly. It is expected that the transportation industry, the main consumer of aluminum alloys of silicon, will increase its requirements for weight reducing alloys.

Ferrosilicon demand is determined mainly by the iron and steel industry and to some extent by manufacturers of magnesium and nickel using the silicothermic process. Little growth is expected in the short-term for these industries and only moderate growth in the longer-term.

The domestic availability and huge resources of silicon could make it a desirable substitute for other metals. However, research would be necessary before extensive substitution in alloys is likely. Other areas of interest include solar energy conversion systems and micro electronics. Successful applications in these areas would increase greatly the demand for silicon.

Table 4. Canada, consumption, exports and imports of ferrosilicon, 1965, 1970 and 1975-78

	Consumption	Exports		Imports	
	(tonnes)	(tonnes)	($)	(tonnes)	($)
1965	30 672	42 115	4 706 724	5 678	1 799 546
1970	50 556	45 345	8 284 000	9 477	2 386 000
1975	54 904	29 029ʳ	8 075 000ʳ	26 353	15 665 000
1976	61 734	34 673ʳ	11 416 000ʳ	10 424ʳ	7 121 000
1977	63 521	45 490	17 225 000	9 131	5 552 000
1978ᵖ	. .	60 147	27 053 000	10 482	7 890 000

Source: Statistics Canada.
ᵖPreliminary; . . Not available; ʳRevised.

Table 5. Canada, manufacturers' shipments of crude silicon carbide, 1965, 1970 and 1975-77

	(tonnes)	($)
1965	89 398	13 967 000
1970	104 113	17 653 000
1975	89 346	24 597 000
1976	99 195	32 116 000
1977	104 011	36 965 000

Source: Statistics Canada.

Table 6. Canada, exports of silicon carbide, 1965, 1970 and 1975-78

	(tonnes)	($)
1965	82 465	12 243 784
1970	96 159	15 976 000
1975	78 615ʳ	17 441 000ʳ
1976	86 455ʳ	23 743 000ʳ
1977	86 016	28 511 000
1978ᵖ	107 352	33 817 000

Source: Statistics Canada.
ᵖPreliminary; ʳRevised.

Table 7. Canada, manufacturers' shipments of crude fused alumina, 1965, 1970 and 1975-77

	(tonnes)	($)
1965	153 576	19 635 000
1970	131 364	18 088 000
1975	110 736	26 162 000
1976	141 695	39 966 000
1977	139 859	41 977 000

Source: Statistics Canada.

Table 8. Canada, exports of fused alumina crude, 1965, 1970 and 1975-78

	(tonnes)	($)
1965	160 832	20 159 149
1970	152 572	23 234 000
1975	127 658	26 650 000
1976	154 003	38 844 000
1977	154 291	43 087 000
1978[p]	167 346	48 830 000

Source: Statistics Canada.
[p] Preliminary.

Prices

Prices published by "Metals Week" in December 1977 and 1978

		1977	1978
		(U.S. ¢)	
Ferrosilicon, per pound contained silicon, fob shipping point, freight equalized to nearest main producer, carloads lots, lump bulk			
	(% Si)		
High-purity	75	37.0	39.25-42.00
Regular	50	33.5	35.50-38.00
Silicon metal, per pound contained silicon, fob shipping point, freight equalized to nearest main producer, carloads lots, lump bulk			
(% max. Fe)	(% max. Ca)		
0.35	0.07	46.4	52.9
0.50	0.07	44.7	51.2
1.00	0.07	42.5	49.0

Prices published by "American Metal Market" in December 1977 and 1978

	1977	1978
	(U.S. ¢)	
SMZ alloy: 60-65% Si, 5-7% Mn, 5-6% Zr, 15-ton lots, per pound of alloy	35.50	39.25
Calcium-silicon and calsibar alloy, fob producer, 15-ton lots, per pound	57.0	57.00
	($ U.S.)	
Electric furnace silvery pig iron, fob Keobuck, Iowa		
16% Si, per ton	190.00	178.00
20% Si, per ton	212.00	202.00

Prices published by "Industrial Minerals" in December 1977 and 1978

(tonnes, cif main Europe port)

	1977	1978
	(£)	
Fused alumina, 8-220 mesh, cif		
Brown, min. 94% Al_2O_3	250-260	315-325
White, min. 99.5% Al_2O_3	300-320	350-380
Silicon carbide, 8-220 mesh, cif		
Black, about 99% SiC	450-460	560-580
Green, over 99.5% SiC	570-580	710-730

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(¢)	(¢)	(¢)	(¢)
37502-1	Silicomanganese – alloys of manganese and iron containing more than 1%, by weight, of silicon per pound or fraction thereof, on the manganese contained therein	free	0.75	1.75	free
37503-1	Ferrosilicon, being an alloy of iron and silicon containing 8% or more, by weight, of silicon and less than 60%, per pound or fraction thereof, on the silicon contained therein	free	free	1.75	free
37504-1	Ferrosilicon being an alloy of iron and silicon containing 60% or more, by weight, of silicon and less than 90%, per pound or fraction thereof, on the silicon contained therein	free	0.75	2.75	free
37505-1	Ferrosilicon, being an alloy of iron and silicon containing 90% or more, by weight, of silicon per pound or fraction thereof, on the silicon contained therein	free	2.50	5.50	free
92804-1	Silicon metal	10%	15%	25%	10%
92815-4	Silicon sulphide	10%	15%	25%	10%

United States

Item No.		General
		(¢)
519.21	Crude silicon carbide	free
519.37	Silicon carbide in grains, ground, pulverized or refined, per pound	0.40
607.50	Ferrosilicon, per pound Si content, containing over 8% but not over 60% by weight of silicon	free
607.51	Ferrosilicon, per pound Si content, containing over 60% but not over 80% by weight of silicon	0.50
607.52	Ferrosilicon, per pound Si content, containing over 80% but not over 90% by weight of silicon	1.00
607.53	Ferrosilicon, per pound Si content, containing over 90% by weight of silicon	2.00
607.55	Ferrosilicon chromium	10%
607.57	Ferrosilicon manganese, per pound Mn content	0.46 + 3.5%

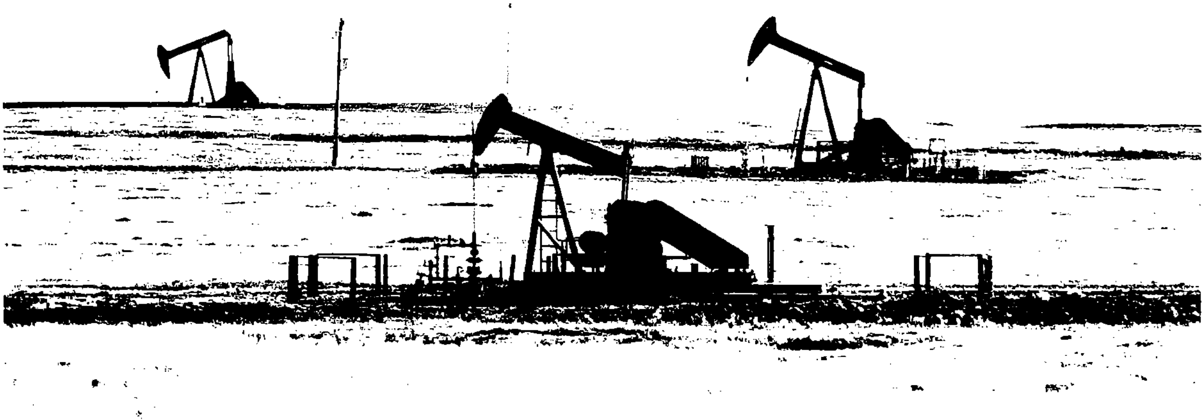
Japan

Item No.		General	GATT	Preferential
		(%)	(%)	(%)
28-04	Silicon – single crystal	16	12	free
	– other	12	6	free
28-56	Silicon carbide	12	6	free
68-06	Abrasive paper	12	—	free
73-02	Ferrosilicon	8	4	free
	Silicochrome	—	4	—

European Economic Community

Item No.		Autonomous	Conventional
		(%)	(%)
28.13	Silicon dioxide	10	6.4
73.02	Ferrosilicon	10	10 (limit 20 000 tonnes)
	Ferrosilicomanganese	6	5.5 (limit 50 000 tonnes)
	Ferrosilico-chrome	7	7

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States, Annotated (1978), ITC Publication 843; Customs Tariff Schedules of Japan, 1978, Japanese Tariff Association; Official Journal of European Communities, Vol. 21, No. L335, 1978.
— Nil.



Looking like sentinels on the vast empty reaches of prairie in the San Francisco Lake area of Alberta, pump jacks of Pancanadian Petroleum Limited produce their contribution to Canada's supply of crude oil.

Canadian Pacific photo

Silver

J.J. HOGAN

Canada's primary * production of silver is largely derived as a byproduct of base metal ores. Production in 1978 was 1 206 000 kilograms (kg), 107 685 kg less than in 1977. The decrease was mainly attributable to lower tonnage treated by some base metal mines that took action to correct a base metal oversupply situation, and to the mining of ores with lower silver content by some companies. Significant decreases in silver output were reported by Texasgulf Canada Ltd.; Inco Limited, which not only cut production but suspended operations in September because of a labour strike; Sturgeon Lake Joint Venture property of Falconbridge Copper Limited; and Mattabi Mines Limited, all in Ontario. Six silver-producing base metal mines ceased operations in 1977, this action also accounted for a significant portion of the decline in silver output in 1978. Ontario was, by far, the leading silver-producing province, primarily because of substantial byproduct silver produced at the Kidd Creek base metal mine of Texasgulf. The province accounted for over 34 per cent of Canada's total output. The value of Canadian silver production was $238.9 million or $31.1 million more than in 1977 because of an increase in the average price of silver for 1978 and a lower Canadian dollar in relation to its United States counterpart.

Canada's export of silver in ores and concentrates and as refined metal totalled 1 550 008 kg in 1978, or 56 090 kg less than in 1977. The United States continued to be the major market for Canadian exports, accounting for over 84 per cent of Canada's total silver exports. Canadian imports of refined silver were 36 000 kg in 1978, compared with 33 003 kg in 1977. Most of the imports came from the United States.

Canadian consumption of silver for both industrial and coinage uses in 1978 was estimated at 329 320 kg by Statistics Canada, compared with 298 724 kg in 1977.

Domestic production

Mine production. The principal source of silver was again base metal ores, and byproduct silver derived from this source accounted for about 82 per cent of the total output. The remainder, with the exception of a small amount of silver recovered as a byproduct from lode and placer gold ores, was derived from mines whose primary product was silver. The principal mine producers of silver in Canada are listed in Table 5, while the map, "Silver Producers in Canada 1978" shows their approximate locations. The four largest silver mine producers in declining order of output were: Texasgulf Canada Ltd., in Ontario, by far the largest; Brunswick Mining and Smelting Corporation Limited, in New Brunswick; Cominco Ltd. (Sullivan mine), in southeastern British Columbia; and United Keno Hill Mines Limited, in the Mayo district, Yukon Territory. Base metal ores mined by these four producers in 1978 accounted for almost 43 per cent of the total Canadian silver production. The largest producer in the Cobalt area of northern Ontario was Teck Corporation, Silverfields Division, with an output of 24 510 kg of silver contained in ores and concentrates produced.

Metal production. Production of refined silver in 1978 at the six Canadian primary silver refineries was as follows:

	Production[1] Refined Silver	Annual Rated Capacity[2]
	(kilograms)	
Brunswick Mining and Smelting Corporation Limited, Smelting Division, Belledune, New Brunswick	114 088[3]	125 000
Canadian Copper Refiners Limited, Montreal East, Quebec	702 939	777 600
Royal Canadian Mint, Ottawa, Ontario	5 331[4]	217 705[5]
Canadian Smelting & Refining (1974) Limited, Cobalt, Ontario	. .	186 600[6]
Inco Metals Company, Copper Cliff, Ontario	35 458[7]	. .
Cominco Ltd., Trail, British Columbia	314 674	373 200

Sources: Company Reports; Royal Canadian Mint.

* As reported by Statistics Canada.

[1]Production of refined silver includes silver produced or derived from domestic and imported ores and concentrates as well as secondary materials. The largest portion of such refined silver was however derived from domestic ores and concentrates. [2]As of December 31, 1978. [3]The refined bullion produced by Brunswick Mining and Smelting Corporation Limited was shipped to Canadian Copper Refiners Limited (CCR) at Montreal East, Quebec, for further refining; and the 702 939 kg of silver reported as production for CCR includes all of that silver bullion produced by Brunswick and refined by CCR in 1978. [4]Silver derived from refining gold bullion. [5]Total capacity for producing refined gold and silver of which about 10 per cent is silver. [6]Up to this amount, depending on nature of material processed. [7]Silver delivered to markets.
. . Not available.

Canadian Copper Refiners Limited at Montreal East, Quebec, was again Canada's largest producer of refined silver, recovering it mainly from the treatment of anode and blister copper and the further refining of lower-grade silver bullion. The silver refinery of Cominco Ltd. at Trail, British Columbia, was the second-largest producer, recovering byproduct silver in the processing of its own, as well as custom lead and zinc ores and concentrates. Other producers of refined silver were Inco Metals Company at Copper Cliff, Ontario (from nickel-copper concentrates); and the Royal Canadian Mint at Ottawa, Ontario (from gold bullion). At Cobalt, Ontario, Canadian Smelting & Refining (1974) Limited recovered silver in processing silver-cobalt ores and concentrates produced in that area of northern Ontario. At Belledune, New Brunswick, Brunswick Mining and Smelting Corporation Limited, Smelting Division, recovered byproduct silver from lead concentrates treated in a blast furnace.

At its electronic materials plant at Trail, British Columbia, Cominco also produced a high-purity silver metal with metallic impurities totalling one part per million or less. This specialty metal product was manufactured mainly for applications such as solder preforms, brazing preforms and lead wire in the electronics industry.

World production, consumption and economic factors

New production of silver in the non-communist world in 1978, as estimated by The Silver Institute of Washington, D.C., U.S.A. was 8 084.4 tonnes* or 61.3 tonnes more than in 1977. Production of silver in the Eastern Bloc countries in 1978 was estimated to be 2 264.3 tonnes, compared with 2 189.7 tonnes in 1977.

Based on preliminary figures, Canada was the third-largest mine producer of silver in 1978, being surpassed by Mexico and the U.S.S.R. The United States and Peru were also substantial producers of silver. These five countries accounted for over 64 per cent of the world's total primary silver production.

In 1978, non-communist world consumption for both industrial and coinage uses, as estimated by Handy & Harman*, was 13 156.77 tonnes, compared with 12 755.54 tonnes in 1977. The gap between primary production and consumption was 5 072.4 tonnes. Consumption of silver for coinage in the non-communist world in 1978, as estimated by the Silver Institute, was 954.40 tonnes, compared with 678.35 tonnes in 1977.

According to the United States Bureau of Mines, new production of silver in the United States in 1978 was 1 199.7 tonnes, slightly above the 1 187.1 tonnes produced in 1977. In the United States, the world's largest silver consumer, consumption for industrial uses and coinage was 4 981.7 tonnes and 1.4 tonnes respectively in 1978. Comparable figures for 1977 were 4 777.9 tonnes and 2.8 tonnes. The large deficit in requirements was again met by imports, demonetized coinage, secondary silver derived from discarded jewellery, silverware and films, liquidation of speculative holdings and withdrawals from industrial and United States Treasury stocks. Most of the requirements for United States coinage were again obtained from Treasury stocks (balance in Bureau of the Mint only) which declined slightly during 1978 from 1 224.2 tonnes in 1977 to 1 217.9 tonnes. The General Services Administration (GSA) did not sell any silver from the nation's strategic and critical stockpile. The new goal of zero established late in 1976 by the U.S. Federal Preparedness Agency (FPA) remained unchanged at the end of 1978, when the stockpile contained 4 338.9 tonnes, all of which is surplus to the goal. None of this surplus silver, however, may be disposed of without congressional approval. A number of bills have been introduced in Congress on the format to dispose of this surplus silver, but to date no consensus has been attained.

* The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

**The Silver Market 1978*, compiled by Handy & Harman, a leading United States refiner and fabricator of precious metals and a large consumer of silver.

Table 1. Canada, silver production, trade and consumption, 1977 and 1978

	1977		1978p	
	(kilograms)	($)	(kilograms)	($)
Production[1]				
By province and territory				
Ontario	524 324	82 938 369	421 000	83 382 000
British Columbia	241 526	38 204 966	212 000	41 923 000
New Brunswick	151 982	24 040 748	179 000	35 429 000
Yukon Territory	127 415	20 154 760	148 000	29 405 000
Northwest Territories	118 326	18 716 934	122 000	24 192 000
Quebec	92 977	14 707 237	73 000	14 479 000
Manitoba	29 527	4 670 581	28 000	5 509 000
Newfoundland	17 910	2 833 029	15 000	3 048 000
Saskatchewan	9 698	1 534 007	8 000	1 516 000
Alberta	. .	34	—	—
Total	1 313 685	207 800 665	1 206 000	238 883 000
By source[2]				
Base-metal ores	1 266 091	200 272 303	1 170 480	231 856 000
Gold ores	6 787	1 073 446	6 900	1 362 000
Silver-cobalt ores	40 692	6 436 722	28 500	5 642 000
Placer gold ores	115	18 194	120	23 000
Total	1 313 685	207 800 665	1 206 000	238 883 000
Refined silver[3]	987 510	. .	1 026 998	. .
Exports				
In ores and concentrates				
United States	302 534	39 564 516	281 562	41 819 720
Japan	102 928	13 702 691	122 334	13 952 311
West Germany	21 162	1 786 056	35 292	2 103 150
United Kingdom	9 750	759 347	12 853	1 481 116
Italy	3 176	159 457	9 031	742 209
Belgium-Luxembourg	20 640	1 225 067	8 666	710 367
Others	4 051	527 677	9 986	1 266 604
Total	464 241	57 724 811	479 724	62 075 477
Refined metal				
United States	1 092 578	169 373 606	1 025 270	202 155 668
United Kingdom	43 812	6 902 895	22 801	4 450 764
Netherlands	—	—	16 558	3 399 633
Trinidad-Tobago	2 751	434 310	2 358	459 346
Jamaica	2 178	363 817	1 415	282 594
Others	538	61 410	1 882	368 864
Total	1 141 857	177 136 038	1 070 284	211 116 869

Table 1. (cont'd)

	1977		1978p	
	(kilograms)	($)	(kilograms)	($)
Imports				
Refined metal				
United States	31 748	4 663 683	30 097	4 572 576
United Kingdom	893	156 210	5 505	863 400
West Germany	153	26 964	119	40 782
Others	209	16 434	279	46 351
Total	33 003	4 863 291	36 000	5 523 109
Consumption, by use				
Sterling	55 824	..	69 938	..
Silver alloys	75 951	..	70 779	..
Wire rod	3 354	..	3 212	..
Others[4]	163 595e	..	185 391	..
Total	298 724	..	329 320	..

Source: Statistics Canada.
[1] Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; and base and other bullion produced from domestic ores. [2] Estimated by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa. [3] From all sources, domestic and imported materials of both primary and secondary origin. [4] Includes sheet, partial coinage and miscellaneous uses.
p Preliminary; — Nil; .. Not available; e Estimated.

Table 2. Canada, silver production, trade and consumption, 1969-78

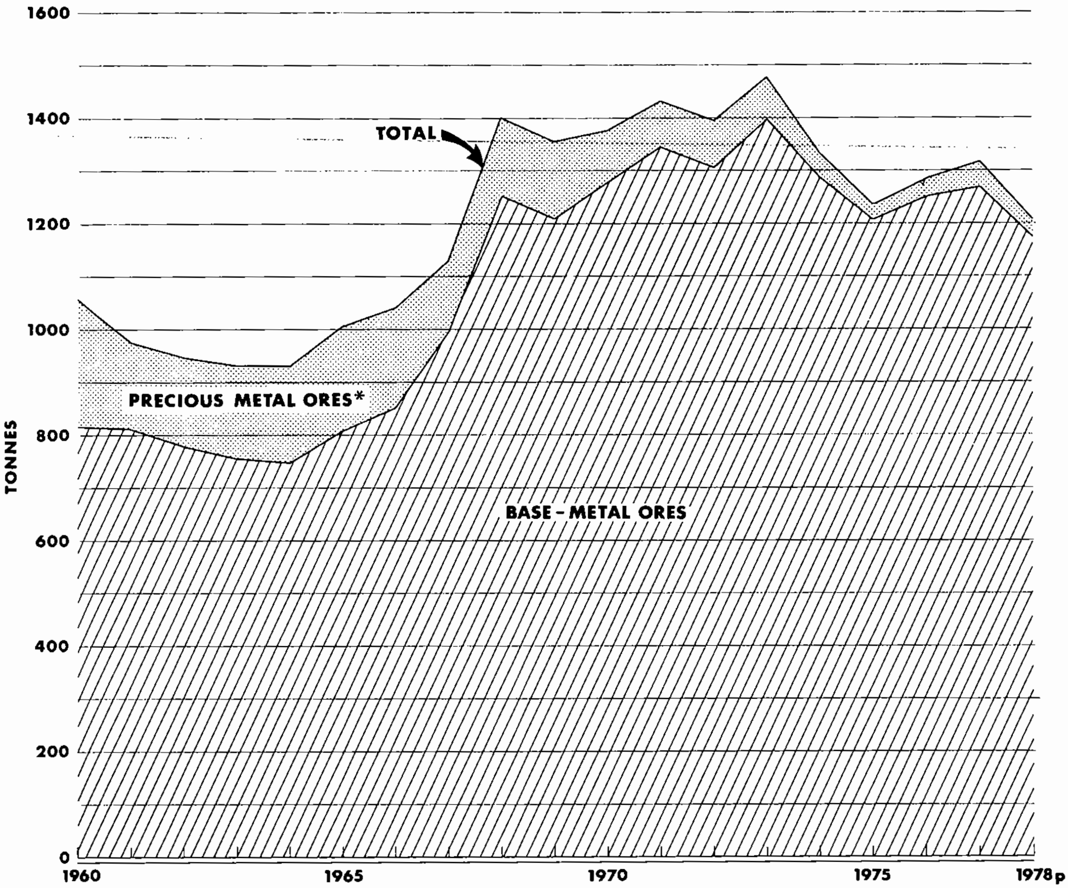
	Production		Exports			Imports, Refined Silver	Consumption[3] Refined Silver
	All Forms[1]	Refined[2] Silver	In Ores and Concentrates	Refined Silver	Total		
				(kilograms)			
1969	1 353 964	1 203 036	680 638	1 078 013	1 758 651	596 216	178 754
1970	1 376 354	955 668	678 676	752 689	1 431 365	134 347	187 679
1971	1 431 493	638 996	795 085	566 126	1 361 211	22 482	219 309
1972	1 393 193	714 361	688 749	616 641	1 305 390	37 874	262 025
1973	1 477 029	802 751	814 975	712 422	1 527 397	272 304	529 090
1974	1 331 531	852 755	602 892	663 709	1 266 601	909 655	598 114
1975	1 234 642	931 540	471 410	713 566	1 184 976	420 078	642 089
1976	1 281 437	1 023 928	435 790	947 413	1 383 203	59 136	551 212
1977	1 313 685	987 510	464 241	1 141 857	1 606 098	33 003	298 724
1978p	1 206 000	1 026 998	479 724	1 070 284	1 550 008	36 000	329 320

Source: Statistics Canada.
[1] Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; base and other bullion produced from domestic ores. [2] From all sources, domestic and imported materials of both primary and secondary origin. [3] In some cases includes only partial consumption for coinage.
p Preliminary.

A sharp increase in silver consumption in the coinage sector occurred in 1978. The Silver Institute, in its publication *Modern Silver Coinage 1978*, reported that silver used in official coins was 954 402 kg, up significantly from the 678 349 kg consumed in 1977. The leading consumers of silver in coinage in 1978 and the amount used were: France, 324 240 kg; Mexico, 197 575 kg; Austria, 140 790 kg; U.S.S.R., 107 995; and the Federal Republic of Germany, 56 011 kg. These five countries accounted for over 86 per cent of the total silver used in coinage. The Mexican government issued its 100-peso silver coins, worth approximately $5 each in 1977, as part of an effort to stem inflation through purchase of these coins. Also silver used in coinage would reduce the amount of silver available for other purposes and would have a bearing on maintaining the price level or forcing it upwards. Mexico also issued 280 000 "bullion coins" (onza troy) containing one troy ounce of fine silver.

To commemorate the 1980 Olympics to be held in Moscow, the U.S.S.R. is issuing a number of legal tender silver, gold and platinum coins. The silver coin program will comprise a total of 28 different coins issued in six series at approximately six-month intervals before the summer of 1980. Fourteen of the coins will have a face value of 5 rubles each and the remaining fourteen a face value of 10 rubles each. (1 ruble is approximately $Can. 1.68). The 5-ruble coin weighs 16.67 grams (g) and contains 15 g of silver, and the 10-ruble coin weighs 33.33 g and contains 30 g of silver. It is planned to mint a maximum of 450 000 of each of these silver coins.

PRIMARY SILVER PRODUCTION in CANADA by SOURCE



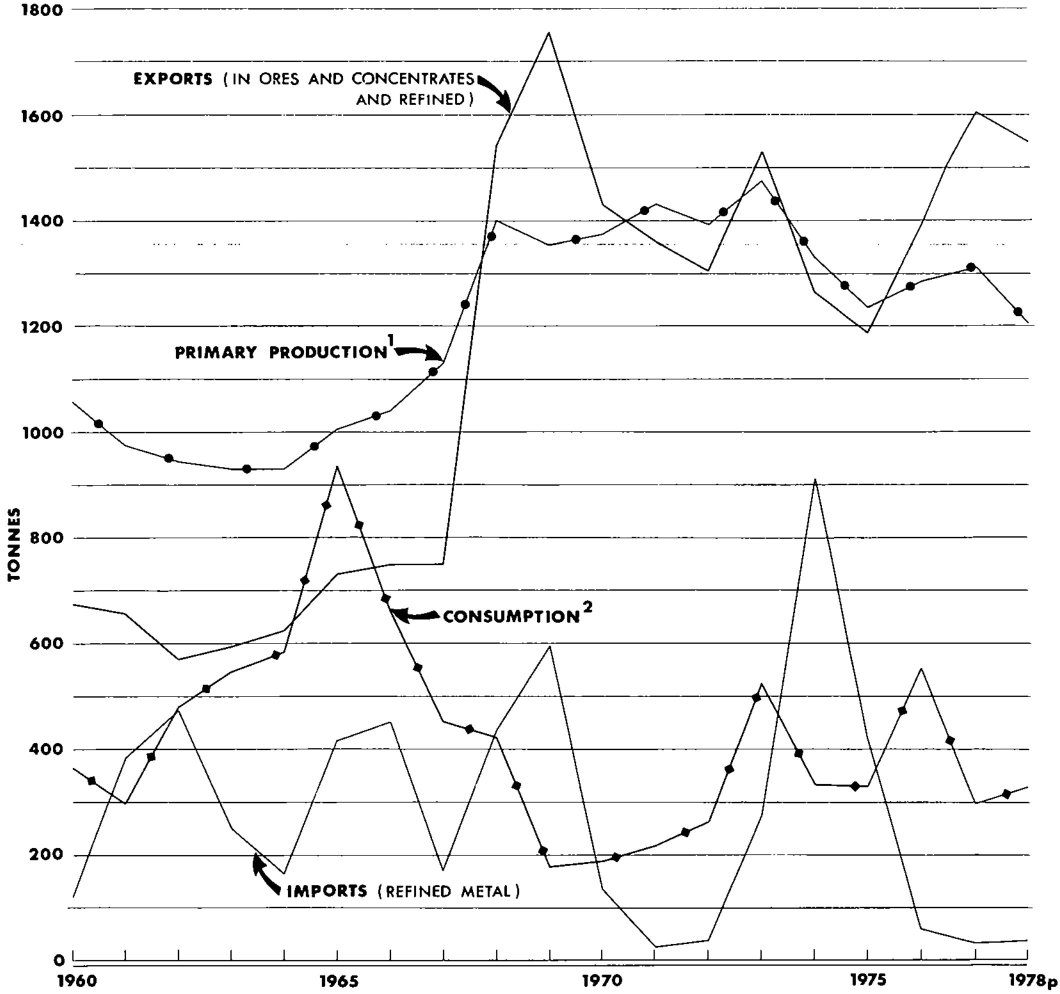
* Mostly from Silver-cobalt ores; some from Gold ores.
p Preliminary

Industrial consumption of silver in West Germany in 1978 amounted to about 821.1 tonnes, a decline of about 22 per cent from 1977.

Japan is a substantial consumer of silver and in 1978 consumption amounted to about 2 025 tonnes, about 2.9 per cent more than in 1977. Japan is the non-communist world's second-largest user of silver next to the United States. No silver was used in coinage. Dowa Mining Co. Ltd. planned to begin mining operations at its Ezuri mine located in Akita Prefecture, in October 1979. Reserves were estimated at 3 million tonnes, averaging 0.89 per cent copper, 3.32 per cent lead, 10.10 per cent zinc, 15 g of gold and 216 g of silver per tonne. Japan produces about 333 tonnes of primary silver annually.

Since August 26, 1976 all sales abroad of Indian silver have been handled by the country's State Trading Corporation (STC). The Indian government sets quotas on the maximum amount of silver to be exported. Exports are also related to market price, if the silver price drops significantly exports would be reduced. In 1978 India exported about 855 tonnes of silver which was lower than the 1 000-tonne quota established. There is virtually no mine production of silver in India and whatever silver is exported comes from above-ground supplies accumulated over the centuries.

SILVER IN CANADA*



* As reported by Statistics Canada

1 As defined in Footnote 1 to Table 1.

2 Statistics for years 1960 to 1973 inclusive include consumption for coinage; 1974 to 1976 statistics include only partial consumption for coinage.

p Preliminary

Varying estimates have placed these Indian stocks at between 30 000 and 150 000 tonnes. Although very large, the Indian holdings are extremely widespread. Given sufficient price inducement, India will continue to be an important source of silver. However, an indeterminable amount of silver will be retained in private hands regardless of price.

In the United States, ASARCO Incorporated decided to proceed with the development of its Troy deposit in Montana which contains an estimated 58 000 000 tonnes of ore, averaging 0.74 per cent copper and 52.8 g of silver per tonne. The Troy concentrator will be designed to produce 130 635 kg of silver and 18 000 tonnes of copper annually. It is expected to be in production by mid-1981, at an estimated cost of $82.6 million. The ore will be mined by room and pillar methods. It will be necessary to obtain certain regulatory permits before work can begin. ASARCO operates the Galena and Coeur silver mines in Idaho. Both these mines increased output and reserves in 1978.

Bunker Hill Company completed a new electrolytic silver refinery replacing the pyrometallurgical process used in the past by the company. The new $750 000 silver refinery increased the firm's refined silver capacity to 373 240 kg annually, an increase of 93 310 kg. The new refinery will produce a 99.99 per cent pure silver product, suitable for the photographic industry.

Silver in Honduras is recovered from mines that are operated primarily for their silver content. The El Mochito mine of Rosario Resources Corporation in Honduras carried out an extensive exploration program on its San Juan deposit, resulting in increasing ore reserves. Production capacity is being expanded to obtain improved cost efficiency. A new shaft and the installation of ancillary equipment is expected to be completed in 1980. The mill capacity is being increased from 1 100 tonnes per day to 2 250 tonnes per day. Completion date is expected to be late 1981. The Pan American Exploration Co. carried out some exploration work on the Arena Blanca silver property near El Progresso, northern Honduras. Exploration on silver properties in Honduras by others was limited.

The Mexican mineral industry experienced an active year in 1978 based partly on a new law "Tax Law and Mining Promotion" which became effective on January 1, 1978. The new law established a fixed percentage tax on minerals produced and abolished all other mining taxes including the export tax. The new law reduces the tax burden on mine operations.

Mexico is the world's major producer of silver. Much of the silver produced in Mexico is recovered from mines in which silver is the major or most important metal. Exploration on silver prospects in 1978 suffered somewhat by lack of financing.

The silver mining operations of Compania Fresnillo, S.A. and Zimapan S.A., which are owned 40 per cent by Fresnillo Company, a wholly owned subsidiary of Rosario Resources Corporation with headquarters in New York, had a successful year in 1978 at their five mining units. An exploration and development program at these mines added significantly to reserves. Silver output in 1978 was 211 960 kg. At Cuale, in the State of Jalisco, Fresnillo has started construction on facilities for a 1 000-tonne-per-day silver-lead-zinc operation. The project is expected to be completed in the latter part of 1980. Reserves are estimated to be 1 460 000 tonnes, averaging 168 g of silver plus some gold, zinc, lead and copper. The company is also investigating other properties in Mexico that contain significant amounts of silver.

In 1978 La Encantada Mining Group, which is owned 40 per cent by Lacana Mining Corporation, a Canadian company with headquarters in Toronto, and 60 per cent by Industrias Penoles, S.A., one of Mexico's largest private mining enterprises, completed the expansion of its concentrator from 500 tonnes per day to 1 200 tonnes per day. Underground development lagged behind completion of the surface facilities resulting in mill feed being below projected tonnage. Production from the Mining Group, which consists of three mines, was about 40 435 kg of silver in 1978.

Ore from four silver-gold underground mines of Compania Minera Las Torres, S.A., located near Guanajuato Central Mexico, was treated at a centrally located 2 000 tonne-per-day concentrator. Production was 150 985 kg of silver and 10 098 kg of gold in 1978. An active exploration program, at both the producing mines and nearby silver properties is being undertaken to ensure a continued supply of ore to the concentrator. Las Torres is owned 30 per cent by Lacana, 33 per cent by Penoles and 37 per cent by Compania Fresnillo, which has operating responsibility.

Australia is a major producer of silver and in 1978 operations at those mines that produce silver as one of their major metals were generally normal. The Mount Isa Mines Ltd. operations of M-I-M Holdings Ltd. in Queensland produced 465 383 kg of silver in 1978, about one half of Australia's output. Pilot tests of the lead-zinc-silver ore of EZ Industries Limited's Elura prospect in New South Wales, near Cobar, indicated that it could be treated successfully. Drilling has defined a zone containing 16 million tonnes, averaging 5.4 per cent lead; 8.4 per cent zinc and 137 g of silver per tonne. In 1978 the zinc-lead-copper-silver property at Woodlawn came into production at a rate of 2 725 tonnes of ore per day. Ore reserves are estimated at 9 million tonnes, grading 9.1 per cent zinc, 3.5 per cent lead, 1.8 per cent copper and 62.7 g of silver per tonne. The mine-mill facility is a three-way joint venture, the participants being St. Joe Minerals Corporation, and Phelps Dodge Corporation of the United States and Australian Mining & Smelting Ltd. of Australia.

In Chile, Compania Minera San Jose, Inc., a subsidiary of St. Joe Minerals, had outlined a gold-silver-copper zone at its El Indo property about 480 kilometres (km) north of Santiago, containing an estimated 1.5 million tonnes, averaging 2.25 per cent copper, 16.1 g of gold and 253.7 g of silver per tonne. A feasibility study is being undertaken to determine the viability of a 1 250-tonne-per-day operation. The El Indo project is 80 per cent owned by San Jose and 20 per cent by private Chilean investors.

On the New York Commodity Exchange, Inc. (Comex), one of the principle futures markets for contracts in silver in the United States, the volume of trading in silver in 1978

Table 3. World mine production of silver, 1977 and 1978

	1977[1p]		1978[2p]	
	(troy ounces)	(kilograms)	(troy ounces)	(kilograms)
Mexico	47 029 000	1 462 800	50 800 000	1 580 000
U.S.S.R.	45 000 000[e3]	1 399 700[e3]	46 000 000	1 430 800
Canada	42 235 900	1 313 700	40 239 200	1 251 600
United States	38 166 000	1 187 100	38 900 000	1 209 900
Peru	30 100 000	936 200	38 600 000	1 200 600
Australia	27 424 000	853 000	23 100 000	718 500
Poland	17 700 000[e]	550 500[e]	19 200 000	597 200
Japan	9 646 000	300 000	10 700 000	332 800
Bolivia	5 887 000	183 100	6 000 000	186 600
Sweden	4 820 000[e]	149 900[e]	5 700 000	177 300
Chile	7 650 000[e]	237 900[e]	5 500 000	171 100
Yugoslavia	4 694 000[3]	146 000[3]	4 700 000	146 200
Republic of South Africa	3 130 000	97 400	3 100 000	96 400
Zaire	2 730 000	84 900	2 900 000	90 200
Honduras	3 210 000	99 800	2 500 000	77 800
France	3 100 000[e]	96 400[e]	2 500 000	77 800
Morocco	2 244 000	69 800	2 200 000	68 400
South Korea	2 040 000	63 500	2 100 000	65 300
Philippines	1 622 000	50 500	2 000 000	62 200
Dominican Republic	1 357 000	42 200	1 800 000	56 000
Papua-New Guinea	1 906 000[e]	59 300[e]	1 700 000	52 900
Spain	3 540 000[e]	110 000[e]	1 700 000	52 900
Argentina	1 800 000[e]	56 000[e]	1 600 000	49 800
North Korea	1 600 000[e]	49 800[e]	1 600 000	49 800
Greece	374 000	11 600	1 600 000	49 800
German Democratic Republic	1 600 000[e]	49 800[e]	1 500 000	46 600
South-West Africa	1 300 000[e4]	40 400[e4]	1 400 000	43 500
Romania	1 250 000[e]	38 900[e]	1 300 000	40 400
Czechoslovakia	1 190 000[e]	37 000[e]	1 300 000	40 400
Italy	1 207 000[3]	37 500[3]	1 200 000	37 300
Bulgaria	890 000[e]	27 700[e]	1 000 000	31 100
Ireland	936 000[e]	29 100[e]	900 000	28 000
Finland	813 000	25 300	860 000	26 700
Other countries	6 762 000	210 300	5 860 000	182 300
Total	324 952 900	10 107 200	332 059 200	10 328 200

Sources: United States Department of the Interior, Bureau of Mines, *Mineral Trade Notes* for 1977; The Silver Institute of Washington, D.C., U.S.A. for 1978.
[1] Recoverable content of ores and concentrates produced unless otherwise noted. [2] Figures represent mine production of silver reported on an accountable basis. [3] Smelter and/or refinery production. [4] Data include estimate of silver production from Klein Aub Koper Maatskappy Ltd. copper mines.
[p] Preliminary; [e] Estimated.

amounted to 3 822 085 contracts of 5 000 ounces each, compared with 3 540 047 contracts of 5 000 ounces each in 1977. The volume of silver traded on the Chicago Board of Trade in 1978 amounted to 2 657 833 contracts of 5 000 ounces, compared with 2 257 059 contracts of the same size traded in 1977. The volume of silver contracts traded on the MidAmerican Commodity Exchange at Chicago, in fiscal year 1978, was near 400 000 contracts of 1 000 ounces each. Silver traded on the London Metal Exchange was 430.53 million ounces in 1978, compared with 459.44 million ounces in 1977.

New York Commodity Exchange silver stocks at the end of 1978 were 58.23 million ounces, compared with 69.28 million ounces at December 31, 1977. Chicago Board of Trade silver in storage at the end of 1978 and registered for delivery against futures' contracts was 59.88 million ounces, compared with 62.22 million ounces in 1977. Both figures for the Chicago Exchange are exclusive of some additional silver that may have been in stocks at such times, but not registered for future delivery. London Metal Exchange silver stocks at the end of 1978 were 22.96 million troy ounces, compared with 19.21 million ounces at the end of 1977. United States industrial stocks* on December 31, 1978 were reported to be some 28.79 million ounces, compared with 35.94 million ounces at the end of 1977.

*Refiners, fabricator and dealer stocks.

Table 4. Non-communist world consumption of silver, 1977 and 1978

	1977		1978^{p}	
	(troy ounces)	(kilograms)	(troy ounces)	(kilograms)
Industrial uses				
United States	153 600 000	4 777 500	159 500 000	4 961 010
Japan	62 700 000	1 950 190	64 300 000	1 999 950
United Kingdom	32 000 000	995 310	29 000 000	902 000
West Germany	33 800 000	1 051 300	26 400 000	821 130
Italy	27 000 000	839 790	26 000 000	808 690
France	20 600 000	640 730	22 200 000	690 500
India	17 600 000	547 420	20 000 000	622 070
Canada	8 800 000	273 710	9 000 000	279 930
Mexico	5 500 000	171 070	5 800 000	180 400
Other countries	25 500 000	793 140	25 800 000	802 470
Total industrial uses	387 100 000	12 040 160	388 000 000	12 068 150
Coinage				
France	6 900 000	214 620	11 100 000	345 250
Austria	7 000 000	217 720	9 500 000	295 480
West Germany	2 400 000	74 650	3 600 000	111 970
Canada	300 000	9 330	300 000	9 330
United States	400 000	12 440	100 000	3 110
Other countries	6 000 000	186 620	10 400 000	323 480
Total coinage	23 000 000	715 380	35 000 000	1 088 620
Total consumption	410 100 000	12 755 540	423 000 000	13 156 770

Source: Handy & Harman, *The Silver Market 1978*.
^{p} Preliminary.

Outlook

Canada's primary production* of silver in 1979 and 1980 is forecast to be in the range of 1 175 to 1 200 tonnes. Production is expected to increase in 1981 and 1982 to an annual output of about 1 300 tonnes in 1982.

Canada has for many years been one of the world's leading primary producers of silver and will continue to be a major silver producer for the next several years, although it could lose its ranking in world output to the United States and Peru. Canada has always produced more than its requirements and has been a significant exporter of silver; its role in this capacity will continue.

World demand for silver in 1978 increased by about 3 per cent; largely on account of a substantial increase in coinage. With the exception of photographic applications, which increased, other industrial uses were approximately of the same magnitude as those of the previous year. Consumption in 1979 could be slightly lower, however, because of less silver being used in official coinage. The long-term demand for silver for industrial uses is expected to increase, although a high price could reduce consumption in jewellery, silverware and objects of art.

* As defined in the footnote to Table 1.

Consumption of silver will continue to exceed primary production by a wide margin as mine output of silver is largely related to the production of the major base metal ores. About 80 per cent of the world's mine output of silver is derived as a byproduct or coproduct in the mining of such ores and accordingly, the supply of newly-mined silver will continue to depend more on demand for base metals than on the demand for silver. The silver price will not have a bearing on increased output from these mines but an increase in silver price could increase output significantly in those countries such as Mexico, Central American and possibly the United States in which a large proportion of silver produced is recovered from mines whose primary product is silver.

In the short- or medium-term there should be no real shortage of silver for industrial requirements. Sufficient quantities of secondary silver, speculative holdings, Indian exports and some hoarded silver coins will continue to find their way into the market.

Among the "bullish" factors affecting the primary producers of silver are the large perennial, and now increasing deficiency between new production and consumption, a projected increase in industrial usages and a continuing small decline in the world's visible stock of silver. Overhanging the market are 4 338.9 tonnes of surplus silver in the United States government's strategic stockpile. As mentioned previously, congressional approval is required for this silver to be released from the stockpile but to date legislation brought forward has not received approval. If or when this silver is released it could have a short-term affect on the market, but it is expected that it would be made available in a manner least disruptive to the market.

The shortfall between primary production and consumption and the unstable world situation were factors that sparked an increase in the price of silver in the early part of 1979. Speculative buying is playing an increasingly more important role in the silver market, making it more difficult to determine price movements.

Canadian developments

Atlantic provinces. Silver production in the Atlantic provinces was considerably higher in 1978 than in the previous year, mainly because of increased byproduct silver output by Brunswick Mining and Smelting Corporation Limited at its silver and base metals property near Bathurst, New Brunswick. With the improved market outlook for its products, (silver and base metals) in the latter half of 1978, Brunswick Mining decided to reinstate its program of expanding its plant capacity to 10 000 tonnes per day. The program was deferred in 1977 because of depressed zinc prices and worldwide oversupply of the metal. This project is expected to be completed in early 1981 at an estimated cost of $53 million, of which about $43 million has been spent to the end of 1978.

Production at the zinc-lead-copper-silver Buchans mine of ASARCO Incorporated in Newfoundland increased slightly in 1978. Despite an intensive exploration program during the year no deposits of economic importance were discovered and unless additional ore is found ore reserves will likely be exhausted in 1980. The property is a joint venture of ASARCO and The Price Company Limited, with ASARCO managing the mining and milling operations.

Quebec. Silver output in Quebec, derived mostly as a byproduct from base metal ores, was significantly lower in 1978 than in 1977, mainly because of closures of base metal mines in 1977, a strike at Gaspé Copper Mines, Limited and lower tonnage treated at Orchan Mines Limited.

Campbell Chibougamau Mines Ltd. and Orchan Mines Limited signed agreements with the Quebec Ministry of Natural Resources whereby the government advanced loans to each company for the purpose of underground exploration and the development of ore reserves, the object being to avert possible shutdowns and to extend the life of the operations. Orchan reported that deep development at its Norita property indicated a significant ore discovery. Effective December 31, 1978 Orchan amalgamated with Noranda Mines Limited. Also a planned merger between Mattagami Lake Mines Limited and Noranda became effective in January 1979.

Falconbridge Copper Limited completed the sinking of the Corbet shaft at its Lake Dufault Division property, near Noranda, and was preparing the mine for production in 1979. Operations at the Louvicourt mine of Louvem Mining Company Inc. in the Val d'Or district were suspended in 1978 pending improved market conditions for zinc. The Manitou Barvue Division of Louvem exhausted all underground ore reserves at its mine, near Val d'Or, in October 1978. A small tonnage of open-pit ore at this property is expected to be mined-out in 1979. Work continued on the deep exploration program at the zinc-copper-silver mine of Mattagami Lake mine in northwestern Quebec. The project involves driving a decline from the 265 m level to the 610 m level to provide access for diamond drilling stations. Drilling will be done to a depth of 1 220 m to explore the favourable structure below the No. 1 orebody.

Selco Mining Corporation Limited and Pickands Mather & Co. of Cleveland Ohio are carrying out a joint venture exploration program on three copper-zinc-silver mineralized zones, A-1, A-2 and B, at the "Detour Project", in Brouillan township in northwestern Quebec. In December 1978, Selco and Pickands Mather reached an agreement whereby Selco has the right to acquire from Pickands Mather its interest in the joint venture. Under this arrangement Pickands Mather has no obligation to contribute further to project costs. Underground development work on the B zone was completed in 1978. Feasibility studies of A-1 and B zones were completed during the year. The studies indicated that initially the B zone be brought into production and that exploration and feasibility studies be continued on the other zones. At year-end Selco was entering into negotiations with other possible partners in order to bring the B zone into production. Surface and underground exploration work on the B zone has reportedly indicated a deposit of 3.4 million tonnes, with an average diluted grade of 3.6 per cent copper, 0.5 per cent zinc, 31 g of silver per tonne and 1.0 g of gold per tonne. In the A-1 zone, surface diamond drilling has indicated a near-surface deposit of 32 million tonnes, with an average diluted grade of 0.39 per cent copper, 2.30 per cent zinc and 35.7 g of silver per tonne.

Ontario. Ontario was again, by far, the leading silver-producing province or territory, with its output in 1978 accounting for about 35 per cent of Canadian production. The leading silver producer was Texasgulf Canada Ltd., which recovered 243 403 kg in copper, lead and zinc concentrates at its Kidd Creek property, near Timmins. It is the largest single mine producer of silver in Canada, and probably the world. Silver output by Texasgulf in 1978 was 12 per cent less than in 1977 because the company lowered base metal output to adjust to market conditions.

At the Kidd Creek property of Texasgulf work continued on the $140 million mine-mill expansion program and the $280 million copper smelter and refinery complex. These projects were originally scheduled for completion in 1979, but were delayed because of weak copper and zinc markets. Expansion of the concentrator from a capacity of 3.3 million tonnes to 4.5 million tonnes of ore per year was completed in May and was put into operation. In the No. 2 mine, installation of the steel work in the shaft was completed. The copper smelter and refinery was over 50 per cent complete at the end of 1978 and is scheduled to go on stream in 1981. The No. 2 mine development program is also scheduled for completion by 1981. Included in the new copper refinery complex is a silver refinery, which could

(text continued on page 410)

Table 5. Principal silver (mine) producers in Canada, 1978 and (1977)

Company and Location	Mill Capacity	Grade of Ore Milled: Silver	Grade of Ore Milled: Copper	Grade of Ore Milled: Lead	Grade of Ore Milled: Zinc	Ore Milled	Silver Contained in Concentrates Produced	Remarks
	(tonnes of ore/day)	(grams/ tonne)	(%)	(%)	(%)	(tonnes)	(kilograms)	
Newfoundland								
ASARCO Incorporated, Buchans	1 100 (1 100)	104.91 (106.97)	1.04 (0.99)	6.07 (6.12)	10.78 (10.76)	183 251 (174 179)	16 757.3 (16 500.4)	Known ore reserves limited, expected to close in 1980.
Consolidated Rambler Mines Limited, Baie Verte	1 100 (1 100)	26.47 (23.07)	4.70 (4.25)	— (—)	— (—)	247 874 (218 201)	4 556.8 (3 659.6)	Improved operating results in 1978.
New Brunswick								
Brunswick Mining and Smelting Corporation Limited, Nos. 12 and 6 mines, Bathurst[1]	9 050 (8 950)	93.94 (84.69)	0.29 (0.37)	3.56 (3.12)	8.88 (7.82)	3 058 300 (3 134 419)	187 076.4 (173 570.0)	Reinstated mine expansion program.
Heath Steele Mines Limited, Newcastle	3 650 (3 650)	77.49 (68.23)	1.03 (1.19)	1.53 (1.50)	4.43 (3.83)	1 137 767 (1 150 318)	46 592.5 (39 303.6)	Completed mill expansion program in latter half of 1977.
Quebec								
Campbell Chibougamau Mines Ltd., Henderson and Cedar Bay Chibougamau	3 650 (3 650)	8.57 (7.51)	1.38 (1.43)	— (—)	— (—)	230 489 (264 308)	1 268.9 (1 174.8)	Merrill open pit closed in latter part 1977.
Falconbridge Copper Limited, Lake Dufault Division, Millenbach mine and Norbec stockpile ore, Noranda	1 400 (1 400)	43.54 (38.73)	3.36 (3.27)	— (—)	3.85 (3.74)	372 722 (389 967)	13 517.4 (11 104.4)	Preparing Corbet mine for production.
Falconbridge Copper Limited, Opemiska Division, Perry, Springer and Cooke mines, Chapais	2 900 (2 900)	14.06 (13.89)	1.99 (2.04)	— (—)	— (—)	967 823 (926 917)	11 154.9 (10 673.7)	Increased output from higher grade gold ore zones, mainly Cooke mine.

Table 5. (cont'd)

Company and Location	Mill Capacity	Grade of Ore Milled: Silver	Copper	Lead	Zinc	Ore Milled	Silver Contained in Concentrates Produced	Remarks
	(tonnes of ore/day)	(grams/ tonne)	(%)	(%)	(%)	(tonnes)	(kilograms)	
Quebec (cont'd)								
Gaspé Copper Mines, Limited, Needle Mountain and Copper Mountain mines, Murdochville	30 400 (30 400)	3.19 (3.43)	0.51 (0.53)	— (—)	— (—)	7 985 273 (11 051 406)	15 263.0 (19 533.9)	Production stopped because of a labour strike beginning October 16.
Lemoine Mines Limited, (Patino, N.V.), Chibougamau	350 (350)	94.63 (100.80)	4.97 (4.67)	— (—)	11.18 (10.64)	105 611 (110 305)	8 855.2 (8 358.1)	Intensive exploration program.
Louvem Mining Company Inc., (SOQUEM) Louvicourt	900 (900)	87.77 (41.83)	0.15 (0.12)	0.29 (0.16)	5.33 (5.95)	248 073 (277 837)	16 680.2 (10 557.7)	Underground ore at Manitou-Barvue division exhausted. Production at Louvem suspended pending improved zinc market.
Mattagami Lake Mines Limited, Matagami	3 500 (3 500)	32.57 (30.86)	0.52 (0.52)	. . (. .)	7.56 6.64	878 484 (946 342)	12 566.6 (14 465.3)	Carrying out development program for deep exploration project.
Orchan Mines Limited, Matagami	1 900 (1 900)	34.29 (31.89)	0.61 (0.54)	— (—)	5.89 (6.35)	368 602 (507 817)	2 040.3 (5 994.5)	Production cuts made to lower inventory build-up.
Patino Mines (Quebec) Limited, (Patino, N.V.), Chibougamau	2 725 (2 725)	9.70 (10.63)	1.60 (1.74)	— (—)	— (—)	616 381 (605 102)	4 204.3 (4 508.0)	Work on internal shaft and decline progressed on schedule.
Ontario								
Agnico-Eagle Mines Limited, Cobalt district	350 (350)	230.40 (181.37)	. . (. .)	— (—)	— (—)	40 157 (40 245)	8 339.6 (6 186.3)	Exploration work continuing at Beaver-Temiskaming property.

Canadaka Mines Limited, Cobalt district	275 (275)	166.97 (120.68)	. . (. .)	— (—)	— (—)	70 614 (91 009)	10 494.5 (9 442.6)	Processing newly mined ore, old mill tailings and material from old mine dumps.
Falconbridge Copper Limited, Sturgeon Lake Joint Venture, Sturgeon Lake	1 100 (1 100)	171.77 (206.40)	2.73 (3.46)	1.17 (1.26)	9.14 (10.44)	370 087 (383 882)	57 908.0 (71 114.1)	Improved recovery of all metals.
Falconbridge Nickel Mines Limited, Ontario Mines, Sudbury district	11 200 (11 200)	. . (. .)	. . (. .)	— (—)	— (—)	2 073 500 (2 599 318)	. . (. .)	Curtailed production to reduce nickel inventory.
Inco Limited, Sudbury and Shebandowan Ont., and Thompson, Man.	73 950 (73 950)	. . (. .)	. . (. .)	— (—)	— (—)	8 897 257 (17 611 159)	35 458.0[2] (66 872.5)[2]	Production lower because of planned production cuts and labour strike starting in September.
Mattabi Mines Limited, Sturgeon Lake	2 700 (2 700)	93.26 (121.71)	0.83 (1.01)	0.67 (0.84)	6.49 (8.40)	871 675 (938 427)	67 698.8 (90 566.1)	Developing underground ore.
Noranda Mines Limited, Geco Division, Manitouwadge	4 550 (4 550)	38.74 (41.83)	1.54 (1.94)	0.12 (0.11)	2.19 (2.62)	1 572 458 (1 591 673)	46 036.1 (52 850.9)	Production of metals lower because bulk mining in lower grade sections of mine.
Selco Mining Corporation Limited, South Bay Division, Uchi Lake area	450 (450)	75.77 (76.78)	1.43 (1.68)	— (. .)	12.20 (9.87)	121 635 (164 745)	7 239.6 (8 419.5)	
Teck Corporation, Silverfields Division, Cobalt district	250 (250)	342.86 (357.60)	0.60 (0.60)	— (—)	— (—)	77 247 (76 628)	24 509.8 (27 370.3)	
Texasgulf Canada Ltd., Kidd Creek mine, Timmins	8 165 (8 165)	102.7 (104.0)	1.87 (1.84)	0.77 (0.22)	6.43 (7.26)	3 002 148 (3 299 051)	262 725.3 (275 283.6)	Continuing with construction of copper smelter and preparing No. 2 shaft for production.
Union Minière Explorations and Mining Corporation Limited, Thierry mine, Pickle Lake area	3 650 (3 650)	8.23 (8.23)	1.29 (1.26)	— (—)	— (—)	836 119 (875 810)	4 365.2 (4 550.5)	Stockpile of open-pit ore exhausted.

Table 5. (cont'd)

Company and Location	Mill Capacity	Grade of Ore Milled: Silver	Copper	Lead	Zinc	Ore Milled	Silver Contained in Concentrates Produced	Remarks
	(tonnes of ore/day)	(grams/ tonne)	(%)	(%)	(%)	(tonnes)	(kilograms)	
Manitoba-Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon and Snow Lake districts	7 700 (7 700)	20.57 (20.57)	2.26 (2.18)	0.43 (0.22)	3.16 (2.79)	1 679 000 (1 652 526)	24 541.1 (22 802.9)	Westarm mine brought into production in 1978.
Inco Limited, Thompson, Man.	(Output included with company's listing for Ontario)							
Sherritt Gordon Mines Limited, Fox mine, Lynn Lake	2 600 (2 600)	. . (. .)	1.24 (1.50)	— (—)	1.73 (1.91)	874 933 (807 687)	4 234.0[e] (5 360.0)[e]	To explore mineralized zone below lower level by diamond drilling.
Sherritt Gordon Mines Limited, Ruttan mine, Ruttan	9 050 (9 050)	. . (. .)	1.15 (1.13)	— (—)	1.53 (1.95)	2 307 069 (2 256 486)	13 097.0[e] (14 974.0)[e]	Preparing underground mine for production in 1979.
British Columbia								
Afton Mines Ltd., Dominion pit, Kamloops	6 350 (6 350)	4.97 (. .)	1.01 (0.76)	— (—)	— (—)	2 456 770 (122 339)	8 066.9 (229.3)	Copper mine and smelter officially opened in April 1978.
Bethlehem Copper Corporation, Highland Valley	18 150 (18 150)	. . (. .)	0.41 (0.43)	— (—)	— (—)	6 490 760 (5 554 884)	8 511.7 (7 620.7)	New molybdenum plant completed in June 1978.
Brenda Mines Ltd., Peachland	21 750 (21 750)	. . (. .)	0.16 (0.19)	— (—)	— (—)	9 995 801 (9 634 472)	7 104.4 (8 009.4)	All time high of 17 500 000 tonnes of waste rock and ore removed from open pit.
Cominco Ltd., Sullivan Mine, Kimberley	9 075 (9 075)	62.06 (46.63)	— (—)	4.64 (3.74)	3.31 (3.83)	2 107 876 (2 194 230)	115 482.9 (90 213.2)	Major expansion and modernization program for the metallurgical plants at Trail and the Sullivan mine underway.

Dankoe Mines Ltd., Keremeos	150 (150)	286.29 (353.14)	. . (. .)	. . (. .)	. . (. .)	28 677 (31 984)	7 520.0 (8 850.1)	Development work on orebody continued.
Gibraltar Mines Ltd., McLeese Lake, Cariboo district	36 300 (36 300)	. . (. .)	0.38 (0.38)	— (—)	— (—)	5 135 682 (12 765 211)	. . (. .)	Company suspended operations on May 26 because of unsuccessful agreement to labour negotiations.
Granby Mining Corporation, Granisle mine, Babine Lake	14 300 (14 300)	. . (. .)	0.41 (0.44)	— (—)	— (—)	4 549 288 (4 474 144)	5 181.0[e] (5 239.0)[e]	
Granby Mining Corporation, Phoenix Copper Division, Greenwood	2 600 (2 600)	4.29 (5.07)	0.44 (0.39)	— (—)	— (—)	198 640 (833 829)	334.9 (1 766.6)	Treated low-grade stockpile ore. Mill closed in September 1978.
Lornex Mining Corporation Ltd., Highland Valley	43 500 (43 500)	. . (. .)	0.45 (0.48)	— (—)	— (—)	15 927 148 (15 480 792)	18 340.9 (18 076.3)	Output and price of molybdenum higher.
Newmont Mines Limited, Granduc mine, Stewart	6 800 (6 800)	. . (. .)	1.43 (1.31)	— (—)	— (—)	740 119 (1 333 143)	6 060.1 (10 526.6)	Mine closed in June 1978.
Newmont Mines Limited, Similkameen Division, Princeton	19 150 (19 150)	1.37 (0.65)	0.41 (0.38)	— (—)	— (—)	6 826 464 (7 144 987)	4 313.7 (4 294.9)	Copper Mountain property being developed for production in 1981.
Northair Mines Ltd., Alta Lake	250 (250)	70.63 (140.57)	0.20 (. .)	1.30 (1.54)	1.96 (2.03)	93 397 (92 130)	5 656.1 (10 332.8)	Ore coming from 853 m level, the lowest mine level.
Silvana Mines Inc., Silmonac mine, Slocan district	100 (100)	508.80 (670.63)	. . (. .)	5.81 (7.15)	4.34 (6.04)	15 966 (15 996)	7 792.0 (10 043.2)	An extensive exploration program underway, mainly on and from the 1 220 m level.
Teck Corporation Limited, Beaverdell mine, Beaverdell	100 (100)	323.66 (356.57)	. . (. .)	0.35 (0.36)	0.60 (0.41)	35 280 (33 977)	11 210.8 (12 030.0)	Continuing exploration program to outline new ore blocks.
Utah Mines Ltd., Island Copper mine, Coal Harbour, Vancouver Island	34 450 (34 450)	. . (. .)	0.40 (0.42)	— (—)	— (—)	14 200 278 (13 106 073)	10 144.9 (9 417.2)	

Table 5. (cont'd)

Company and Location	Mill Capacity	Grade of Ore Milled: Silver	Copper	Lead	Zinc	Ore Milled	Silver Contained in Concentrates Produced	Remarks
	(tonnes of ore/day)	(grams/ tonne)	(%)	(%)	(%)	(tonnes)	(kilograms)	
British Columbia (cont'd)								
Wesfrob Mines Limited, Tasu Harbour, Queen Charlotte Islands	4 650 (4 650)	4.11 (1.37)	0.35 (0.81)	— (—)	— (—)	889 933 (1 002 501)	2 744.0 (1 353.6)	Open-pit ore extracted.
Western Mines Limited, Buttle Lake, Vancouver Island	700 (700)	139.89 (147.09)	1.25 (1.14)	1.33 (1.34)	8.24 (7.58)	269 035 (269 069)	33 619.9 (35 123.8)	Task force established to study areas in which new reserves may be found near the mine.
Yukon Territory								
Cyprus Anvil Mining Corporation, Faro	9 050 (9 050)	19.89 (19.89)	0.20 (0.19)	3.17 (2.74)	5.14 (4.88)	3 280 660 (3 116 004)	49 905.4 (51 686.3)	Continued exploratory work on DY deposit.
United Keno Hill Mines Limited, Elsa	450 (450)	1 224.69 (1 216.80)	— (—)	5.50 (4.57)	0.79 (1.12)	81 721 (82 995)	90 735.0 (90 647.3)	Treating open-pit ore; reactivated cyanide plant.
Whitehorse Copper Mines Ltd., Whitehorse	2 250 (2 250)	7.82 (9.60)	1.40 (1.65)	— (—)	— (—)	782 984 (817 790)	6 133.5 (7 760.9)	Ore reserves sufficient until 1981.
Northwest Territories								
Echo Bay Mines Ltd., Port Radium	100 (100)	2 170.29 (2 213.83)	0.83 (0.90)	. . (. .)	. . (. .)	34 232 (31 091)	72 852.7 (67 450.6)	Rehabilitating leased old Contact Lake mine 22 km southeast of plant site.
Nanisivik Mines Ltd., Strathcona Sound, Baffin Island	11 350 (11 350)	61.71 (69.94)	. . (. .)	1.44 (1.98)	13.24 (13.27)	574 314 (546 085)	27 708.8 (28 656.9)	Production being maintained at a satisfactory level.
Terra Mining and Exploration Limited, Silver Bear mine, Camsell River area	200 (200)	831.7 (1 242.0)	0.29 (0.27)	. . (. .)	. . (. .)	26 323 (26 334)	21 892.0 (32 020.0)	Decline in output in latter part of year; development work tied up some manpower and equipment.

Terra Mining and Exploration Limited, Norex Joint Venture, Norex mine, Camsell River area	Ore custom milled	3 060.6 (1 949.0)	.. (0.19)	.. (1.4)	.. (0.6)	7 110 (7 174)	23 979.1 (13 890.0)	Extensive exploration and development program planned for 1979.

Sources: Company reports and technical press.
[1] All statistical data, including mill capacity represents combined results for No. 12 and 6 mines and mills. [2] Silver delivered to markets.
[e] Estimated; — Nil; .. Not available.

Table 6. Prospective silver-producing mines in Canada

Company and Location	Year Production Expected	Planned Mill or Mine Capacity	Indicated Ore Reserves	Average Grade of Deposit: Silver	Copper	Lead	Zinc	Remarks
		(tonnes ore/day)	(tonnes)	(grams/tonne)	(%)	(%)	(%)	
Quebec								
Noranda Mines Limited, Magusi property, Northwestern Quebec	..	1 350	1 379 000	34.3	1.0	—	4.8	Property contains copper and zinc zones which also have average gold content of 1.37 g per tonne. Higher zinc and copper prices required before development for production is considered. No work done on property in 1978.
Noranda Mines Limited, West Macdonald mine, Northwestern Quebec	..	..	2 502 000	24.0	0.15	—	4.5	Deposit also contains 1.03 g gold per tonne. At year-end higher prices for zinc initiated resumption of engineering studies. Water treatment pilot plant tests were completed. Advantages of underground versus open-pit mining being investigated.
Noranda Mines Limited, Orchan Division, Barvue zinc-silver property, Barraute township	..	..	3 629 000	37.3	—	—	3.5	Production depends on metal market prices for silver and zinc.

Table 6. (cont'd)

Company and Location	Year Production Expected	Planned Mill or Mine Capacity	Indicated Ore Reserves	Average Grade of Deposit: Silver	Copper	Lead	Zinc	Remarks
		(tonnes ore/day)	(tonnes)	(grams/ tonne)	(%)	(%)	(%)	
Quebec (cont'd)								
Noranda Mines Limited, Orchan Division, P.D. prospect, La Gauchetiere township, Matagami area	..	..	1 402 000	17.1	0.9	—	4.5	Shaft and decline portal collarwork. Work suspended pending improvement in copper and zinc market.
Selco Mining Corporation Limited, Pickands Mather & Co., Detour project – B zone Brouillan township	1981-84	1 800	3 084 000	31.8	3.6	—	0.5	Discussions underway with other joint ventures to put property into production.
Selco Mining Corporation Limited, Pickands Mather & Co., Detour project – A-1 zone	..	..	32 114 000	35.7	0.39	—	2.3	To continue exploration and feasibility studies. High capital costs to bring into production.
Ontario Mattagami Lake Mines Limited, Lyon Lake Division, Sturgeon Lake	..	900	3 580 000	117.2	1.24	0.63	6.53	Resumption of development planned for 1979.
British Columbia Equity Silver Mines Limited, (Equity Mining Corporation) Sam Goosly deposit, near Houston	1980	4 500	28 000 000	106.3	0.38	—	—	Two separate ore zones, the Main zone containing 21 200 000 tonnes and the Southern Tail containing 6 800 000 tonnes. The Southern Tail will be mined first because of higher silver content. Company controlled by Placer Development Limited which will be the operator.
Noranda Mines Limited, Goldstream River Property, about 90 km north of Revelstoke	1983-85		3 600 000	21.26[e]	3.6	—	2.6	Environmental studies to obtain water use permits to develop a power supply are continuing.

Yukon Territory Placer Development Limited, Howards Pass deposit, Summit Lake area	..	..	180 000 000 to 270 000 000	..	—	(5-10%) combined lead and zinc		Completed 4 880 m of diamond drilling on two main areas of interest. Program was successful in expanding tonnage potential in one zone. Program being funded by U.S. Steel Corp. which is continuing its option to purchase 49 per cent interest.
Hudson Bay Mining and Smelting Co., Limited, Tom claims, MacMillan Pass, on Canol Road	..	..	7 843 000	94.3	—	8.19	8.4	Underground work concluded in 1972, further work planned.
Northwest Territories Arvik Mines Ltd., Polaris deposit, Little Cornwallis Island, Arctic area	..	2 000	22 700 000	34.0	—	4.1	14.1	Owned 75 per cent by Cominco Ltd. Feasibility study completed – discussion being held with federal government on production ramifications.

Sources: Company reports, technical press and private sources; Estimates by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[e] Estimated; — Nil; .. Not available.

come on stream as much as two years later than the copper refinery, although it is possible that the two could open simultaneously. It is anticipated that the silver refinery will ultimately have an annual capacity of 311 000 to 373 000 kg of refined silver. According to Texasgulf, the proven and probable ore reserves at its Kidd Creek property at the end of 1978 are estimated at 94 million tonnes, containing an estimated 2.81 per cent copper, 0.18 per cent lead, 5.10 per cent zinc and 69.6 g of silver per tonne.

In the Cobalt district of Ontario the silver-bearing ores are mined primarily for the recovery of silver. In 1978 the output from the three main producers was estimated to be 43 345 kg, slightly above the 1977 output. Some cobalt was also produced.

The silver treatment plant and refinery of Canadian Smelting & Refining (1974) Limited (CSR) at Cobalt began operations in 1976. The plant, designed especially to treat the high-arsenic ores and concentrates produced by the Cobalt area mines, is a hydrometallurgical operation using an acid-wash cyanidation process. The plant can also treat similar-type concentrates, or silver-containing precipitates, residues or secondary materials produced elsewhere. The major product is refined silver, with an annual plant capacity of up to 187 000 kg of silver, depending on the nature of the materials processed. Grade of the refined silver is 99.95+ per cent silver. Byproducts produced are precipitates, residues and other materials containing cobalt, nickel, copper, lead and antimony, as well as CSR brand arsenic trioxide grading 99.0+ per cent As_2O_3. One of these byproducts is 10 to 20 tonnes monthly of a lead bullion containing 0.7 per cent silver. The silver-cobalt ores and concentrates produced by the mines in the Cobalt area are all processed at the CSR plant.

Manitoba-Saskatchewan. In 1978 much of the silver produced in Manitoba and Saskatchewan came from several base metal mines operated by Hudson Bay Mining and Smelting Co., Limited near Flin Flon and Snow Lake, in northern Manitoba. Significant quantities were also derived from the Fox and Ruttan copper-zinc mines operated by Sherritt Gordon Mines Limited at Lynn Lake and Ruttan, Manitoba, respectively. The White Lake mine of Hudson Bay in the Flin Flon area resumed operations in 1978 after being out of production for a shaft deepening and development program. Also the company brought its Westarm mine into production in January 1978. In the Snow Lake area, the Anderson Lake mine was shut down in February 1978, to develop the orebody between the 808 and 914 m levels and at year-end the shaft deepening project was completed and development well advanced. The 3 450-tonne-per-day concentrator, being built adjacent to the Stall Lake mine in the Snow Lake area by Hudson Bay, is scheduled for completion in early 1979. Ore mined in the Snow Lake area will be processed at this concentrator. At present, ore mined in this district is shipped to the Flin Flon concentrator for treatment.

Sherritt Gordon Mines Limited carried out an underground development program at its Ruttan mine and expected to start underground production in 1979. The open-pit ore should be exhausted in 1980.

British Columbia. Base metal ores continued to be the main source of British Columbia's mine output of silver. Cominco Ltd., the largest silver producer in the province, derived its output from the lead-zinc-silver ores of its Sullivan mine and from purchased ores and concentrates. Tonnage processed at the Sullivan mine concentrator in 1978 was slightly lower than in 1977, but silver output was greater because of the mining of higher grade silver-containing lead ore.

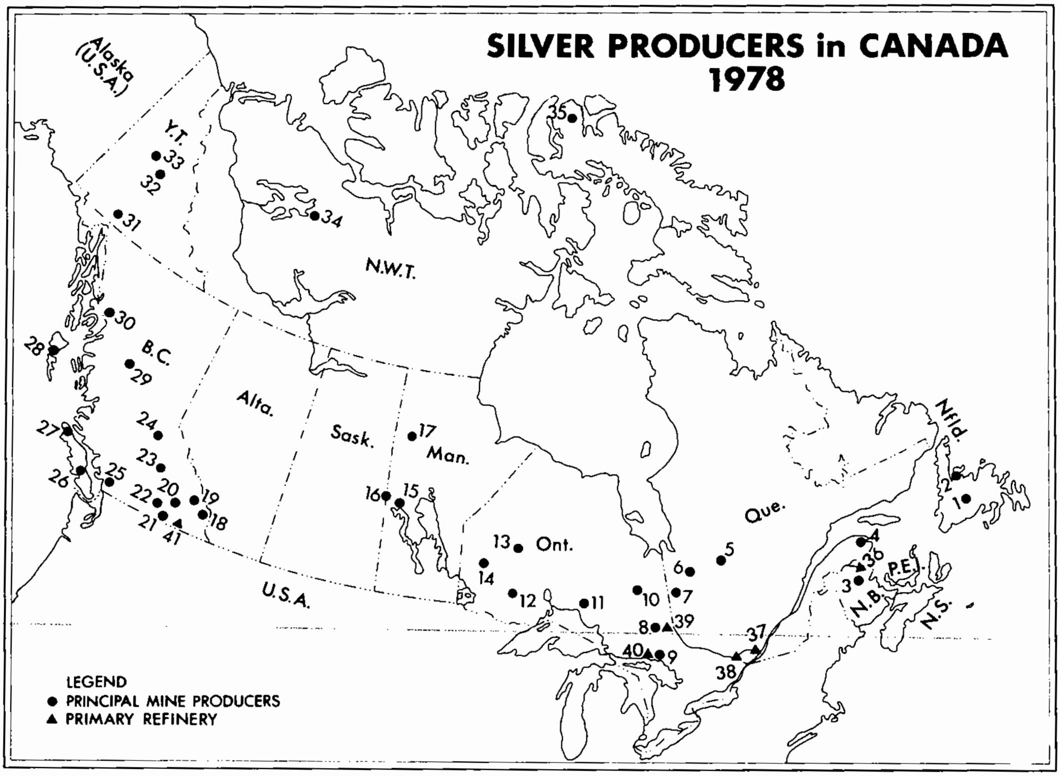
Ores from the mine of Dankoe Mines Ltd., Silvana Mines Inc. and Teck Corporation (Beaverdell mine) were mined principally for their silver content. The overall silver output from these mines was small, contained silver in concentrates amounting to an estimated 26 523 kg. Dankoe carried out an extensive exploration program at its property near Keremeos, the main project being the driving of a 1 340 m adit on the 535 m level. Dankoe received a grant from the British Columbia government under the Accelerated Mine Development Program of that province. Silvana Mines rehabilitated the 1 220-m level and carried out a development and diamond drill program on that level, at its property in the Slocan district. The project cost over $800 000. The company also received a grant under the Accelerated Mine Development Program.

Effective January 1, 1979, Granby Mining Corporation, Zapata Canada Limited and Granisle Copper Limited amalgamated to form Zapata Granby Corporation, a wholly-owned subsidiary of Zapata Corporation of Houston, Texas. The stockpiled ore at the Phoenix operation of Granby near Greenwood was exhausted and the mill closed in September.

At the Northair Mines Ltd. property, about 113 km north of Vancouver, a cross-cut adit from the 853 m level was advanced 1 266 m to reach the ore-bearing structure. Some drifting along the vein was done and raises were driven from this level to the 991 m level. About 30 per cent of the mill feed came from the 853 m level and it will be increased to 50 per cent. The silver grade of the ore declined in 1978 resulting in a significant drop in silver output.

Yukon Territory. Mine production of silver in the Yukon Territory in 1978 was somewhat higher than in 1977, mainly because of the greater output from the lead-zinc-silver mine of Cyprus Anvil Mining Corporation at Faro. The largest producer in the Yukon was again the silver-lead-zinc property of United Keno Hill Mines Limited at Elsa. It is also one of the major Canadian silver producers. Silver output at United Keno was 85 154 kg, slightly lower than the previous year. The year 1978 was one of significant change for the company as ore developed in new open-pit ore zones became part of the mill feed. The surface ores are oxidized and to improve the metallurgical recovery of the contained silver the cyanide section of the concentrator, which has been idle for a number of years, was rehabilitated. It was operated intermittently in the latter part of the year.

Cyprus Anvil Mining Corporation continued its program of mineral exploration on the DY deposit located about 20 km southeast of the Anvil mine. The company reported that encouraging results have been obtained and further



Principal mine producers

(numbers refer to numbers on the map)

1. ASARCO Incorporated
   (Buchans unit)
2. Consolidated Rambler Mines Limited
3. Brunswick Mining and Smelting Corporation Limited
   (Nos. 12 and 6 mines)
   Heath Steele Mines Limited
4. Gaspé Copper Mines, Limited
5. Campbell Chibougamau Mines Ltd.
   Falconbridge Copper, Limited,
   Opemiska Division
   Lemoine Mines Limited
   Patino Mines (Quebec) Limited
6. Mattagami Lake Mines Limited
   Orchan Mines Limited
7. Falconbridge Copper Limited,
   Lake Dufault Division
8. Agnico-Eagle Mines Limited
   Canadaka Mines Limited
   Teck Corporation
   Silverfields Division
9. Falconbridge Nickel Mines Limited
   Inco Limited
10. Texasgulf Canada Ltd.,
    Kidd Creek mine
11. Noranda Mines Limited,
    Geco Division
12. Falconbridge Copper Limited,
    Sturgeon Lake Joint Venture
    Mattabi Mines Limited
13. Union Miniere Explorations and Mining Corporation Limited,
    Thierry mine
14. Selco Mining Corporation Limited,
    South Bay Division
15. Hudson Bay Mining and Smelting Co., Limited,
    (Anderson Lake, Centennial, Chisel Lake, Osborne Lake, and Stall Lake mines)
16. Hudson Bay Mining and Smelting Co., Limited
    (Flin Flon, Ghost Lake, Schist Lake and White Lake mines)
17. Sherritt Gordon Mines Limited
    (Fox and Ruttan mines)
18. Cominco Ltd. (Sullivan mine)
19. Silvana Mines Inc.
    (Silmonac mine)
20. Brenda Mines Ltd.
    Similkameen Mining Company Limited

21. Granby Mining Corporation[1]
    Phoenix Copper Division
22. Dankoe Mines Ltd.
    Teck Corporation
    (Beaverdell mine)
23. Afton Mines Ltd.[2]
    Bethlehem Copper Corporation
    Lornex Mining Corporation Ltd.
24. Gibraltar Mines Ltd.
25. Northair Mines Ltd.
26. Western Mines Limited
27. Utah Mines Ltd.
28. Wesfrob Mines Limited
29. Granby Mining Corporation,
    Granisle mine
30. Newmont Mines Limited,
    Granduc mine[1]
31. Whitehorse Copper Mines Ltd.
32. Cyprus Anvil Mining Corporation
33. United Keno Hill Mines Limited
34. Echo Bay Mines Ltd.
    Terra Mining and Exploration Limited
35. Nanisivik Mines Ltd.

Primary refineries

(numbers refer to numbers on the map)

36. Brunswick Mining and Smelting Corporation Limited, Smelting Division
37. Canadian Copper Refiners Limited
38. Royal Canadian Mint
39. Canadian Smelting & Refining (1974) Limited
40. Inco Limited
41. Cominco Ltd.

[1]Closed in 1978. [2]Official opening in 1978.

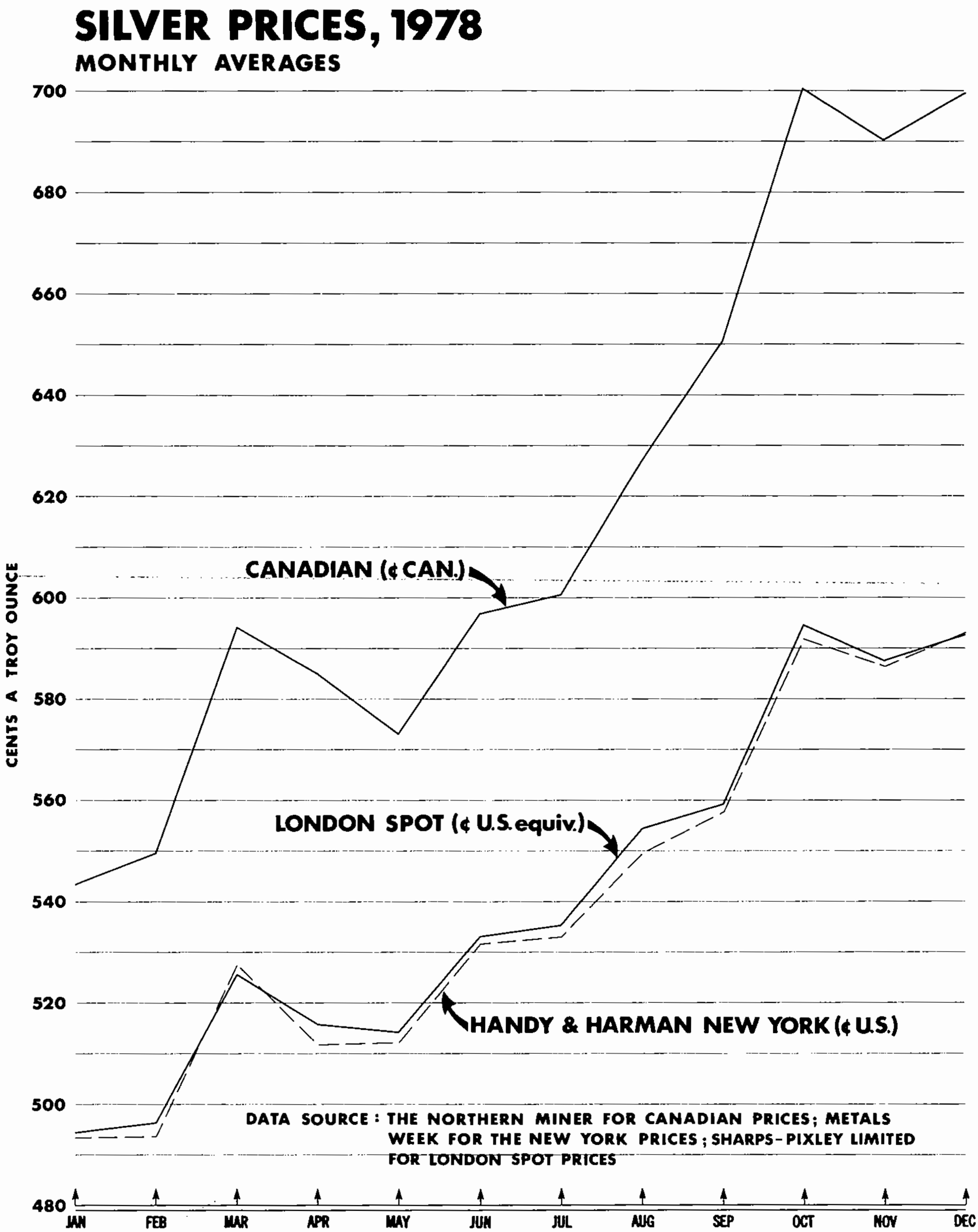
diamond drilling will be undertaken in 1979 to better define the deposit. Late in 1978, Cyprus Anvil reached an agreement with Kerr Addison Mines Limited and Canadian Natural Resources Limited whereby Cyprus Anvil would acquire all the mineral properties of these two companies within the Anvil district, as well as Kerr Addison's 70 per cent interest in Vangorda Mines Limited, and all the outstanding shares of Vangorda Mines. The agreement is subject to approval by the Foreign Investment Review Agency. The acquisition of these properties will add substantial new potential lead-zinc-silver ore reserves, extend the favourable exploration areas and establish a base for long-term future planning and growth in the Faro district.

Northwest Territories. Silver production in the Northwest Territories in 1978 amounted to 122 000 kg, slightly above the 1977 output. Echo Bay Mines Ltd., near Port Radium on the east shore of Great Bear Lake, is the largest silver producer in the Territories. The company has the former Contact Lake mine, located 23 km southeast of Echo's mill site, under lease from Ulster Petroleums Ltd. and expects to have the property in production in 1979. Terra Mining and Exploration Limited advanced the decline haulageway to the 395 m level at its Silver Bear silver-copper mine on the east shore of Great Bear Lake and mined a significant amount of ore from this level. A vertical borehole shaft to the 395 m level is expected to be completed in 1979. Exploration work was carried out on the North mine. This property has a number of parallel veins and is supplying part of the mill feed. A small tonnage of high-grade silver ore was mined from the Graham vein of the Norex Joint Venture. Also an underground diamond drill program was undertaken at this mine to delimit further ore reserves.

Table 7. United States consumption of silver by end-use[1], 1977 and 1978

	1977[2]		1978[2]	
	(kilograms)[3]	(%)	(kilograms)[3]	(%)
Electroplated ware	212 872	4.5	226 247	4.5
Sterling ware	519 117	10.9	557 001	11.2
Jewellery	250 663	5.2	210 446	4.2
Photographic materials	1 669 604	34.9	1 999 922	40.1
Dental and medical supplies	69 423	1.4	63 233	1.3
Mirrors	66 282	1.4	57 915	1.2
Brazing alloys and solders	384 501	8.0	341 734	6.9
Electrical and electronic products:				
Batteries	179 871	3.8	187 523	3.8
Contacts and conductors	974 036	20.4	956 618	19.2
Bearings	16 267	0.3	11 602	0.2
Catalysts	276 292	5.8	254 955	5.1
Coins, medallions and commemorative objects	132 252	2.8	84 819	1.7
Miscellaneous[4]	26 718	0.6	29 673	0.6
Total net industrial consumption	4 777 898	100.0	4 981 688	100.0
Coinage	2 830		1 400	
Total consumption	4 780 728		4 983 088	

Sources: United States Department of the Interior, Bureau of Mines, Mineral Industry Surveys, Gold and Silver in December 1978 for 1977 statistics, and Gold and Silver in March 1979 for 1978 statistics.
[1]End-use as reported by converters of refined silver. [2]Final figures: includes companies reporting annually. [3]Statistics originally reported in troy ounces have been converted to kilograms. [4]Includes silver-bearing copper, silver-bearing lead anodes, ceramic paints, etc.


SILVER PRICES, 1978
MONTHLY AVERAGES
700
680
660
640
620
600
580
560
540
520
500
480
CENTS A TROY OUNCE
CANADIAN (¢ CAN.)
LONDON SPOT (¢ U.S. equiv.)
HANDY & HARMAN NEW YORK (¢ U.S.)
DATA SOURCE : THE NORTHERN MINER FOR CANADIAN PRICES; METALS WEEK FOR THE NEW YORK PRICES; SHARPS-PIXLEY LIMITED FOR LONDON SPOT PRICES
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Uses

There was no marked change in the pattern of silver usage in 1978 from the previous year, with the exception perhaps of the metal playing an increasingly more important role as a hedge against inflation or as a speculative metal. The silver chapter of the *Canadian Minerals Yearbook 1977* detailed the many uses of silver.

Prices

In 1978 the New York silver price (Handy & Harman) displayed an erratic pattern but the trend was significantly upwards. The price changed on the strength or weakness of the United States dollar in relationship to other major currencies, continuing inflation, political or economic announcements or actions, profit taking, industrial buying and speculative buying.

The opening silver price for the year 1978 was $U.S. 4.910 per ounce. The low for the year of $U.S. 4.829 was recorded on January 5 and the high, $U.S. 6.296 on October 30. At year-end the price was $U.S. 6.074. The average silver price for the year was $U.S. 5.401 per ounce, up significantly from the average price of $U.S. 4.623 per ounce for 1977. The London spot silver price ranged between a low of 250.0 pence per ounce at the beginning of 1978, equivalent to $U.S. 4.870 per ounce and a high of 311.2 pence ($U.S. 6.037) per ounce on November 24. At year-end the price was 296.0 pence ($U.S. 6.021) per ounce. Average spot silver price for the year was 282.2 pence ($U.S. 5.423) per ounce.

In 1978 the Canadian silver price closely followed its United States counterpart, with the essential difference being the currency exchange differential. It opened the year at $Cdn. 5.365 per troy ounce and fluctuated between a low of $Cdn. 5.292 per ounce on January 5 to a high of $Cdn. 7.378 per ounce on October 30. At year-end, the price was $Cdn. 7.209 per ounce and the average silver price for the year was $Cdn. 6.175 per ounce, compared with $Cdn. 4.922 for 1977.

Table 8. Annual average silver prices: Canada, United States and United Kingdom, 1969-1978

		United States	United Kingdom	
	Canada	Handy & Harman, New York	London Spot	London Spot
	($Cdn.)	($U.S.)	(pence)[2]	($U.S. equiv.)[3]
		(per troy ounce)		
1969	1.931	1.791	180.774	1.800
1970	1.851	1.771	177.068	1.768
1971	1.571	1.546	63.086	1.542
1972	1.671	1.685	67.403	1.686
1973	2.567	2.558[1]	103.783	2.544
1974	4.595	4.708	199.819	4.675
1975	4.503	4.419	200.118	4.446
1976	4.291	4.353	242.423	4.377
1977	4.922	4.623	265.512	4.634
1978	6.171	5.401	282.203	5.423

Sources: Canadian prices as quoted in the *Northern Miner* (arithmetical average of daily quotations); United States and United Kingdom prices, as quoted in *Metals Week*.
[1]The 60-day, general price freeze in effect in the United States from June 13 through August 12, 1973 forced intermittent suspension of Handy and Harman's daily quotation during July and August for a total of 22 days. [2]1971-77 prices are expressed in new British pence, following British conversion to decimal currency, February 11, 1971, at the rate of 100 pence per pound sterling. Previous rate was 240 pence per pound. [3]Prices have been converted at the yearly average exchange rates quoted by *Metals Week*.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
32900-1	Ores of metals, nop	free	free	free	free
35800-1	Anodes of silver	free	free	10%	free
35900-1	Silver in ingots, blocks, bars, drops, sheets or plates, unmanufactured; silver sweepings	free	free	free	free
35905-1	Scrap silver and metal alloy scrap containing silver (expires June 30, 1979)	free	free	25%	free
36100-1	Silver leaf	12½%	20%	30%	12½%
36200-1	Articles consisting wholly or in part of sterling or other silverware, nop; manufactures of silver, nop	17½%	22½%	45%	15%

United States

Item No.		Non-communist countries	Communist countries[1]
420.60	Silver compounds	5%	25%
601.39	Precious metal ores, silver content	free	free
605.20	Silver bullion, silver dore and silver precipitates	free	free
605.46	Platinum-plated silver, unwrought or semimanufactured	16%	65%
605.47	Gold-plated silver, unwrought or semimanufactured	25%	65%
605.48	Other unwrought or semimanufactured silver	10.5%	65%
605.65	Rolled silver, unworked or semimanufactured	10.5%	65%
605.70	Precious metal sweepings and other precious metal waste and scrap, silver content	free	free
644.56	Silver leaf	2.5¢ per 100 leaves	5¢ per 100 leaves

European Economic Community

Item No.		Autonomous	Conventional
		(%)	(%)
28.49	Colloidal silver, amalgams, salts and other compounds of silver		
A.	Colloidal silver	10	8
B.	Amalgams of silver	12	8
C.	Salts and other compounds, inorganic or organic of silver	12	9.6
71.05	Silver, including silver gilt and platinum-plated silver, unwrought or semi-manufactured		
A.	Unwrought	free	free
B.	Bars, rods, wire and sections, plates, sheets, strips	4	2
C.	Tubes, pipes and hollow bars	7	3.5
D.	Foil of a thickness, excluding any backing, not exceeding 0.15 mm	13	6.5
E.	Powder, purls, spangles, cuttings and other forms	13	5
71.06	Rolled silver, unworked, or semi-manufactured		
A.	Unworked	10	5
B.	Semimanufactured	13	6.5
71.08	Rolled gold on silver, unworked or semimanufactured	9	3.5
71.10	Rolled platinum or other platinum group metals on silver, unworked or semimanufactured	7	3.5

European Economic Community (cont'd)

Item No.		Autonomous	Conventional
		(%)	(%)
71.11	Silversmith's sweepings, residues, and other waste and scrap	free	free
71.12	Articles of jewellery and parts thereof, of silver or rolled silver		
A.	Of silver	9	4.5
B.	Of rolled silver	12	9
71.13	Articles of silversmiths' wares and parts thereof, of silver, other than above		
A.	Of silver	9	7.5
B.	Of rolled silver	12	5
71.14	Other articles of silver or rolled silver		
A,	Of silver	9	7.5
B.	Of rolled silver	12	6

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978), ITC Publication 843; Official Journal of the European Communities, Volume 21, No. L. 335, December 1978.

[1] Present exceptions: Yugoslavia, Romania and effective July 7, 1978, Hungary.

nop Not otherwise provided for.

Sodium Sulphate

G.S. BARRY

Sodium sulphate is an industrial chemical used principally in the manufacture of pulp and paper by the "kraft" process, in detergents, glass and chemicals. It is produced from natural brines and deposits in alkaline lakes in areas with dry climates and restricted drainage, from subsurface deposits and brines, or as a byproduct of chemical processes. Canada's sodium sulphate industry is based on extraction from natural brines and deposits from several alkaline lakes in Saskatchewan and Alberta. Nine plants operated in Canada in 1978 with one closing during the year. Small quantities of byproduct sodium sulphate are recovered at a viscose-rayon plant and at a paper mill in Ontario.

In the United States natural and byproduct sodium sulphate production is almost evenly split. Natural sodium sulphate is produced in California, Texas and Utah. In Europe, sodium sulphate is almost entirely produced as a byproduct of chemical processes.

Production and developments in Canada

Shipments of sodium sulphate from Canadian producers declined in 1978 to 378 000 tonnes*, 4.3 per cent less than in 1977, and 20 per cent below the record production of 472 196 tonnes achieved in 1975.

The value of shipments, at $19.5 million, was proportionally lower since unit values decreased only marginally from $51.80 to $51.52 per tonne.

Deposits. In addition to the lakes in Saskatchewan and Alberta, sodium sulphate has been found in association with magnesium sulphate in lakes in British Columbia and with calcium sulphate in deeply buried deposits of glauberite in New Brunswick. Only minor production has been obtained in British Columbia and none in New Brunswick.

The sodium sulphate deposits in Saskatchewan and Alberta have formed in shallow, undrained lakes and ponds where in-flow is greater than out-flow. Percolating ground waters carry dissolved salts into the basins from the surrounding soils. High rates of summer evaporation concentrate the brine to near saturation, and cooler fall temperatures cause crystallization and precipitation of sodium sulphate as mirabilite ($Na_2SO_4 \cdot 10\ H_2O$). The cycle has been repeated year after year and thick deposits of hydrous sodium sulphate, accompanied by other salts and mud, have accumulated. Occasionally, where sodium chloride is present, some of the sodium sulphate is precipitated as thenardite (Na_2SO_4), the anhydrous variety of the salt.

Some lakes have not accumulated thick beds because the crystals of sodium sulphate deposited in the fall and winter are redissolved each spring, to re-form a brine rich in sodium sulphate. These same lakes commonly contain a high concentration of magnesium sulphate, a mineral that may prove valuable in the future.

Deposits in Saskatchewan have been identified that contain, in total, approximately 90 million tonnes of anhydrous sodium sulphate. Of this amount, a total of about 51 million tonnes is in 21 individual deposits, each containing more than 500 000 tonnes of sodium sulphate. One deposit in Alberta contains 2.7 million tonnes of Na_2SO_4. Exploitation currently takes place on the following lakes (with reserves, in millions of tonnes, in brackets): Whitehorse Lake (6.5), Horseshoe Lake (3.7), Frederic Lake (2.4), Chaplin Lake (3.0), Ingebrigt Lake (9.0), Alsack Lake (2.6), East Coteau Lake (3.5) and Snakehole Lake (1.7), all in Saskatchewan. Production in Alberta is from Horseshoe Lake (3.0).

Recovery and processing. Because sodium sulphate is recovered by evaporation of concentrated brines or by dredging of the permanent beds of crystals, weather is as important for recovery of sodium sulphate as it is for its deposition. A large supply of fresh water is also essential. One method of sodium sulphate recovery is to pump lake brines that have been concentrated by hot summer weather into evaporating ponds or reservoirs. Continued evaporation produces a saturated or near-saturated solution of mirabilite. Differential crystallization occurs in the fall when the solution cools. Hydrous sodium sulphate crystallizes and precipitates, whereas sodium chloride, magnesium sulphate and other impurities remain in solution. Before freezing weather sets in, the impure solution remaining in the reservoir is drained or pumped back into the source lake.

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, sodium sulphate production and trade, 1977 and 1978

	1977		1978p	
	(tonnes)	($)	(tonnes)	($)
Production				
Shipments	394 795	20 450 196	378 000	19 474 000
Imports				
Total salt cake and Glauber's salt				
United Kingdom	13 569	511 000	14 562	570 000
United States	9 839	546 000	10 616	545 000
Belgium – Luxembourg	11 214	632 000	—	—
West Germany	17	14 000	—	—
Total	34 639	1 703 000	25 178	1 115 000
Exports				
Crude sodium sulphate				
United States	117 008	6 954 000	128 663	7 811 000
New Zealand	18	3 000	—	—
Australia	1	. . .	—	—
Total	117 027	6 957 000	128 663	7 811 000

Source: Statistics Canada.
p Preliminary; — Nil; . . . Less than $1 000.

Table 2. Canada, natural sodium sulphate plants, 1978

	Plant Location	Source Lake	Annual Capacity
			(tonnes)
Alberta			
Alberta Sulphate Limited	Metiskow	Horseshoe	90 700
Saskatchewan			
Francana Minerals Ltd.	Grant	Snakehole	90 700
Francana Minerals Ltd.	Hardene	Alsask	45 350
Midwest Chemicals Limited	Palo	Whiteshore	109 000
Ormiston Mining and Smelting Co. Ltd.	Ormiston	Horseshoe	90 700
Saskatchewan Minerals	Chaplin	Chaplin	135 000
Saskatchewan Minerals	Fox Valley	Ingebrigt	135 000
Sybouts Sodium Sulphate Co., Ltd.	Gladmar	East Coteau	45 350
Total			741 800

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.

After the crystal bed has become frozen, harvesting is carried out using conventional earthmoving equipment. The harvested crystal is stockpiled adjacent to the plant.

In Saskatchewan, three operators: Francana Minerals Ltd. at Snakehole Lake, Ormiston Mining and Smelting Co. Ltd. at Horseshoe Lake, and Sybouts Sodium Sulphate Co., Ltd. at East Coteau Lake, use floating dredges to mine the permanent crystal bed. The slurry of crystal and brine is transported to a screening house at the plant by pipeline. If sufficiently concentrated, the brine from the screens is collected in an evaporation pond.

The Ingebrigt Lake plant of Saskatchewan Minerals uses a combination of dredging and solution mining, and pumps a concentrated brine to an aircooled crystallizer at the plant. At their Chaplin Lake plant, brine reservoir precipitation is followed by draining of the reservoir water back into the lake and mechanical harvesting. Removal of the crystallized sodium sulphate usually takes place in the coldest months of January and February. In Alberta, Alberta Sulphate Limited uses solution-mining techniques at Horseshoe Lake near Metiskow.

Table 3. Canada, sodium sulphate production, trade and consumption, 1960, 1965, 1970 and 1975-78

	Production[1]	Imports[2]	Exports	Consumption
		(tonnes)		
1960	194 326	23 457	57 907	166 071
1965	313 404	26 623	105 546	250 038
1970	445 017	26 449	108 761	291 439
1975	472 196	22 638	178 182[r]	256 385
1976	460 193	29 266	146 396	265 608
1977	394 795	34 639	117 027	254 872
1978[p]	378 000	25 178	128 663	. .

Source: Statistics Canada.
[1]Producers' shipments of crude sodium sulphate. [2]Includes Glauber's salt and crude salt cake.
[p]Preliminary; [r]Revised; . . Not available.

Processing of natural salt consists of dehydration (Glauber's salt contains 55.9 per cent water of crystallization) and drying. Commercial processes used in Saskatchewan include Holland evaporators, gas-fired rotary kilns, submerged combustion and multiple effect evaporators. Auxiliary equipment includes screens, classifiers, centrifuges, rotary kiln driers and crushers. Salt cake, the product used principally in the pulp and paper industry, contains a minimum of 97 per cent Na_2SO_4. Detergent-grade material analyzes up to 99.77 per sent Na_2SO_4. Uniform grain size and free-flow are important in material handling and use.

Table 4. Canada, available data on sodium sulphate consumption, 1976-78

	1976	1977	1978
		(tonnes)	
Pulp and paper	208 601	192 078[e]	. .
Soaps	37 341[e]	37 029[e]	. .
Glass and glass wool	9 746	8 919	. .
Other products[1]	9 920	16 846	. .
Total	265 608	254 872	. .

Source: Statistics Canada, breakdown by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1]Colours, pigments, foundries, feed supplements and other minor uses.
[e]Estimated; . . Not available.

Byproduct recovery. Courtaulds (Canada) Limited produces approximately 20 000 tonnes of detergent-grade sodium sulphate as a byproduct of viscose rayon production at its Cornwall, Ontario plant. Ontario Paper Company Limited at Thorold, Ontario produced 54 000 tonnes of salt cake in 1978, as a byproduct of paper manufacturing. The capacity of the plant is 77 000 tonnes per year. Domtar Inc. in Cornwall, Ontario produces some byproduct salt cake for internal consumption. The Great Lakes Paper Co. Ltd at Thunder Bay, which until now produced small quantities of salt cake for internal consumption, is expanding capacity, possibly to 20 000 tonnes per year and some salt cake will be offered for sale.

Consumption and trade

There are three main consuming industries for sodium sulphate: the kraft pulp and paper industry, the detergent industry and the glass industry. Other users include the dyeing industry and the producers of mineral feed supplements and chemical products. Because of reduced activity in the pulp and paper industry in North America, consumption of salt cake for the production of kraft paper declined in 1977 and 1978. Shipments of detergent grade increased, but not enough to offset the decline in salt cake shipments. Markets and other considerations caused Saskatchewan Minerals to close its Bishopric Lake operation in June 1977.

Canadian exports of sodium sulphate in 1978, at 128 663 tonnes, increased by 10.0 per cent from 117 008 tonnes in 1977. All exports were to the United States although in the past few years small quantities went to Europe. Imports of sodium sulphate in 1978 decreased 27 per cent to 25 178 tonnes. Western Europe supplied eastern Canada and western Canada imported its requirements mainly from the United States.

Table 5. Canada, railway train loadings of sodium sulphate, 1977 and 1978

	1977	1978
	(tonnes)	
Nova Scotia	127	—
New Brunswick	259	260
Quebec	197	699
Ontario	17 468	32 786
Manitoba	222	—
Saskatchewan	352 188	320 644
Alberta	25 556	38 916
British Columbia	52 639	60 909
Canada total	448 656	454 214

Source: Statistics Canada.
— Nil.

Outlook

Demand for salt cake was on the decline for a few years but appears to have stabilized at lower levels. For the next two or three years consumption in the pulp and paper industry should either remain constant or show a very slight decrease, while usage in the detergent industry will remain strong. A modest growth in the rate of demand is therefore forecast for the foreseeable future.

Prices

Canadian prices of sodium sulphate, as quoted in *Canadian Chemical Processing*, December 1, 1978.

	$ Canadian per tonne
Sodium sulphate (salt cake)	
Regular, bulk, carlots, fob works	55.12
Detergent grade bulk, carlots, fob works	68.20

United States prices as quoted in *Chemical Marketing Reporter*, December 29, 1978.

	$ U.S. per short ton
Salt cake, domestic, bulk, 100% Na_2SO_4 basis, fob plant east	47.00-52.00
Same basis, west	45.00
Sodium sulphate, technical, detergent, rayon-grade, bags, carlots, works, east	70.00-72.00

Tariffs

Canada

Item no.		British Preferential	Most Favoured Nation	General	General Preferential
21000-1	Natural sodium sulphate	10%	15%	25%	10%

United States

Item No.		
421-42	Crude sodium sulfate (salt cake)	Free
421-44	Anhydrous	40¢ per long ton
421-46	Crystallized (Glauber's salt)	80¢ per long ton

Sources: Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978), ITC Publication 843.

Stone

D.H. STONEHOUSE

Canadian industry

Production of stone of all types in Canada in 1978 decreased 6.8 per cent to 112 million tonnes*, while the value assigned to production increased 6.8 per cent to $317 million. Stone is produced in direct response to the demands of the construction industry, which utilizes 95 per cent of output principally as crushed stone. Less than one per cent of stone production is used as building stone in the form of panels or blocks now that concrete products have become widely accepted in such applications. The chemical uses are limited to the cement, lime, glass, sugar and metal-smelting industries and account for about 3 per cent of stone production, mainly limestone. The remaining 2 per cent is consumed in pulverized form as filler and extender materials.

The large number of stone-producing operations in Canada precludes describing within this review individual plants or facilities. Many are part-time or seasonal operations, many are operated subsidiary to construction or manufacturing activities by establishments not classified to the stone industry, and some are operated directly by municipal or provincial government departments producing stone for their own direct use. Detailed information can be obtained through the individual provincial departments of mines or equivalent. Most provinces have accumulated data relative to occurrences of stone of all types and in many cases have published such studies. The federal government, through the Geological Survey of Canada, has also gathered and published a great number of geological papers pertaining to stone occurrences. Works by W.A. Parks[1] and by M.F. Goudge[2] have become classics in the fields of building stones and limestones, respectively.

Atlantic provinces. *Limestone.* The many occurrences of limestone in the Atlantic provinces have been systematically catalogued during the past few years[3,4,5]. Deposits of commercial importance are being worked in three of the four provinces.

In Newfoundland limestone is available from small, impure exposures in the eastern portion of the island, from small, high-calcium deposits in the central region, and from large, high-purity, high-calcium occurrences in the west. Other than periodic operation to secure aggregate for highway work, the main exploitation is by North Star Cement Limited at Corner Brook[6]. Large quantities of high-calcium limestone have been outlined in the Port au Port district. The provincial government is continuing its efforts to identify available aggregates near major use centres and adjacent to the Trans Canada Highway route through the province.

In Nova Scotia limestones occur in the central and eastern parts of the province in thin, tilted lenses typical of deposits in Atlantic Canada and in contrast to deposits of much greater thickness and areal extent in central Canada. Large proven reserves in the Glencoe region of Inverness County have been assessed with the object of establishing a portland cement facility on site or at the Strait of Canso to supply an offshore market. A bouyant and continuing market for cement and clinker would be necessary to support such an undertaking.

In New Brunswick limestone is quarried at three locations—Brookville, Elm Tree and Havelock — for use as a crushed stone, as an aggregate, for agricultural application, and for use as a flux. In 1978 Elm Tree Resources opened a quarry to supply the lead smelter at Bathurst with flux stone. The new plant has a capacity of about 50 000 tonnes per year.

Granite. Occurrences of granites in the Atlantic region have been described by Carr[7]. Current operations in Nova Scotia are at Nictaux, Shelburne and Erinville. A grey granite is produced from operations near Nictaux and from one quarry at Shelburne for use mainly in the monument industry. A black granite from Shelburne and a diorite from Erinville are used for monuments and for dimension stone. Quartzitic rock referred to as "bluestone" is quarried at Lake Echo, north of Dartmouth, for use as facing stone. Crushed quartzite for use as an aggregate is produced at a number of locations in Halifax County. At Folly Lake in Colchester County a diorite is quarried, mainly for use as railway ballast. A new quarry in a "quartzite-granite" on the mainland side of the Strait of Canso has been opened recently to supply aggregate material to Prince Edward Island and other Atlantic areas. The company indicates its long-term objectives include marketing aggregates in offshore regions.

Granites are quarried intermittently from a number of deposits within New Brunswick to obtain stone of required colour and texture for specific application. A red, fine - to medium-grained granite is quarried near St. Stephen, and fine-grained, pink, grey and blue-grey granites are available in the Hampstead (Spoon Island) district. In the Bathurst

* The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, total production (shipments) of stone, 1976-78

	1976		1977		1978^p	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
By province						
Newfoundland	365 350	1 282 914	616 779	2 205 701	635 000	2 310 000
Nova Scotia	1 576 652	4 843 827	1 974 215	6 919 179	2 087 000	7 590 000
New Brunswick	3 029 114	8 513 926	3 091 665	9 541 779	3 175 000	10 150 000
Quebec	48 861 437	124 670 778	78 425 529	176 818 607	67 999 000	183 588 000
Ontario	28 165 405	71 860 589	28 869 132	77 884 277	30 481 000	87 360 000
Manitoba	2 338 661	8 558 370	3 022 867	11 303 411	3 175 000	12 250 000
Alberta	357 735	1 498 982	224 409	728 128	272 000	900 000
British Columbia	3 181 582	9 409 076	3 938 003	11 166 228	4 173 000	12 650 000
Canada	87 875 936	230 638 462	120 162 599	296 567 310	111 997 000	316 798 000
By use						
Building stone						
Rough	248 570	2 817 725	320 673	2 889 799	. .	. .
Monument and ornamental stone	30 869	1 700 371	23 661	1 640 633	. .	. .
Other (flagstone, curbstone, paving blocks, etc.)	22 411	718 516	23 238	888 738	. .	. .
Chemical and metallurgical						
Cement plants, foreign	1 157 935	1 639 205	1 205 482	1 285 616	. .	. .
Lining, open-hearth furnaces	39 545	67 714	34 536	62 302	. .	. .
Flux in iron and steel furnaces	411 192	987 127	421 467	1 524 365	. .	. .
Flux in nonferrous smelters	71 209	154 358	84 306	218 203	. .	. .
Glass factories	221 529	1 453 106	277 828	2 085 426	. .	. .
Lime kilns, foreign	523 993	961 622	332 317	819 818	. .	. .
Pulp and paper mills	258 947	1 725 919	308 668	1 881 921	. .	. .
Sugar refineries	50 458	245 198	35 280	164 807	. .	. .
Other chemical uses	818 762	3 073 218	826 105	3 475 959	. .	. .
Pulverized stone						
Whiting (substitute)	16 449	549 724	19 533	670 922	. .	. .
Asphalt filler	49 512	457 136	31 035	166 079	. .	. .
Dusting, coal mines	9 733	69 682	3 538	56 400	. .	. .
Agricultural purposes and fertilizer plants	642 337	4 111 008	717 431	4 802 926	. .	. .
Other uses	48 677	416 064	57 094	478 630	. .	. .

Crushed stone for						
Manufacture of artificial stone	9 936	167 620	9 579	168 064	. .	. .
Roofing granules	245 297	7 216 482	230 288	7 478 853	. .	. .
Poultry grit	38 064	295 916	33 588	430 779	. .	. .
Stucco dash	31 564	1 192 315	32 119	1 157 871	. .	. .
Terrazzo chips	12 674	359 435	9 919	344 895	. .	. .
Rock wool	43 558	156 324	—	—	. .	. .
Rubble and riprap	13 218 391	23 304 609	41 639 850	65 201 294	. .	. .
Concrete aggregate	10 976 873	29 955 214	12 368 628	34 562 618	. .	. .
Asphalt aggregate	5 177 432	13 603 481	5 470 039	15 020 731	. .	. .
Road metal	24 113 247	61 208 838	25 382 239	69 476 894	. .	. .
Railroad ballast	4 570 121	12 806 805	5 570 667	17 590 395	. .	. .
Other uses	24 816 651	59 223 730	24 693 491	62 022 372	. .	. .
Total	87 875 936	230 638 462	120 162 599	296 567 310	111 997 000	316 798 000

Source: Statistics Canada.
p Preliminary; — Nil; . . Not available.

area, a brown-to-grey, coarse-grained granite is quarried upon demand, as is a salmon-coloured, medium-grained granite near Antinouri Lake, and a black, ferromagnesian rock in the Bocabec River area. Red granite is available in the St. George district. Granite for use as a crushed stone is produced near Fredericton and near Moncton.

Sandstone. A medium-grained buff sandstone is quarried at Wallace, Nova Scotia, for use as heavy riprap and for dimension stone applications. Small deposits in many parts of the province are quarried periodically for local use.

In New Brunswick, a red, fine- to medium-grained sandstone has been quarried in Sackville for use in construction of buildings on the Mount Allison University campus. Deposits are exploited from time to time throughout Kent and Westmorland counties for local projects and for highway work.

Quebec. *Limestone.* Limestone occurs in the St. Lawrence and Ottawa river valleys and in the Eastern Townships. Other major deposits in the province are located in the Gaspé region. The limestones range in age from Precambrian to Carboniferous and vary widely in purity, colour, texture and chemical composition[2].

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Table 2. Canada, production (shipments) of limestone, 1976 and 1977

	1976		1977	
	(000 tonnes)	($000)	(000 tonnes)	($000)
By province				
Newfoundland	132	470	453	1 410
Nova Scotia	81	446	193	1 532
New Brunswick	722	3 289	752	3 600
Quebec	27 275	74 036	27 821	79 116
Ontario	26 299	58 959	27 126	64 742
Manitoba	789	1 866	1 147	2 669
Alberta	133	1 171	88	536
British Columbia	2 361	6 463	2 581	6 788
Canada[1]	57 793	146 700	60 161	160 393
	(tonnes)	($)	(tonnes)	($)
By use				
Building stone				
Rough	205 642	1 106 389	279 771	1 187 173
Monument and ornamental	916	57 880	915	77 567
Other (flagstone, curbstone, paving blocks, etc.)	7 458	223 575	8 221	257 533
Chemical and metallurgical				
Cement plants, foreign	1 157 935	1 639 205	1 205 482	1 285 616
Lining, open-hearth furnaces	39 545	67 714	34 536	62 302
Flux, iron and steel furnaces	411 192	987 127	421 467	1 524 365
Flux, nonferrous smelters	71 209	154 358	84 306	218 203
Glass factories	221 529	1 453 106	277 828	2 085 426
Lime kilns, foreign	523 993	961 622	332 317	819 818
Pulp and paper mills	252 968	1 671 682	301 999	1 815 540
Sugar refineries	50 458	245 198	35 280	164 807
Other chemical uses	818 762	3 073 218	826 105	3 475 959
Pulverized stone				
Whiting substitute	16 449	549 724	19 532	670 922
Asphalt filler	41 902	429 830	25 092	140 597
Dusting, coal mines	9 733	69 682	3 538	56 400
Agricultural purposes and fertilizer plants	589 504	3 824 407	633 842	4 291 258
Other uses	46 085	372 773	53 653	404 927

Table 2. (cont'd)

	1976		1977	
	(tonnes)	($)	(tonnes)	($)
Crushed stone for				
Artificial stone	2 313	71 656	1 379	53 200
Roofing granules	39 137	135 279	41 327	209 392
Poultry grit	37 384	281 426	32 978	416 808
Stucco dash	27 883	1 065 594	26 445	1 097 430
Rock wool	43 558	156 324	—	—
Rubble and riprap	538 046	1 016 566	692 890	1 849 022
Concrete aggregate	9 157 690	23 280 034	10 661 288	28 313 202
Asphalt aggregate	3 547 019	8 916 390	3 673 566	9 616 631
Road metal	17 772 106	44 585 715	19 831 967	52 065 162
Railroad ballast	2 452 526	5 144 952	2 618 317	5 732 379
Other uses	19 710 062	45 158 398	18 037 192	42 501 203
Total	57 793 004	146 699 824	60 161 233	160 392 842

Source: Statistics Canada.
[1] Figures may not add to totals due to rounding.
— Nil.

Table 3. Canada, production (shipments) of marble, 1976 and 1977

	1976		1977	
	(000 tonnes)	($000)	(000 tonnes)	($000)
By province				
Quebec	391	1 703	390	1 783
Ontario	7	272	7	279
Canada [1]	398	1 974	397	2 062
	(tonnes)	($)	(tonnes)	($)
By use				
Chemical process stone				
Pulp and paper mills	5 979	54 237	6 669	66 381
Pulverized stone				
Agricultural purposes and fertilizer plants	52 833	286 601	83 589	511 668
Other uses	2 592	43 291	3 441	73 703
Crushed stone				
For manufacture of artificial stone	7 623	95 964	8 200	114 864
Stucco dash	1 478	44 769	5 673	60 441
Terrazzo chips	12 674	359 435	9 919	344 895
Concrete aggregate	82 424	529 735	69 803	366 566
Asphalt aggregate	13 942	50 243	15 702	68 468
Road metal	133 605	325 958	79 847	225 064
Other uses	85 167	184 235	114 062	230 171
Total	398 317	1 974 468	396 905	2 062 221

Source: Statistics Canada.
[1] Figures may not add to totals due to rounding.

operating limestone properties in 1977[8], including portland cement and lime producers and also including four producers of dimension stone. Quarries are located near major market areas such as Montreal, Quebec City, Sherbrooke, Ottawa-Hull and Trois-Rivières and supply crushed stone to the construction industry, mainly for use in concrete and asphalt and as highway subgrade.

Limestone blocks and other shapes are produced for the construction trade in the Montreal region and at various locations throughout the province as the need arises. Marble has been produced in the Stukely and Philipsburg areas. Five operations are listed by the Quebec Department of Natural Resources[8].

Granite. Normally about 60 per cent of Canada's granite production comes from Quebec from long-established operations in two general regions – one north of the St. Lawrence and Ottawa Rivers, including the Lac Saint-Jean area, and one south of the St. Lawrence River. Precambrian rocks contain granites of various colours, compositions and textures. The Quebec Department of Natural Resources indicated that 25 plants were processing granite as building or ornamental stone[8]. Many areas underlain by granite are too remote from transportation and markets to be economically attractive. These deposits are, however, the logical source of construction material should a regional demand arise. Such was the case, beginning in 1975, in the James Bay region when the requirements for heavy riprap for the well-publicized hydro electric project were met from regional deposits of granite. Increased granite production from Quebec peaked in 1977 at 55 million tonnes, nearly 90 per cent of the Canadian total.

Sandstone. There are far fewer sandstone-producing operations in Quebec than there are producers of limestones and granites. Of six operations producing from sandstone resources only one is listed as marketing flagstone and construction blocks[8].

Ontario. *Limestone*. Although limestones in Ontario range from Precambrian through Devonian, the major production

Table 4. Canada, production (shipments) of granite, 1976 and 1977

	1976		1977	
	(000 tonnes)	($000)	(000 tonnes)	($000)
By province				
Newfoundland	58	243	6	61
Nova Scotia	2	18	. . .	23
New Brunswick	1 901	4 178	1 664	4 158
Quebec	18 519	42 287	48 200	88 921
Ontario	1 842	12 192	1 719	12 404
Manitoba	1 549	6 692	1 876	8 635
British Columbia	820	2 947	1 357	4 378
Canada	24 691	68 557	54 822	118 580
	(tonnes)	($)	(tonnes)	($)
By use				
Building stone				
Rough	16 978	927 238	14 787	852 766
Monument and ornamental	26 778	1 614 491	22 746	1 563 066
Other (flagstone, curbstone, paving blocks, etc.)	2 670	117 132	3 885	295 564
Pulverized stone				
Asphalt filler	7 610	27 306	5 943	25 482
Crushed stone for				
Roofing granules	206 160	7 081 203	188 961	7 269 461
Poultry grit	680	14 490	610	13 971
Stucco dash	2 203	81 952	—	—
Rubble and riprap	12 234 023	21 380 229	40 870 680	63 188 390
Concrete aggregate	1 418 037	5 102 170	1 258 859	4 351 695
Asphalt aggregate	991 963	2 772 494	1 164 027	3 402 219
Road metal	5 078 386	13 232 696	3 975 761	12 512 090
Railroad ballast	1 698 561	6 493 199	2 135 298	9 079 012
Other uses	3 006 934	9 712 752	5 180 980	16 025 909
Total	24 690 983	68 557 352	54 822 537	118 579 625

Source: Statistics Canada.
— Nil; . . . Negligible.

comes from Ordovician, Silurian and Devonian deposits[9,10]. Of particular importance are the limestones and dolomite from the following geological sequences: the Black River and Trenton formations, extending from the lower end of Georgian Bay across southern Ontario to Kingston; the Guelph-Lockport Formation, extending from Niagara falls to the Bruce Peninsula and forming the Niagara Escarpment; and the Middle Devonian limestone extending from Fort Erie through London and Woodstock to Lake Huron. Production of building stone, fluxstone and crushed aggregate from the limestones of these areas normally accounts for about 90 per cent of total stone production in Ontario.

Marble is widely distributed over southeastern Ontario and, according to the Ontario Ministry of Natural Resources reports, underlies as much as 250 square kilometres (km^2)[11].

During 1977, production of calcium carbonate for filler markets, for the glass and ceramics industries and for agricultural use was begun near Perth by William R. Barnes Company from a new $4 million plant with an annual capacity of about 120 000 tonnes. The filler markets have become extremely attractive recently, not only to new ventures but also to companies hitherto interested in production of only coarser aggregate materials. Many lime operations now produce a filler-grade limestone product.

Granite. Granites occur in northern, northwestern and southeastern Ontario[12]. Few deposits have been exploited for the production of building stone because the major-consuming centres are in southern and southwestern Ontario where ample, good-quality limestones and sandstones are readily available. The areas most active in granite building stone production have been the Vermilion Bay area near Kenora, the River Valley area near North Bay, and the Lyndhurst-Gananoque area in southeastern Ontario. Rough building blocks were quarried from a gneissic rock near Parry Sound, while at Havelock a massive red-granite rock was quarried.

Sandstone. Sandstone quarried near Toronto, Ottawa and Kingston has been used widely in Ontario as building stone[13]. Production is currently from the Limehouse-Georgetown-Inglewood district where Potsdam sandstone is quarried. Medina sandstones vary from grey, through buff and brown to red, and some are mottled. They are fine- to medium-grained. The Potsdam stone is medium-grained;

Table 5. Canada, production (shipments) of sandstone, 1976 and 1977

	1976		1977	
	(000 tonnes)	($000)	(000 tonnes)	($000)
By province				
Newfoundland	163	557	146	722
Nova Scotia	1 495	4 379	1 781	5 365
New Brunswick	406	1 047	676	1 783
Quebec	1 599	4 846	1 192	4 976
Ontario	15	438	17	460
Alberta	15	31	22	31
Canada[1]	3 694	11 298	3 834	13 337
	(tonnes)	($)	(tonnes)	($)
By use				
Building stone				
Rough	25 950	784 098	26 115	849 860
Monument and ornamental	3 175	28 000	—	—
Other (flagstone, curbstone, paving blocks, etc.)	12 283	377 809	11 132	335 641
Crushed stone for				
Rubble and riprap	376 469	800 014	76 281	163 882
Concrete aggregate	318 722	1 043 275	378 678	1 531 155
Asphalt aggregate	413 622	1 249 707	451 979	1 388 018
Road metal	1 006 680	2 874 217	1 172 859	3 784 620
Railroad ballast	419 034	1 168 654	817 052	2 779 004
Other uses	1 117 982	2 972 267	899 915	2 504 505
Total[1]	3 693 917	11 298 041	2 834 011	13 336 685

Source: Statistics Canada.
[1] Figures may not add to totals due to rounding.
— Nil.

the colour ranges from grey-white through salmon-red to purple, and it can also be mottled. Current uses are as rough building stone, mill blocks from which sawn pieces are obtained, ashlar, flagstone and as a source of silica for ferrosilicon and glass.

Recent news releases from the Ontario Ministry of Natural Resources identified six major sites in eastern Ontario in which high-grade silica deposits occur. The Ministry study was undertaken to stimulate exploration that could develop silica resources to serve the Canadian consuming industries, which now use about 1.5 million tonnes of silica per year.

Western provinces. *Limestone.* From east to west through the southern half of Manitoba rocks of the following ages are represented: Precambrian, Ordovician, Silurian, Devonian and Cretaceous. Limestones of commercial importance occur in the three middle periods and range from magnesian limestone through dolomite to high-calcium limestones[2,14].

Although building stone does not account for a large percentage of total limestone produced, the best known Manitoba limestone is Tyndall Stone, a mottled dolomitic limestone often referred to as "tapestry" stone. It is widely accepted as an attractive building stone, and is quarried at Garson, Manitoba, about 50 kilometres (km) northeast of Winnipeg.

Limestone from Moosehorn, 160 km northwest of Winnipeg and from Mafeking, 40 km east of the Saskatchewan border and 160 km south of The Pas, is transported to Manitoba and Saskatchewan centres for use in the metallurgical, chemical, agricultural and construction industries. Limestone from Steep Rock and from Lily Bay is used by cement manufacturers in Winnipeg, and limestone from Faulkner is now being used by the lime plant at Spearhill. The possibility of utilizing marl, an unconsolidated calcareous material, from deposits in the Sturgeon Lake region of Saskatchewan in the pulp and paper, cement, and lime industries has been investigated. Marl from a deposit 100 km north of Edmonton is being used as raw material in cement manufacture[6]. Two limestone deposits in the Lac La Ronge and Pinehouse Lake regions of northern Saskatchewan are being assessed, principally for use in the manufacture of quicklime for use in uranium refining.

The eastern ranges of the Rocky Mountains contain limestone spanning the geologic ages from Cambrian to Triassic, with major deposits in the Devonian and Carboniferous periods in which a wide variety of types occur[15]. In southwestern Alberta, high-calcium limestone is mined at Exshaw, Kananaskis and Crowsnest, chiefly for the production of cement and lime, for metallurgical and chemical uses and for use as a crushed stone. Similar uses are made of limestone quarried at Cadomin, near Jasper[6].

In British Columbia large volumes of limestone are mined each year for cement and lime manufacture, for use by the pulp and paper industry and for various construction applications[6,7]. A large amount is exported to the northwestern United States for cement and lime manufacture. Four companies mined limestone on Texada Island, with the entire output being moved by barge to Vancouver and the State of Washington. Deposits on Aristazabal Island have recently been developed for the export market. Other operations at Terrace, Clinton, Westwold, Popkum, Dahl Lake, Doeye River and Cobble Hill produced stone for construction and for filler use[16]. Periodically, interest is revived in the possible use of travertine from a British Columbia source.

Granite. In Manitoba, at Lac du Bonnet northeast of Winnipeg, a durable, red granite is quarried for building and monument use. Grey granite located east of Winnipeg near the Ontario border is a potential source of building stone.

Table 6. Canada, production (shipments) of shale, 1976 and 1977

	1976		1977	
	(000 tonnes)	($000)	(000 tonnes)	($000)
By province				
Newfoundland	12	13	12	13
Quebec	1 078	1 799	822	2 022
Alberta	210	297	114	161
Canada	1 300	2 109	948	2 196
By use				
Crushed stone for				
Rubble and riprap	69 853	107 800	—	—
Asphalt aggregate	210 886	614 647	164 766	545 395
Road metal	122 470	190 252	321 805	889 958
Other uses	896 506	1 196 078	461 342	760 584
Total	1 299 715	2 108 777	947 913	2 195 937

Source: Statistics Canada.
— Nil.

Table 7. Canada, production (shipments) of stone by types, 1965, 1970 and 1975-77

	1965		1970		1975		1976		1977	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Granite	7 102 549	16 569 762	4 388 270	15 231 891	11 469 656	34 912 787	24 690 983	68 557 352	54 822 537	118 579 625
Limestone	56 407 688	69 974 005	52 522 637	67 563 790	72 284 032	152 521 587	57 793 004	146 699 824	60 161 233	160 392 842
Marble	71 160	1 049 264	56 096	350 903	356 111	1 842 715	398 317	1 974 468	396 905	2 062 221
Sandstone	3 785 665	5 328 404	2 112 794	4 133 708	3 753 357	10 880 645	3 693 917	11 297 041	3 834 011	13 336 685
Shale	2 121 415	1 837 492	180 087	695 458	1 550 450	2 566 306	1 299 715	2 108 777	947 913	2 195 937
Slate	145 305	88 094	—	—	—	—	—	—	—	—
Total[1]	69 633 782	94 847 021	59 259 884	87 975 750	89 413 611	202 724 040	87 875 936	230 638 462	120 162 599	296 567 310

Source: Statistics Canada.
[1] Figures may not add to totals due to rounding.
— Nil.

In British Columbia a light-grey to blue-grey, even-grained granodiorite of medium texture is available from Nelson Island. An andesite has been quarried at Haddington Island, off the northeast coast of Vancouver Island, for use as a building stone.

Sandstone. Sandstone for building and ornamental uses, quarried near Banff, Alberta is hard, fine-grained, medium-grey and is referred to as "Rundal Stone".

Markets

Naturally occurring rock material, quarried or mined for industrial use with no change in its chemical state and with its physical character altered only by shaping or by sizing, is commercially termed "stone". Dimension stone is shaped for use as a building block, slab or panel. It may be rough-cut, sawn or polished, and its application may depend on its strength, hardness, durability and ornamental qualities. Broken, irregular, screened and sized pieces constitute the crushed stone category. Material in this category is used mainly as an aggregate in concrete and asphalt, in highway and railway construction and as heavy riprap for facing wharves and breakwaters.

Dimension stone. Granite, limestone, marble and sandstone are the principal rock types from which building and ornamental stone is fashioned. Over 90 per cent is used in construction-oriented projects, while less than 10 per cent is used as monument stone. Imports of rough blocks, particularly of granite, for sawing and polishing, as well as of finished stones for distribution to retailers, have cut into markets formerly supplied from domestic sources.

Today, in the building sector of the construction industry, granite, limestone and marble are used as facing stone in the form of cut and polished panels, in conjunction with steel and concrete, for institutional and commercial buildings. In residential buildings the use of limestone or sandstone ashlar, or coursing stone, is becoming increasingly popular. The emphasis has changed from stone used for structural purposes to stone used for its aesthetic qualities. The architect and contractor can design and build for lasting beauty using Canadian building stone.

High costs associated with quarrying, finishing, transporting and placing dimension stone in the building construction sector have contributed to the erosion of this industry and have made market penetration by concrete products possible.

Table 8. Canada, stone exports and imports, 1976-78

	1976		1977		1978p	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Exports						
Building stone, rough	10 349	1 013 000	13 494	1 447 000	17 472	975 000
Crushed limestone, limestone refuse	1 287 976	2 733 000	1 502 492	3 251 000	1 710 340	4 011 000
Stone crude, nes	559 125	1 574 000	182 047	683 000	294 047	656 000
Natural stone, basic products	. .	1 989 000	. .	1 731 000	. .	3 730 000
Total		7 309 000		7 112 000		9 372 000
Imports						
Building stone, rough	16 875r	951 000r	13 756	1 226 000	11 023	893 000
Crushed limestone, limestone refuse	3 513 824	7 381 000	2 922 684	8 611 000	2 873 586	9 961 000
Crushed stone including stone refuse, nes	507 860	3 143 000	69 225	3 459 000	59 648	3 201 000
Stone crude, nes	5 985r	337 000r	6 469	488 000	6 590	699 000
Granite, rough	19 167	922 000	22 156	1 686 000	17 063	1 544 000
Marble, rough	9 095	1 247 000	7 665	1 153 000	5 937	1 307 000
Shaped or dressed granite	. .	1 912 000	. .	842 000	. .	1 080 000
Shaped or dressed marble	. .	1 701 000	. .	1 526 000	. .	1 442 000
Natural stone basic products	. .	696 000	. .	960 000	. .	1 078 000
Total		18 290 000		19 951 000		21 205 000

Source: Statistics Canada.
p Preliminary; nes Not elsewhere specified; . . Not available; r Revised.

Crushed stone. Many quarries that produce crushed stone are operated primarily to produce stone for other purposes, e.g., granite for building blocks and monuments, limestones for cement or lime manufacture, or for metallurgical use, marble for monuments and building panels, sandstone for riprap and cut stone. Quarries removing solid rock by drilling, blasting and crushing are not likely to be operated for small, local needs as are gravel pits and are, therefore, usually operated by large companies associated with the construction industry. Depending on costs and availability, crushed stone competes with gravel and crushed gravel as an aggregate in concrete and asphalt, and as railway ballast and road metal. In these applications it is subject to the same physical and chemical testing procedures as the gravel and sand aggregates.

Limestones are widely distributed in Canada and generally are available in sufficient quantity and with such chemical or physical specifications that long transportation hauls are unnecessary. Limestone products are low-priced commodities and only rarely, when a market exists for a high-quality, specialized product such as white portland cement or a high-purity extender, are they beneficiated or moved long distances. Provided the specifications are met, the nearest source is usually considered, regardless of provincial or national boundaries.

Over 70 per cent of Canada's annual production of limestone is used as crushed stone. This includes about 50 per cent used as road metal (broken, screened stone for asphalt roads), about 20 per cent as concrete aggregate and about 2 per cent as railroad ballast.

Table 9. Canada, value of construction by province, 1977-79

	1977[1]	1978[2]	1979[3]
	(millions of dollars)		
Newfoundland	623.1	664.0	838.1
Prince Edward Island	119.0	144.8	150.7
Nova Scotia	914.5	1 015.8	1 066.8
New Brunswick	873.7	921.8	977.5
Quebec	8 589.9	8 736.2	9 199.2
Ontario	10 613.6	10 914.5	11 758.3
Manitoba	1 397.6	1 532.3	1 546.1
Saskatchewan	1 564.0	1 663.2	1 840.7
Alberta	6 124.8	7 387.8	8 316.2
British Columbia	4 492.7	4 976.4	5 372.2
Yukon and Northwest Territories	490.5	428.3	449.1
Canada	35 803.4	38 385.1	41 514.9

Source: Statistics Canada.
[1] Actual; [2] Preliminary; [3] Forecast.

Some major uses in the chemical field are: neutralization of acid waste liquors; extraction of aluminum oxide from bauxite; manufacture of soda ash, calcium carbide, calcium nitrate and carbon dioxide; in pharmaceuticals; as a disinfectant; in the manufacture of dyes, rayons, paper, sugar and glass; and in the treatment of water. Dolomitic limestone is used in the production of magnesium chloride and other magnesium compounds.

Limestone is used in the metallurgical industries as a fluxing material where it combines with impurities in ore to form a fluid slag that can be separated from molten metal. Calcium limestones are used in openhearth steel manufacture, whereas both calcium limestones and dolomitic limestones are used as a flux in the production of pig iron in blast furnaces.

Limestone is used extensively as a filler or an extender and, where quality permits, as whiting. In such applications both physical and chemical properties are important. Specifications vary widely but, in general, a uniform, white material passing 325 mesh would meet the physical requirements. Whiting is used in ceramic bodies, plastics, floor coverings, insecticides, paper, wood putty, rubber, paints and as a filler in many other commodities. In paint manufacture the material may be used as a pigment extender.

Agricultural limestone is used to control soil acidity and to add calcium and magnesium to the soil. Limestone and lime are used as soil stabilizers, particularly on highway construction projects.

Dolomite is the source of magnesium metal produced at Haley, Ontario; the company also uses a high-calcium lime

Table 10. Canada, value of construction by type, 1977

	(millions of dollars)
Building construction	
Residential	13 126
Industrial	1 729
Commercial	3 639
Institutional	1 662
Other building	1 152
Total	21 308
Engineering construction	
Marine	242
Highways, airport runways	2 691
Waterworks, sewage systems	1 669
Dams, irrigation	154
Electric power	3 401
Railway, telephones	1 356
Gas and oil facilities	2 724
Other engineering	2 259
Total	14 497
Total construction	35 804

Source: Statistics Canada.
Note: Data for the preliminary and forecast years (1978 and 1979) are not available by type of construction, hence they are not shown.

Table 11. Canada, value of construction work performed, by principal type of construction, by industry, 1976-79

Industry	1976[1] Building	1976[1] Engineering	1976[1] Total	1977[1] Building	1977[1] Engineering	1977[1] Total	1978[2] Total	1979[3] Total
				(millions of dollars)				
Agriculture and fishing	481	262	743	552	301	853	1 008	1 127
Forestry	20	115	135	21	129	150	152	167
Mining, quarrying, oil wells	351	2 374	2 725	352	2 890	3 242	3 434	4 078
Construction	136	2	138	147	2	149	161	174
Manufacturing	1 116	762	1 878	1 389	800	2 189	2 220	2 226
Utilities	489	4 737	5 226	558	5 420	5 978	6 782	7 434
Trade	493	25	518	467	20	487	472	492
Finance, insurance, real estate	1 612	239	1 851	1 695	313	2 008	2 253	2 579
Commercial services	643	6	649	406	5	411	463	570
Housing	12 669	—	12 669	13 126	—	13 126	13 708	14 347
Institutional services	1 341	15	1 356	1 400	17	1 417	1 425	1 639
Government departments	1 121	4 122	5 243	1 194	4 599	5 793	6 307	6 682
Total	20 472	12 659	33 131	21 307	14 496	35 803	38 385	41 515

Source: Statistics Canada.
[1] Actual. [2] Preliminary. [3] Forecast.
— Nil.
Note: Data for the preliminary and forecast years are not available by principal type of construction.

from southeastern Ontario in the production of calcium metal. Dead-burned dolomitic limestone for use as a refractory is produced at Dundas, Ontario, by Steetley Industries Limited.

Limestone from deposits in coastal areas of British Columbia is mined, crushed, loaded on barges of up to 20 000 tonnes capacity, and transported as much as 600 km to consuming centres along the west coast in both Canada and the United States. One Canadian company, Domtar Inc., manufactures lime at Tacoma, Washington, using limestone from Texada Island.

Comparatively small amounts of granite and sandstone are used as building and monument stone. Engineering construction projects, utilizing all sizes from riprap to sand, are the principal consumer. High-silica sands can be the source of silica for glass and ceramics manufacture and for moulding sands. Canada currently imports nearly 80 per cent of it's silica for these uses.

Outlook

Crushed stone will continue to compete with sand and gravel for major markets where the latter are scarce. Through vertical integration, large operations based on construction materials can, by mergers and acquisitions, obtain captive markets for their products in operating construction firms. Construction firms can also integrate backwards into the resource field.

The possibility of substitutes for aggregates is not likely to occur soon in Canada, although in countries where such resources are scarce other materials such as compressed garbage are being used. The use of lime or cement to stabilize soils could reduce the amount of aggregate fill required on some highway or railway projects.

Traditional markets for building stone have been lost to competitive building materials such as steel and concrete. Modern design and construction methods favour the flexibility offered by use of steel and precast or cast-in-place concrete. For aesthetic qualities not available in other materials, rough or polished stone is used in many modern structures. Monument stone continues to be in demand.

The present structure of the building stone industry in Canada is unlikely to change in the near future. Efforts have been made on behalf of the industry to illustrate to contractors and architects the availability of a wide range of Canadian building stones and their adaptability in modern building design.

There is justifiable concern for the future development, operation, and rehabilitation of pits and quarries in all locations, especially in and near areas of urban development. Rehabilitation of stone quarries for subsequent land use is generally more difficult and costly than rehabilitation of gravel pits.

Although an open-pit mining operation close to residential areas is seldom desirable, nonrenewable mineral resources must be fully and wisely utilized. When urban sprawl has been unexpectedly rapid, conflicts for land use can materialize and potential sources of raw mineral materials for the construction industry can be overrun. Master plans for land use are required to coordinate all phases of development so that mineral exploitation is part of the urban growth pattern.

Although there is no absolute shortage of aggregate, a shortage of aggregate at reasonable prices could result from growing opposition to the industry. Already large deposits of accessible aggregate material have been removed from the "reserves" category by legislation. Further restrictions could curtail sand and gravel operations in Ontario in about 20 years. Industry has been hesitant to invest in new plant sites, which would increase their reserve base, until the impact of proposed legislation is known.

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Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)	(%)	(%)	(%)
29635-1	Limestone, not further processed than crushed or screened	free	free	25	free
30500-1	Flagstone, sandstone and all building stone, not hammered, sawn or chiselled	free	free	20	free
30505-1	Marble, rough, not hammered or chiselled	10	10	20	free
	General Agreement on Tariffs and Trade				
30510-1	Granite, rough, not hammered or chiselled	free	free	20	free
30515-1	Marble, sawn or sand rubbed, not polished	free	10	35	free
	General Agreement on Tariffs and Trade		5		
30520-1	Granite, sawn	free	$7^{1}/_{2}$	35	free
30525-1	Paving blocks of stone	free	$7^{1}/_{2}$	35	free
30530-1	Flagstone and building stone, other than marble or granite, sawn on not more than two sides	free	$7^{1}/_{2}$	35	free
30605-1	Building stone, other than marble or granite, sawn on more than two sides but not sawn on more than four sides	5	$7^{1}/_{2}$	10	5
30610-1	Building stone, other than marble or granite, planed, turned, cut or further manufactured than sawn on four sides	$7^{1}/_{2}$	$12^{1}/_{2}$	15	$7^{1}/_{2}$
30615-1	Marble, not further manufactured than sawn, when imported by manufacturers of tombstones to be used exclusively in the manufacture of such articles, in their own factories	free	15	20	free
	General Agreement on Tariffs and Trade		free		
30700-1	Marble, nop	$17^{1}/_{2}$	$17^{1}/_{2}$	40	$11^{1}/_{2}$
30705-1	Manufacturers of marble, nop	$17^{1}/_{2}$	$17^{1}/_{2}$	40	$11^{1}/_{2}$
30710-1	Granite, nop	$17^{1}/_{2}$	$17^{1}/_{2}$	40	$11^{1}/_{2}$
30715-1	Manufacturers of granite, nop	$17^{1}/_{2}$	$17^{1}/_{2}$	40	$11^{1}/_{2}$
30800-1	Manufacturers of stone, nop	$17^{1}/_{2}$	$17^{1}/_{2}$	35	$11^{1}/_{2}$
30900-1	Roofing slate, per square of 100 square feet	free	free	75¢	free
30905-1	Granules, whether or not coloured or coated, for use in manufacture of roofing, including shingles and siding	free	free	25	free

United States

Item No.		
513.21	Marble chips and crushed	5% ad valorem
513.61	Granite, not manufactured, and not suitable for use as monument, paving or building stone	free
514.11	Limestone, crude, not suitable for use as monument, paving or building stone, per short ton	10¢
514.91	Quartzite, whether or not manufactured	free
515.11	Roofing slate	12.5% ad valorem
515.14	Other slate	5% ad valorem
515.41	Stone, other, not manufactured and not suitable for use as monument, paving or building stone	free

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1978), USITC Publication 843.
Note: Varying tariffs are in effect on the more fabricated stone categories.
nop Not otherwise provided for.

Sulphur

G.H.K. PEARSE

Sulphur, one of the most important industrial raw materials, is distributed throughout the world in both elemental and combined forms. It has been used by man since antiquity and today it is used at some stage in the production of almost everything we eat, wear or use. Almost two thirds of the world's sulphur output is in elemental form, nearly all obtained from native sulphur deposits or sour natural gas. The remainder is recovered from pyrite and smelter stack gases, principally as sulphuric acid (H_2SO_4), in which form 87 per cent of all sulphur is consumed. Fertilizer manufacture accounts for over half of all sulphur consumed, followed by the manufacture of chemicals, pigments and pulp and paper as the next-largest consuming sectors.

World sulphur production in all forms, at 53.5 million tonnes* in 1978, is little changed from the previous four years. Western world production declined for the fourth consecutive year, and the 34.1 million-tonne output is 3 per cent below the peak year of 1974.

World consumption, on the other hand, rose an estimated 6 per cent to a new high of 53.0 million tonnes. Western world consumption exceeded production for the first time since 1970, signalling the onset of a new era of tight supply.

Canada's total elemental sulphur sales in 1978, a record 5.8 million tonnes, were 11 per cent greater than in 1977. Sulphur stockpiles on the prairies peaked in March 1978 at 20.9 million tonnes and were 20.8 million tonnes at year-end.

The Canadian sulphur industry

Canadian sulphur is obtained from three sources: elemental sulphur derived from sour natural gas and petroleum, sulphur recovered from smelter gases in the form of sulphuric acid and sulphur contained in pyrite concentrates used in sulphuric acid manufacture. Minor tonnages of elemental sulphur are recovered as a byproduct of electrolytic refining of nickel sulphide matte, and about 85 000 tonnes per year of liquid sulphur dioxide are produced from smelter gases. In 1978, 90 per cent of Canadian sulphur shipments were in elemental form, nearly all from sour natural gas in western Canada. Canada has been the world's largest exporter of elemental sulphur since 1968.

Hydrocarbon sources. Highly toxic and corrosive hydrogen sulphide (H_2S), the dominant sulphur compound occurring in sour natural gas, is presently the largest source of sulphur in Canada.

Sulphur recovery from Athabasca oil sands and crude oil is comparatively minor at present, and recovery from coal is virtually nil. However, with increasing energy requirements, and with stringent air pollution regulations coming into force, these vast sources of sulphur will, in future, contribute substantially to world supply.

Sour natural gas. Although the H_2S content of sour gas fields ranges as high as 91 per cent by weight, most producing fields contain from 1 to 20 per cent. The modified Claus process is used to recover sulphur from sour natural gas. H_2S is extracted by absorption into a solution of either diethanolamine, monoethanolamine, hot potassium carbonate, or sulfinol. The solution is heated in a stripper tower where H_2S is evolved. The H_2S passes into a furnace where partial oxidation and reaction occurs as follows:

$$2H_2S + 3O_2 \leqq 2H_2O + 2SO_2$$

$$2H_2S + SO_2 \leqq 2H_2O + 3S$$

Gas from this furnace enters a condenser-converter series and liquid sulphur is removed in each unit until 95 per cent or more of the original sulphur has been drawn off. The liquid sulphur is fed into underground storage for pumping to: outside blocks (vats) where the liquid solidifies; storage tanks, for direct shipping to North American markets in liquid form; a slating plant, where it is quenched in water on a special belt, subsequently breaking up into "slates"; or to a prilling plant.

A variety of prilling or pelletizing processes have been under investigation over the years and a few have been

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

commercialized. The Sulpel and Kaltenback processes, which use water as a quenching medium; and a Polish process and the French Perlomatic process, which use rising currents of air as a quenching medium, have been developed in Europe. A 300-tonne-per-day Perlomatic plant was installed at Petrogas Processing Ltd.'s Balzac, Alberta operation in 1977; the product is destined primarily for use as a soil nutrient. The Procor GX dry granulation process is

Table 1. Canada, sulphur production and trade, 1977 and 1978

	1977		1978[p]	
	(tonnes)	($)	(tonnes)	($)
Production				
Pyrite and pyrrhotite[1]				
Gross weight	24 119	. .	9 000	. .
Sulphur content	12 060	197 027	4 500	72 000
Sulphur in smelter gases[2]	736 009	14 164 459	673 000	13 635 000
Elemental sulphur[3]	5 207 028	80 607 629	5 868 000	100 168 000
Total sulphur content	5 955 097	94 969 115	6 545 500	113 875 000
Imports				
Sulphur, crude or refined				
United States	14 065	774 000	8 007	963 000
West Germany	—	—	62	17 000
France	—	—	64	9 000
Total	14 065	774 000	8 133	989 000
Exports				
Sulphur in ores (pyrite)				
United States	. .	212 000	. .	57 000
Total	. .	212 000	. .	57 000
Sulphuric acid and oleum (contained sulphur)				
United States	94 230	5 359 000	67 090	4 062 000
Other countries	1 905	102 000	. . .	1 000
Total	96 135	5 461 000	67 090	4 063 000
Sulphur, crude or refined, nes				
United States	1 181 431	18 701 000	1 181 546	20 253 000
South Africa	371 702	12 396 000	459 693	18 432 000
Australia	347 291	12 839 000	442 853	17 067 000
Taiwan	225 064	8 589 000	307 978	14 885 000
Brazil	370 475	10 756 000	402 975	12 874 000
South Korea	82 375	3 074 000	267 113	10 990 000
People's Republic of China	241 722	8 484 000	205 235	8 917 000
New Zealand	210 685	8 001 000	260 046	8 888 000
Italy	257 258	6 942 000	296 866	8 312 000
India	184 925	6 329 000	147 298	6 219 000
Mozambique	79 284	2 749 000	131 376	5 471 000
Morocco	47 736	1 584 000	117 480	4 611 000
Belgium and Luxembourg	33 696	1 207 000	108 393	4 251 000
Tunisia	95 683	3 321 000	94 745	3 906 000
Other countries	561 705	17 103 000	560 926	18 807 000
Total	4 291 032	122 075 000	4 984 523	163 883 000

Source: Statistics Canada.
[1] Producers' shipments of byproduct pyrite and pyrrhotite from the processing of metallic sulphide ores. [2] Sulphur in liquid SO_2 and H_2SO_4 recovered from the smelting of metallic sulphides and from the roasting of zinc-sulphide concentrates. [3] Producers' shipments of elemental sulphur produced from natural gas; also included are small quantities of sulphur produced in the refining of domestic crude oil and from the treatment of nickel-sulphide matte.
[p] Preliminary; . . Not available; nes Not elsewhere specified; . . . Negligible; — Nil.

Table 2. Canada, sour gas sulphur extraction plants, 1978

Operating Company	Source Field or Plant Location	H_2S in Raw Gas	Daily Capacity
	(Alberta, except where noted)	(%)	(tonnes)
Amerada Hess Corporation	Olds	11	384
Amoco Canada Petroleum	Bigstone Creek	19	382
Amoco Canada Petroleum	East Crossfield	34	1 757
Aquitaine Company of Canada	Rainbow Lake	4	139
Aquitaine Company of Canada	Ram River	9-35	4 567
Aquitaine Company of Canada	Wimborne		6
Canadian Occidental Petroleum	Taylor Flats, B.C.	3	325
Canadian Superior Oil	Harmattan-Elkton	53	490
Canadian Superior Oil	Lonepine Creek	12	157
CanDel Oil	Minnehik-Bruce Lake		44
Chevron Standard	Kaybob South	19	3 520
Chevron Standard	Nevis	7	260
Esso Resources Canada	Joffre		18
Esso Resources Canada	Quirk Creek	9	300
Esso Resources Canada	Redwater	3	34
Gulf Canada	Nevis	3-7	295
Gulf Canada	Pincher Creek	10	160
Gulf Canada	Rimbey	1-3	353
Gulf Canada	Strachan	10	943
Home Oil	Carstairs	1	72
Hudson's Bay Oil and Gas	Brazeau River	1	110
Hudson's Bay Oil and Gas	Caroline	1	22
Hudson's Bay Oil and Gas	Edson	2	285
Hudson's Bay Oil and Gas	Hespero (Sylvan Lake)	1	17
Hudson's Bay Oil and Gas	Kaybob South (1)	17	1 064
Hudson's Bay Oil and Gas	Kaybob South (2)	17	1 064
Hudson's Bay Oil and Gas	Lonepine Creek	10	283
Hudson's Bay Oil and Gas	Sturgeon Lake	10	97
Hudson's Bay Oil and Gas	Zama		74
Mobil Oil Canada	Wimborne	14	174
Petro-Canada	Gold Creek		431
Petrofina Canada	Wildcat Hills	4	177
Petrogas Processing	Crossfield (Balzac)	31	1 687
Saratoga Processing Company	Savannah Creek (Coleman)	13	389
Shell Canada	Burnt Timber Creek	8-5	403
Shell Canada	Innisfail	14	163
Shell Canada	Jumping Pound	3-5	511
Shell Canada	Simonette River	15	266
Shell Canada	Waterton	18-25	3 066
Steelman Gas	Steelman, Sask.	1	7
Sun Oil	Rosevear		84
Texaco Exploration	Bonnie Glen		15
CDC Oil & Gas Limited	Nordegg		42
Texasgulf Inc.	Okotoks	36	459
Texasgulf Inc.	Windfall	16	1 175
Westcoast Transmission	Fort Nelson, B.C.		1 100
Western Decalta	Turner Valley	4	24
Total Daily rated capacity — December 31, 1978			27 007

Sources: Compilation by *Oilweek*; "H_2S in Raw Gas" figures from Alberta Energy Resources Conservation Board publications.

a recently developed Canadian forming technology. A rotating drum of 360-tonnes-per-day capacity in which cascading sulphur "seeds" accrete into granules under directed liquid sulphur spray nozzles is the basic unit. Two plants are to be installed this spring – Sheel Canada Limited's single-drum facility at Harmattan and Texasgulf Inc's. multiunit plant at Windfall, Alberta.

Declining production has led to the development of sulphur melters to reclaim sulphur from vatted storage. Melters will become important in Canada's sulphur supply picture over the next few years.

Table 3. Proposed new sulphur capacity for 1979

Operating Company	Location	Proposed Daily Rated Capacity
		(tonnes)
PanCanadian Petroleum	Stoney Indian Reservation, Alta.	18
Shell Canada	Rosevear, Alta.	153
Westcoast Transmission	Pine River, B.C.	1 100
Amerada Minerals Corp.	Stolberg, Alta.	32

Source: *Oilweek*.

In 1978, 46 sour gas sulphur plants were operating, including one in Saskatchewan and two in British Columbia, with a combined daily capacity of 27 007 tonnes, virtually no change from the previous year. Production of elemental sulphur from natural gas in Alberta, as reported by the Alberta Energy Resources Conservation Board, was 6 247 912 tonnes in 1978, down 2 per cent from 1977. Production in British Columbia was 98 000 tonnes, down 44 per cent from the previous year; and, in Saskatchewan, 1 721 tonnes. Total production in the three provinces was 6 347 633 tonnes.

Alberta sulphur sales were a record 5 649 675 tonnes in 1978, up 10 per cent from 1977. The value of sales increased 30 per cent to $96 million. Alberta inventories stood at 20 244 000 tonnes at December 31, 1978. British Columbia and Saskatchewan elemental sulphur sales were 90 040 tonnes and 2 000 tonnes, respectively, and inventories were 27 700 tonnes and 4 500 tonnes.

Canadian elemental sulphur productive capacity, having doubled between 1968 and 1972, reached a plateau in 1973 from which output has declined almost one million tonnes. Four plants are scheduled for completion in 1979 (see accompanying table).

Higher gas prices and federal and provincial incentives have stimulated exploration, especially in the foothills belt where most sour gas sulphur occurs. Several discoveries are under evaluation. With a lag of three to four years between discovery and plant start-up however, a marked increment in sulphur capacity would not be possible before the early eighties.

Pollution abatement guidelines for natural gas plants laid down in November 1971 by the Alberta government include: mandatory stack clean-up facilities and recovery efficiencies between 97 and 99 per cent, depending on acid gas quality, for plants rating over 1 016 tonnes a day; minimal stack clean-up, or equipment with efficiency between 94 and 98 per cent, for plants rated between 406 and 1 016 tonnes a day; at least a three-stage Claus unit or equivalent, with efficiency between 92 and 96 per cent, for 102- to 406-tonne plants; and a two-stage Claus unit with recovery efficiency between 90 and 94 per cent for smaller plants. As of December 31, 1976 all Alberta plants comply with the requirements.

Table 4. Canada, principal sulphur operations based on metallic sulphides, 1978

Operating Company	Plant Location	Raw Material	Annual Capacity 100% H_2SO_4	Annual Capacity Approx. S equiv.
			(tonnes)	
Smelter gases				
Brunswick Mining and Smelting	Belledune, N.B.	SO_2 lead-zinc	124 000	42 000
Allied Chemical	Valleyfield, Que.	SO_2 zinc conc.	140 000	47 000
Canadian Electrolytic Zinc	Valleyfield, Que.	SO_2 zinc conc.	120 000	40 000
Canadian Industries[1]	Copper Cliff, Ont.	SO_2 pyrrhotite	900 000	300 000
Cominco[1]	Trail, B.C.	SO_2 lead-zinc	440 000	145 000
	Kimberley, B.C.	SO_2 pyrrhotite	280 000	92 000
Texasgulf Canada Ltd.	Timmins, Ont.	SO_2 zinc conc.	205 000	70 000
Gaspe Copper Mines	Murdochville, Que.	SO_2 copper	245 000	82 000
Falconbridge Nickel Mines Limited	Falconbridge, Ont.	SO_2 pyrrhotite	420 000	140 000
Total			2 874 000	958 000

Sources: Company data.
[1] Does not include 85 000 tonnes sulphur content in liquid SO_2 production.

Table 5. Canada, sulphur production and trade, 1965, 1970 and 1975-78

	Production				Imports	Exports	
	Pyrites[1]	In Smelter Gases	Elemental Sulphur	Total	Elemental Sulphur	Pyrites[2]	Elemental Sulphur
			(tonnes)		(tonnes)	($)	(tonnes)
1965	169 607	403 478	1 876 415	2 449 500	147 146	978 828	1 358 915
1970	159 222	640 360	3 218 973	4 018 555	48 494	1 226 000	2 711 069
1975	10 560	694 666	4 078 780	4 784 006	14 335	170 000	3 284 246
1976	15 377	705 327	4 029 427	4 750 131	15 717	152 000	3 719 992
1977	12 060	736 009	5 207 028	5 955 097	14 065	212 000	4 291 032
1978[p]	4 500	673 000	5 868 000	6 545 500	8 133	57 000	4 984 523

Source: Statistics Canada.
[1] See footnotes for Table 1. [2] Quantities of pyrites exported, not available.
[p] Preliminary.

Prior to 1974, all sulphur destined for offshore markets was railed to loading terminals at Vancouver, some 1 000 kilometres (km) from processing plants. In recent years sulphur has been shipped via Churchill, Manitoba; Thunder Bay, Ontario and Quebec City, Quebec. In 1978 no shipments were made through these ports; however, they are certain to become more important with the recovery of sulphur markets.

Athabasca oil sands. The Athabasca oil sands constitute a vast deposit of relatively unconsolidated sandstone impregnated with bitumen, covering some 80 000 square kilometres of northeastern Alberta. The estimated 300 billion barrels of recoverable oil in the formation contain about 2 billion tonnes of sulphur.

In 1967 Great Canadian Oil Sands Limited (GCOS) completed the first commercial oil-sand extraction plant at a cost of $240 million. The ancillary sulphur recovery plant is designed to produce 300 tonnes of sulphur daily. Twinning of the sulphur unit to permit the expanded production required was completed in 1977.

Shipments of sulphur from GCOS began in October 1974 from Quebec City, destined for offshore markets, and reached 81 000 tonnes in 1976. Since then, only small shipments to an Alberta customer have been made.

Another project, that of Syncrude Canada Ltd., was completed in May 1978. It is designed to produce 125 000 barrels per day of synthetic crude oil and products and, when fully geared up in 1980, the total annual sulphur capacity from the tar sands will be some 400 000 tonnes. In 1978, sulphur recovered from the tar sands was 99 265 tonnes. Imperial Oil Limited has applied for a permit to build the first commercial oil sands plant using *in situ* thermal technology. The plant could be in operation by 1985. Beyond this, it now appears that two other projects originally scheduled for completion in the early 1980s, those of the Petrofina Canada Ltd. group and Shell Canada Limited, will not come on stream until after 1985, if at all. Sulphur from such projects could reach 2 million tonnes annually by the year 2000.

Oil refineries. Some crude oils contain as much as 5 per cent sulphur, either as hydrogen sulphide or in other compounds. Domestic crudes generally contain less than 1 per cent sulphur. The sulphur may either be removed in the form of H_2S, or treated to form nondeleterious di-sulphides. Recovery techniques employed during oil refining are similar to those used in the removal of sulphur from sour gas.

In Canada, sulphur is recovered from imported crudes at oil refineries in Nova Scotia, New Brunswick, Newfoundland and Quebec, and from domestic crudes at oil refineries near Toronto, Sarnia, Winnipeg, Edmonton and Vancouver. Total sulphur output from refineries in 1978 was an estimated 160 000 tonnes. This recovery represents only 20 per cent of total sulphur contained in the crude.

Coal and oil shales. Coke oven gases generally contain some hydrogen sulphide, the quantity dependent upon the sulphur content of the coal being carbonized. Ordinarily the H_2S is removed in the "iron oxide boxes", but it can also be recovered and converted to elemental sulphur.

In response to the demand for increasing amounts of clean fuel, numerous research projects have been initiated over the years with the aim of developing high-quality, pollution-free gas from coal. Middle East oil supply cutbacks since 1973, and rapidly rising prices have given further impetus to gasification projects and oil shale studies. Annual sulphur recovery from these sources, largely in the United States, could reach 1 million tonnes by 1990 and 5 million tonnes by the end of this century. Although coal in western Canada is low in sulphur (less than 0.5%), coal from the Maritimes is notably sulphurous. With more stringent pollution regulations coming into force, coal gasification may become the only way in which this energy source can be utilized in the future.

Metallic sulphide sources. In Canada the use of metallic sulphides for their sulphur content dates back to 1866. Early operations consisted essentially of roasting pyrite for the direct manufacture of sulphuric acid. In the

Table 6. Canadian export markets for sulphur, 1978

Country or Area	Exports	Per cent of Total
	(million tonnes)	
United States	1.18	23.7
Europe	0.73	14.7
South Africa	0.46	9.3
Australia	0.44	8.8
Brazil	0.40	8.0
Taiwan	0.31	6.2
South Korea	0.27	5.4
New Zealand	0.26	5.2
People's Republic of China	0.21	4.2
Others	0.72	14.5
Total	4.98	100.0

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.

1920s the use of base-metal smelter gases for the manufacture of byproduct H_2SO_4 began near Sudbury, Ontario, and at Trail, British Columbia. Virtually all Canada's sulphur production was from metallic sulphides prior to 1951, when the first sour gas sulphur recovery plant was built. In 1978 metallic sulphides, including smelter gas sulphur, provided an estimated 677 500 tonnes of contained sulphur.

Smelter gases. Effluent gas from smelting sulphide ores contains from 1 to 12 per cent sulphur dioxide (SO_2). Recovery of SO_2 includes processes for cleaning, cooling and concentrating. Concentrated SO_2 is then used directly for the manufacture of H_2SO_4 via the contact-acid process. Also, as much as 170 000 tonnes (85 000 tonnes sulphur content) of liquid SO_2 is produced for use as a processing agent in a variety of applications. Some SO_2 is used for the manufacture of oleum (fuming sulphuric acid, $H_2S_2O_7$). Total production in 1978 of sulphur contained in smelter gases was 673 000 tonnes, down 9 per cent from the previous year because of a strike at Inco Limited which began in September and continued into the new year.

Table 7. Canada sulphur consumption, 1965, 1970 and 1975-78

	From Pyrites and Smelter Gases[e]	Sulphur[1,2]	Total
		(tonnes)	
1965	445 225	670 604	1 115 829
1970	693 952	763 661	1 457 613
1975	691 118	832 702	1 523 820
1976	710 992	651 032	1 362 024
1977	735 095	687 381	1 422 476
1978[p]	673 937	..	..

Source: Statistics Canada.
[1] As reported by consumers. [2] Includes elemental (lump, powder, liquid, etc.) sulphur and liquid sulphur dioxide (sulphur content only).
[e] Estimated by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa; [p] Preliminary; .. Not available.

The largest H_2SO_4 plant complex in Canada is that of Canadian Industries Limited (CIL) at Copper Cliff, Ontario. The company operates three acid plants that have a combined annual capacity of 900 000 tonnes of H_2SO_4 based on SO_2 gas from Inco's iron ore recovery plant. In addition, CIL has a liquid sulphur dioxide plant at Inco's nearby Copper Cliff smelter. Acid produced at Copper Cliff is shipped by a 56-car, unit-train about 760 km to CIL's fertilizer works near Sarnia, Ontario. The company also ships to depots at Niagara Falls, Ontario; Sorel, Quebec; Cleveland, Ohio; and River Rouge, Michigan.

Subsidiaries of Noranda Mines Limited produce smelter acid at three localities: Gaspe Copper Mines, Limited's 245 000-tonne-per-year plant at Murdochville, Quebec; Brunswick Mining and Smelting Corporation Limited's 125 000-tonne-per-year plant at Belledune, New Brunswick; and Canadian Electrolytic Zinc Limited's zinc concentrate roasting facility at Valleyfield, Quebec, with a capacity of 120 000 tonnes per year. Expanded zinc capacity at the latter is idle in the face of soft markets. A proposed new copper smelter and associated 100 000-tonne-per-year sulphuric acid installation to be built at Noranda, Quebec has been shelved for the time being.

Table 8. Canada, estimated consumption of sulphur[1] by industry, 1976 and 1977

	1976	1977
	(tonnes)	
Fertilizers	239 211	306 434
Pulp and paper	265 869	261 181
Chemicals	105 448	85 389
Foundry	2 606	3 540
Rubber products	2 137	2 301
Other industries[2]	35 761	28 536
Total	651 032	687 381

Source: Statistics Canada. Compiled by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Includes elemental (lump, powder, liquid, etc.) sulphur and liquid sulphur dioxide (sulphur content only). [2] Includes production of artificial abrasives, aluminum, and other minor uses.

Cominco Ltd's sulphuric acid capacity at Trail, British Columbia, based on its lead-zinc smelter, was increased 30 per cent in 1975 to 440 000 tonnes per year with the replacement of the older units by a single plant. Further expansion is planned for the early 1980s. Acid capacity at the company's Kimberley plant is 280 000 tonnes per year. Much of the acid produced is used by Cominco in the manufacture of fertilizers.

Allied Chemical Canada, Ltd. produces sulphuric acid from the roasting of zinc concentrates supplied under agreement with Canadian Electrolytic Zinc Limited whereby Allied retains the acid for its own use and delivers the zinc calcine to Canadian Electrolytic Zinc's nearby refinery.

Texasgulf Canada Ltd.'s Timmins, Ontario zinc plant has a sulphuric acid capacity of 200 000 tonnes per year. An expansion plan that was to raise acid output to 400 000 tonnes by 1978 has been delayed for two years and a second stage to raise capacity to 560 000 tonnes by 1979 has been shelved. A proposed associated phosphate fertilizer works has also been deferred.

Falconbridge Nickel Mines Limited's new $95-million electric smelter and associated 1 180-tonne-per-day acid plant began operation in July.

Shipments of acid and oleum to the United States in 1978 were 67 090 tonnes of contained sulphur*. Small amounts were shipped elsewhere, mainly to the West Indies.

Pyrite and pyrrhotite. Pyrite and pyrrhotite concentrates produced as a byproduct of base metal mining operations are sometimes marketed for their sulphur content. A distinction is made in this review between this category of sulphur and that converted to SO_2 at integrated base metal operations. For example, although most of the acid production at Copper Cliff, Ontario is dependent upon the roasting of iron sulphides, the sulphur production is reported as smelter gases. In other instances, however, the iron sulphide concentrates are sold and shipped for roasting elsewhere and are reported as pyrite and pyrrhotite production.

Conversion to elemental sulphur feed at acid plants has resulted in a drastic reduction in pyrite usage. Noranda discontinued pyrite sales in 1973. In 1978 Canada's pyrite and pyrrhotite shipments amounted to an estimated 9 000 tonnes of concentrates (4 500 tonnes contained sulphur).

Canadian consumption and trade

In 1978 Canadian consumption of sulphur in all forms, as reported by consumers, amounted to about 1.4 million tonnes.

Canada remains the largest exporter of elemental sulphur, having shipped 4 984 523 tonnes in 1978. From the outset the United States has been the principal destination for Canadian sulphur and presently accounts for about 25 per cent of Canadian exports. Sales to the United States were unchanged from 1977 at 1.2 million tonnes. Shipments to Europe were up 10 per cent from those of 1977, to 730 000 tonnes. This is still 130 000 tonnes below the peak in 1976. Asian sales increased 25 per cent to a record 1 029 446 tonnes, reflecting stronger markets in Taiwan and South Korea. Australasia's Canadian purchases totalling 713 000 tonnes were 25 per cent higher than those of 1977, surpassing the previous peak in 1974.

*Obtained by multiplying H_2SO_4 tonnage by 0.327.

Canadian sales to South America and Africa (mainly Brazil and South Africa) have grown rapidly during the decade. In 1978 South American purchases grew only marginally to 529 000 tonnes but African purchases reached 803 000 tonnes, a gain of 60 per cent over those of 1977, itself a record year.

World review

Sulphur supplies tightened sharply during the latter half of 1978 after almost a decade of surpluses. With the coincidence of stagnant production levels and soft sulphur markets over the past four years, fundamental constraints to sulphur supplies went largely unnoticed by most observers. Voluntary cutbacks by Frasch sulphur producers and reduced smelter production masked the effects of reserves exhaustion, limited exploration success and slower-than-anticipated developments in new source areas; trends which were discernible early in the decade. Finally, the pressure of soaring energy prices on voluntary sulphur producers after the oil crisis in 1973 and the effect of the recession on investment in primary sulphur production made inevitable the sudden turnaround. Some improvement in the world economy and continued growth in the fertilizer industry gave rise to a 6 per cent increase in sulphur consumption in 1978.

The U.S.S.R. now rivals the United States as the world's leading producer of sulphur, with 1978 production estimated at 11 million tonnes. Production doubled during the last ten years as a result of strong growth in both the elemental sulphur and pyrite industries, a period during which pyrite output was declining elsewhere. Frasch and sour-gas sulphur projects have become important in the last few years and it is expected that these sources will account for most future growth in the U.S.S.R. sulphur industry.

Development of the Frasch mining techniques in 1895 made large tonnages of low-cost sulphur available to world markets and established the United States as the world's foremost producer of sulphur, a position it has held for over

Table 9. Canada, sulphuric acid production, trade and apparent consumption, 1965, 1970 and 1975-78

	Production	Imports	Exports	Apparent Consumption
	(tonnes — 100% acid)			
1965	1 964 055	2 790	51 812	1 915 033
1970	2 475 070	9 948	129 327	2 355 691
1975	2 723 202	154 020	225 402	2 651 820
1976	2 842 431	39 537	349 826	2 532 142
1977	3 140 340	6 634	293 994	2 852 980
1978[p]	3 260 846	107 766	205 169	3 163 443

Source: Statistics Canada.
[p] Preliminary.

50 years. In the Frasch process, sulphur is melted by superheated water pumped into the underground deposits through a system of wells. The resulting molten sulphur is extracted by a coaxial pipe in each well. In 1978, United States Frasch production fell for the fourth consecutive year, dropping to 5.65 million tonnes, the lowest output since 1964. Recovered elemental sulphur, from sour crude oil and natural gas, increased 12 per cent to 4.06 million tonnes.

U.S. stocks decreased by 210 000 tonnes to 5.35 million tonnes. Exports in 1978, at 0.87 million tonnes, were 27 per cent below those of the previous year, and the lowest export tonnage since World War II. Imports were up 8 per cent to 2.18 million tonnes. Domestic consumption increased 8 per cent to a record 12.6 million tonnes of sulphur in all forms. Texasgulf Inc. closed the Bully Camp Frasch operation in July 1978, citing reserve depletion and high costs.

Mexican sulphur production, which is 95 per cent elemental, was unchanged from the previous year at just under 2 million tonnes. Domestic consumption, which has grown rapidly during this decade, was about 0.8 million tonnes in 1978. Exports were 1.3 million tonnes, 20 per cent greater than in 1977 but still 30 per cent below the peak year 1974. The United States is the principal destination of Mexican sulphur.

Production of elemental sulphur in 1978 from the Lacq sour natural gas field in France was 2 million tonnes, a production plateau reached in 1969.

Elemental sulphur production from sour gas in northern West Germany and from the nation's oil refineries was little changed from 1977 and with the decline of metallurgical sulphur, overall sulphur output was down 4 per cent to 1.6 million tonnes.

Polish production, at 5.3 million tonnes, was 4 per cent greater than in 1977. Exports were little changed at 4.2 million tonnes.

Iraq became a significant producer of elemental sulphur in 1973. Capacity is reported to have reached 1 million tonnes per year, but no major expansion to the estimated 650 000-tonne output is expected until improved rail transport capability to the Persian Gulf port of Umm Qasr, 725 km to the south, is completed. Shipments by truck for Mediterranean customers began in 1974 but political strife in Lebanon has stalled development of this transportation mode.

Political strife in Iran resulted in force majeure being declared on sulphur shipments in November 1978. The country produced 500 000 tonnes during the year.

Outlook

Supply. As one of the earth's most abundant elements, no ultimate shortage of sulphur is foreseeable; however, an examination of the likely rates of development of various sources provides a less-assuring outlook.

Even assuming continued sluggish growth in world industrial demand, it seems inevitable that the current shortage will deepen over the next few years and prices will escalate sharply. This is based on the view that nonmarket constraints to supply, identified over the last several years in previous issues of the sulphur review, are not amenable to quick resolution.

Although Canada is the world's largest exporter of sulphur, currently with a 34 per cent share of total trade, its impact on world sulphur markets is expected to decline. Production of elemental sulphur from sour natural gas peaked in 1973 at 7.2 million tonnes and output in 1978 was 8 per cent less than that figure. Several of the major plants are recycling operations, i.e., sulphur is stripped from the gas and the gas returned to the reservoir. Output from these plants is now tapering off, and considering the reserve picture for the others, a reduction to about one half of the peak output from existing plants is expected by 1985. Replacement of part of this lost production capability through new discoveries and reserve extensions will occur. However, a reversal in the downtrend during the next decade is unlikely. Declining production will be matched by rising withdrawals from stocks, and annual shipments will level off at 6.5 to 7.0 million tonnes.

Estimated annual production of sulphur from tar sands by 1985 is 500 000 tonnes. Sulphur produced from smelter gases is expected to reach 1 million tonnes contained in sulphuric acid by 1985. In balance, output of sulphur from all sources is not expected to surpass the 1973 peak until after the next decade.

United States Frasch output in 1978 was 30 per cent below the 1974 record of 8.0 million tonnes. Production costs have tripled in recent years because of natural gas price rises and increasing labour and material costs. Despite a trend of improving prices, it seems clear that the numerous mine closures during the past seven or eight years are likely to be permanent. The string of closures is symptomatic of a net decline in reserves. Of 37 mines developed since the inception of the industry, only ten remain in operation. More significant, of 12 mines developed during the last 15 years, eight have closed down. It now seems optimistic to expect much more than 5.0 million tonnes annual output by 1985, although present price increases could result in expansion of current output to 6.5 million tonnes in 1980. Increased shipments from stocks, as prices rise, will have reduced these by as much as 2 million tonnes by the end of 1980. Sulphur produced from oil, gas, pyrite and smelters could expand 30 per cent to 7.0 million tonnes contained sulphur by 1985, but this would be insufficient to alter the United States' recently developed position as a net importer of sulphur.

Although there may be scope for sulphur exploration and development in Mexico, present Frasch operations are experiencing technical difficulties in addition to cost constraints similar to those affecting United States operators. Except for the all-time high of 2.3 million tonnes in 1974, production has varied between 1.2 and 1.8 million tonnes for much of its 25-year history. Mexico's oil and gas reserves, which are proving to be very large, appear to be the most likely source of expanded sulphur production in the country. However, overall sulphur output is not expected to advance significantly until after 1985.

Sulphur production in France from sour natural gas is expected to decline to 1.5 million tonnes by 1985.

Poland's Frasch production may reach 6 to 7 million tonnes, and the output from new Middle East producers — sour gas and Iraqi Frasch — will likely rise to 3.0 million

Table 10. Canada, available data on consumption of sulphuric acid by industry, 1976 and 1977

	1976	1977
	(tonnes — 100% acid)	
Industrial chemicals	1 598 074	1 910 368
Smelting and refining	160 660	260 683
Pulp and paper mills	207 311	227 350
Uranium ore processing	132 602	165 639
Mining[e]	75 296	77 111
Miscellaneous chemicals	31 821	34 276
Soaps and cleaning compounds	18 857	21 762
Petroleum refineries	19 025	18 224
Plastics and synthetic resins	15 959	16 313
Iron and steel mills	10 844	10 594
Wire and wire products	6 524	6 464
Miscellaneous electrical products	5 668	5 616
Mixed fertilizers	11 637	5 424
Metal stamping, pressing and coating	3 347	4 097
Motor vehicle parts and accessories	2 368	2 455
Miscellaneous industries[1]	19 714	20 071
Total	2 319 707	2 786 447

Source: Statistics Canada.
[1] Miscellaneous industries include synthetic textiles, other petroleum and coal, mineral wool, starch and glucose, vegetable oils, sugar refining and municipal water works.
[e] Estimated.

tonnes by 1985. However, rapid consumption growth in the communist bloc and in the Middle East will modify the effects of these additional supplies.

Despite the fact that pollution-abatement sulphur will become more important, its impact, for several reasons, is proving to be less dramatic than earlier predictions suggested. For sulphur removal from electric utility stack gases, the largest source of pollution-sulphur, economic and technologic considerations weigh in favour of a scrubbing process that will result in an impure gypsum waste product. Advances in acid-producing technology could result in a decision to install acid capacity where the net return to a plant covers the higher cost of acid production relative to limestone scrubbing. However, since costs of abatement, even using limestone scrubbing, exceed $100 per ton of H_2SO_4 equivalent for most plants; a third alternative, that of using clean coal, is likely to become attractive. In light of energy supply limitations, attention has been focussed on conservation which will moderate growth in fuel consumption, the major source of sulphur emissions.

Under the influence of the foregoing, a period of world tight supply appears to have begun. Shipments from reserve stocks in the United States and some remelting in Canada could ease the situation somewhat, but tight supply is likely to endure until Polish elemental sulphur and European pyrite capacity can be increased. In the meantime, sulphur supplies for phosphate fertilizer manufacture could prove to be a problem by 1980 and concern for food supply, especially in sulphur deficient countries, could arise.

Demand. Recovery in world industrial output is not expected to be dramatic in the medium term, although the fertilizer sector is expected to continue to show at least modest growth.

For the longer term, fertilizer manufacture, under the stimulus of world food requirements and the expansion of modern agricultural practice in Asia, Africa and Latin America, will continue to consume a growing portion of sulphur output. Many observers interpret growing substitution of hydrochloric and other acids for sulphuric acid in the pigment, steel-pickling and oil-refining sectors as presaging an overall moderation of sulphur consumption growth. Such a view may be too pessimistic. Sulphur's role in the manufacture of substitute reagents must be taken into account; for example, the expected switch to hydrofluoric acid (HF) in petroleum refining could result in an increase in sulphur consumption, since 3 tonnes of H_2SO_4 are needed to produce 1 tonne of HF. Also, in addition to conventional fertilizer use, attention has been drawn in recent years to sulphur's important role as a plant nutrient and to sulphur deficiencies in the soil over broad areas throughout the world. An area of growth in the "other uses" category is that of uranium production. Uranium ore leaching requires 30 to 50 tonnes of sulphuric acid per tonne of uranium produced, plus additional acid indirectly in the manufacture of hydrofluoric acid and other chemicals used in processing. Demand for sulphur contained in acid for world uranium production in 1975 was an estimated 350 000 tonnes. By the year 2000, annual requirements are expected to exceed 2

Table 11. World production of sulphur in all forms, 1977

	Elemental	Other[1]	Total
	(000 tonnes)		
United States	9 513	1 947	10 727
U.S.S.R.	3 020	6 750	9 770
Canada	6 694	736	7 430
Poland	4 825	325	5 150
Japan	1 100	1 725	2 825
France	2 020	160	2 180
Mexico	1 875	101	1 976
West Germany	851	776	1 627
Spain	12	1 323	1 335
Italy	90	603	693
Iran	527	—	527
South Africa	28	445	473
Finland	34	393	427
East Germany	80	270	350
Sweden	13	252	265
Other countries	2 022	4 069	6 091
Total	31 217	19 887	51 104

Sources: British Sulphur Corporation Limited, Statistical Supplement, November/December 1978; Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Sulphur in other forms includes sulphur contained in pyrites and contained sulphur recovered from metallurgical waste gases mostly in the form of sulphuric acid.
— Nil.

million tonnes. Ore and tailings leaching in base-metal production and anticipated developments in hydrometallurgy are other consumption areas with high growth potential. Several new uses for elemental sulphur, based on attractive engineering properties, have been under development in recent years. Although some of these are fairly sensitive to sulphur prices, uses such as sulphur-asphalt road-surfacing mixtures could become important. In summary, the future of a reagent so widely available, cheap and versatile as sulphur, seems assured. It would appear that the historical sulphur demand growth of 4.5 per cent a year will be maintained over the medium to long term.

Prices

Canadian sulphur prices quoted in "Canadian Chemical Processing", December 1978

	($)
Sulphur, elemental, fob works, contract, carload, per tonne	23.50-25.00
Sulphuric acid, fob plants East, 66° Be, tanks, per tonne	57.77

United States Prices in U.S. currency, quoted in "Engineering and Mining Journal", January 1979.

	($)
Sulphur elemental	
U.S. producers, term contracts fob vessel at Gulf ports, Louisiana and Texas, per long ton	
Bright	63.50
Dark	62.50
Export prices, ex terminal Holland, per long ton	
Bright	66.00
Dark	65.00
Mexican export, fob vessel, per long ton	
Bright	63.00
Dark	63.00

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
92503-1	Sulphur of all kinds, other than sublimed sulphur, precipitated sulphur and colloidal sulphur	free	free	free	free
92802-1	Sulphur, sublimed or precipitated; colloidal sulphur	free	free	free	free
92807-1	Sulphur dioxide	free	free	free	free
92808-1	Sulphuric acid, oleum	10%	15%	25%	10%
92813-4	Sulphur trioxide	free	free	free	free

United States

Item No.		
418.90	Pyrites	free
415.45	Sulphur, elemental	free
416.35	Sulphuric acid	free
422.94	Sulphur dioxide	6% ad valorem

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States, Annotated (1978) USITC Publication 843.

Talc, Soapstone and Pyrophyllite

G.H.K. PEARSE

Talc is a hydrous magnesium silicate, $H_2Mg_3(SiO_3)_4$, formed by the alteration of rocks rich in magnesia (most commonly ultrabasic igneous rocks and sedimentary dolomite) within which it occurs as veinlets, tabular bodies, or irregular lenses. It is a soft, flaky mineral with a greasy feel or "slip", it is readily ground to a fine white or nearly white powder, has a high fusion point, low thermal and electrical conductivity and is relatively chemically inert. Most of the uses of talc depend on its physical properties.

Talc is produced in various grades which are usually classified by end use; cosmetic, ceramic, pharmaceutical and paint. A special, high-quality block talc, used in making ceramic insulators and other worked shapes, is designated "steatite grade".

Soapstone is an impure talcose rock generally occurring in massive, compact deposits from which blocks can be sawn. Soapstone has been used since early times in many parts of the world for carving ornaments, pipes, cookware, lamps and other utensils. The art of carving this rock has survived among the Inuit people of Canada up to the present era. Present uses include metalworkers' crayons, refractory bricks, and blocks for sculpturing.

Pyrophyllite is a hydrous aluminum silicate, $H_2Al_2(SiO_3)_4$, formed by hydrothermal alteration of acid igneous rocks, predominantly lavas which are andesitic to rhyolitic in composition. It resembles talc in physical properties and for this reason finds uses similar to talc, notably in ceramic bodies and as a filler in paints, rubber and other commodities.

In Canada, talc is produced in two provinces, Quebec and Ontario, while pyrophyllite is produced only in Newfoundland. The value of talc and soapstone shipments increased from $1 503 785 in 1977 to $2 187 000 in 1978, according to official statistics. Output increased about 15 per cent and average prices increased 25 per cent. The value of pyrophyllite production decreased from $756 104 in 1977 to $471 000 in 1978.

Production and development in Canada

Talc, soapstone. The earliest recorded production in Canada was in 1871-72 when 270 tonnes* of cut soapstone, valued at $1 800, was shipped from a deposit in L 24, R 6 in Bolton Township, southern Quebec, by Slack and Whitney. In 1896 a deposit in Huntingdon Township, in the Madoc district of Ontario, was opened and over the next few years numerous deposits were discovered in this area and mined intermittently.

Several deposits in southern British Columbia and one in southwestern Alberta were discovered prior to 1920 and some were worked on a small scale. At present, talc is mined by four companies – two in Quebec and two in Ontario.

Bakertalc Inc. produces talc and soapstone from an underground mine at South Bolton, Quebec, 95 kilometres (km) southeast of Montreal. Ore from the mine is trucked 16 km south to the company's mill facilities at Highwater.

A modified flotation process is used to produce a high-quality talc for use principally in the paper industry. A small quantity has been used as a filler in plastics and paints. Production of this high-quality material is around 5 000 tonnes per year and a somewhat larger tonnage of lower-grade talc, produced in a dry-milling process, is shipped for a variety of uses. The company also sells soapstone blocks for sculpture to an art supplies dealer.

Shaft sinking to the 182-metre (m) level was completed in 1976 and development and production at this level commenced in 1977. Mining is by open stoping, and access and ore hoisting are by way of a 45° inclined shaft.

Broughton Soapstone & Quarry Company, Limited, quarries talc and soapstone from two deposits near Broughton Station in the Eastern Townships of Quebec, where the same geological conditions as in the South Bolton area are evident. Several low-priced grades of ground talc are produced, and soapstone is sawn to produce metalworkers' crayons and various sizes of blocks for sculpturing, and plates for etching. Much of the Inuit artists' soapstone requirements are supplied by this company and a certain volume is marketed elsewhere through an art supplies company.

Canada Talc Industries Limited produces talc from underground workings at Madoc, Ontario. The deposits at Madoc are extensive and were formed by the alteration of dolomitic marble. Tremolite and dolomite impurities in the deposit limit the use of some ground products. A high-quality product, suitable as a filler material in paint and plastics and for use in pharmaceuticals, cosmetics and lens polishing, is produced. The company also produces dolomite terrazzo chips from the mine.

The talc ore is mined from drawpoints at 9-m intervals along drifts flanking the ore zone. The mill circuit is

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

comprised of a jaw crusher, Raymond mills and cyclones. Recent developments include a changeover from tracked haulage and hoisting, to rubber-wheeled vehicle, slope-transport to the surface, via a decline. The deposit is being developed below the 167-m level.

Johns-Manville Canada Inc. brought its Penhorwood township deposit into production in July 1976 but closed both this operation and one in California in December of the same year, having apparently decided to get out of the talc business. About 10 000 tonnes were produced. The deposit was purchased by the Steetley Minerals Group which, under the subsidiary Steetley Talc Limited, reopened the operation in January 1979. Products for the paper, paint and plastics industries will be marketed in North America and overseas.

Numerous deposits of talc and soapstone occur in the producing areas and in other parts of Canada. A soapstone deposit on Pipestone Lake in Saskatchewan was worked by Indians for the manufacture of pipes and various utensils. Reserves are reported to be considerable. High quality "blue" talc was investigated in the Banff area of Alberta and British Columbia during the 1930s. In the Northwest Territories, a few occurrences of soapstone are known from which Eskimos obtained material for carving. Showings of minor importance occur at several localities in Nova Scotia and Newfoundland.

Table 1. Talc, soapstone and pyrophyllite production, trade and consumption, 1977 and 1978

	1977		1978p	
	(tonnes)	($)	(tonnes)	($)
Production (shipments)				
Talc and soapstone				
Ontario[1]	..	660 189	..	1 097 000
Quebec[2]	..	843 596	..	1 090 000
Total	..	1 503 785	..	2 187 000
Pyrophyllite				
Newfoundland	..	756 104	..	471 000
Total production	72 400	2 259 889	67 000	2 658 000
Imports				
Talc				
United States	33 567	2 819 000	33 099	3 423 000
Italy	163	25 000	191	30 000
Japan	36	7 000	34	4 000
United Kingdom	—	—	24	3 000
France	—	—	1	1 000
West Germany	3	...	—	—
Total	33 769	2 851 000	33 349	3 461 000

	1976	1977e
	(tonnes)	
Consumption[3] (ground talc available data)		
Paints and wall joint sealers	8 880	8 624
Gypsum products	7 121	6 978
Roofing products	7 097	6 985
Ceramic products	6 282	6 214
Pulp and paper products	5 833	5 115
Chemicals	1 972	1 947
Pharmaceutical preparations	1 784	1 292
Rubber	1 566	1 396
Toilet preparations	534	451
Other products[4]	2 526	2 882
Total	43 595	41 884

Source: Statistics Canada.
[1]Ground talc. [2]Ground talc, soapstone, blocks and crayons. [3]Breakdown by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa. [4]Adhesives, floor covering, insecticides and other miscellaneous uses.
[p]Preliminary; .. Not available; [e]Estimated; ... Insignificant.

Pyrophyllite. Newfoundland Minerals Limited, a subsidiary of American Olean Tile Company, Inc., produces pyrophyllite from an open-pit mine near Manuels, 19 km southwest of St. John's, Newfoundland. Ore is crushed, sized and hand-cobbed at the mine site prior to being trucked a short distance to tidewater. Continuous chemical analyses and physical tests are run on all material delivered from the mine to the loading dock. Blended ore is shipped in bulk to the parent company's operation at Lansdale, Pennsylvania, where it is used in the manufacture of ceramic tile. Annual production varies between 20 000 and 35 000 tonnes. The pyrophyllite deposit at Manuels appears to be a hydrothermal alteration of sheared rhyolite. Altered zones are associated for the most part with extensive fracturing near intrusive granite contacts. Reserves are extensive.

Table 2. Canada, talc production and trade, 1965, 1970 and 1975-78

	Production[1]	Imports
	(tonnes)	
1965	47 933	25 272
1970	65 367	29 999
1975	66 029	30 428
1976	68 834	46 397
1977	72 400	33 769
1978[p]	67 000	33 349

Source: Satistics Canada.
[1] Producers' shipments.
[p] Preliminary.

Other known pyrophyllite deposits in Canada include an extensive area of impure pyrophyllite near Stroud's Pond in the southern part of Burin Peninsula, Newfoundland; a deposit near Ashcroft, British Columbia and three deposits on Vancouver Island, British Columbia in the Kyuquot Sound area 320 km northwest of Victoria. The Vancouver Island deposits were worked on a limited scale in the early part of this century.

Trade and markets

All Canadian production of pyrophyllite is exported. Total exports of Canadian pyrophyllite, talc and soapstone are roughly equivalent to our total imports of talc. Except for minor shipments to South Africa, exports go to the United States, where demand for good-quality filler for automobile plastics has grown rapidly over the last few years. Imported talc, most of it from the United States, is high-quality, high-value material suitable for use in the paint, ceramics, paper and cosmetic industries. It is anticipated that imported high-quality talc will be displaced to some extent in other industries by domestic product as capacity for producing these grades increases. Imports, nearly all from the United States, in 1978 amounted to 33 349 tonnes, valued at $3 461 000, unchanged in tonnage but up 21 per cent in value compared with 1977. Average value of imports in 1978 was $150 per tonne, while domestic production sells in the range of $20 to $90 per tonne, depending upon quality.

Uses

Talc is used mostly in a fine-ground state; soapstone in massive or block form. There are many industrial applications for ground talc, but major consumption is limited to less than a dozen countries.

Talc is used as a filler material in the manufacture of high-quality paper where it aids in the dehydration of the pulp, improves sizing characteristics, reduces the tendency of papers to yellow and assures a well-bonded surface to promote ease of printing. For use in the paper industry, talc must be free of chemically active compounds such as carbonates, iron minerals and manganese, have a high reflectance, possess high retention characteristics in the pulp, and be free of abrasive impurities. Micronized material provides a high-gloss finish on coated papers.

The ceramic industry utilizes very finely ground talc to increase the translucence and toughness of the finished product and aid in promoting crack-free glazing. For use in ceramics, talc must be low in iron, manganese and other impurities which would discolour the fired product.

High-quality talc is used as an extender pigment in paints. Specifications for a talc pigment relate to its chemical composition, colour, particle size, oil absorption

Table 3. World production of talc, soapstone, and pyrophyllite, 1976-78

	1976	1977[p]	1978[e]
		(tonnes)	
Japan	1 345 243	1 353 795	1 360 000
United States	963 229	1 093 009	1 150 000
Republic of Korea	496 468	605 230	..
U.S.S.R.	440 000[e]	450 000[e]	..
People's Republic of China	300 000[e]	300 000[e]	..
France	255 800	287 273	450 000
India	241 728	243 879	..
Brazil	225 339	225 000[e]	..
Italy	153 836	162 437	270 000
Finland	148 531	156 584	..
North Korea	130 000	130 000[e]	..
Australia	94 362	126 640	..
Austria	100 649	103 743	..
Norway	100 000	100 000	..
Canada	68 834	72 400	67 000
Other countries	334 191	330 961	2 781 000
Total	5 398 210	5 740 951	6 078 000

Sources: U.S. Bureau of Mines, *Mineral Trade Notes*, Volume 75 No. 9, September 1978; U.S. Bureau of Mines, *Mineral Commodity Summaries*, January 1979; Statistics Canada.
[p] Preliminary; [e] Estimated; .. Not available.

and consistency of and dispersion in a talc-vehicle. A low carbonate content, a nearly white colour, a fine particle size with controlled particle size distribution and a specific oil absorption are important. However, because of the variety of paints, precise specifications for talc pigments are generally based on agreement between consumer and supplier. Paint characteristics influenced by the use of talc as extender are gloss, adhesion, flow, hardness and hiding power.

Talc is well known for its use in pharmaceutical preparations and cosmetics. It is the major ingredient in face, baby and body powders. Finely ground, high-purity material is used as a filler in tablets and as an additive in medical pastes, creams and soaps. Material used for these purposes should be free of deleterious chemical compounds, abrasive impurities and fibrous minerals such as tremolite and asbestos, which are believed to be injurious to health when inhaled or ingested.

Lower-grade talc is used as a dusting agent for asphalt roofing and gypsum board, as a filler in drywall sealing compounds, as a filler material in floor tiles, in asphalt pipeline enamels, in auto-body patching compounds, as a carrier for insecticides and as a filler or dusting compound in the manufacture of rubber products.

Other applications for talc include use in cleaning compounds, polishes, electric cable coating, plastic products, foundry facings, adhesives, linoleum, textiles and in the food industry.

Particle-size specifications for most uses require the talc to be minus 325 mesh. The paint industry demands from 99.8 to 100 per cent minus 325 mesh. For rubber, ceramics, insecticides and pipeline enamels, 95 per cent minus 325 mesh is usual. In the wall tile industry, 90 per cent minus 325 mesh is generally required. For roofing grades the specification is about minus 80 mesh, with a maximum of 30 to 40 per cent minus 200 mesh.

Soapstone has now only very limited use as a refractory brick or block, but, because of its softness and resistance to heat, it is still used by metalworkers as marking crayons. The ease with which it can be carved makes it an excellent artistic medium.

Pyrophyllite can be ground and used in much the same way as talc, but at present the use of the Canadian material is confined to ceramic tile. It must be minus 325 mesh and contain a minimum of quartz and sericite, which are common impurities.

World review

Deposits of talc are widely distributed throughout the world, but have been developed commercially only in the more industrialized countries. Because talc is of relatively low unit value, only a very minor part of world production is traded internationally. The majority of international trade takes place within Europe; in the Far East between Japan, the People's Republic of China and Korea; and in North America between Canada and the United States. However, talc of exceptional purity is valuable enough to withstand the cost of transportation over much greater distances. For example, high-grade French, Italian, Indian and Chinese talcs are shipped throughout the world.

Prices

United States talc prices according to "Oil, Paint and Drug Reporter", December 29, 1978

	($ per short ton)
Canadian	
Ground, bags, carlot, fob mines	20.00-35.00
Vermont	
Domestic, ordinary, off-colour, ground, bags, carlot, fob works	22.25
California	
Domestic, ordinary, bags, carlot fob works	34.00-39.50
New York	
Domestic fibrous ground, bags	35.50

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)	(%)	(%)	(%)
71100-3	Talc or soapstone	10	15	25	10
29646-1	Talc for use in manufacture of pottery or ceramic tile (expires Feb. 28, 1980)	free	free	25	free
29647-1	Micronized talc, not exceeding 20 microns	free	5	25	free
29655-1	Pyrophyllite	free	free	25	free

United States

Talc, steatite, soapstone

Item No.		
523.31	Crude and not ground	0.02¢ per lb
523.33	Ground, washed, powdered, or pulverized	6% ad valorem
523.35	Cut or sawed, or in blanks, crayons, cubes, disks, or other forms	0.20¢ per lb
523.37	All other, not provided for	12% ad valorem

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States, Annotated (1978), USITC Publication 843.

Tin

G. NINACS

Canadian industrial requirements of tin are met mainly by imports. These totalled 4 804 tonnes* (t) in 1978, valued at $69 918 000. Domestic production of tin in concentrates and lead-tin alloy in 1978 was 375 t, valued at $6 054 000. Most of this was exported as concentrates to Mexico, the United States and the United Kingdom.

Canada also imports small quantities of tinplate from the United States. Most tin metal scrap and tinplate scrap is exported to the United States, as facilities for secondary metal processing in Canada are very limited.

Tin-bearing secondary solders are recovered in a few plants; one of which is Federated Genco Limited at its plant in Scarborough, Ontario. Tin solders are recovered from car radiators and scrap plumbing and are re-constituted, but statistics on the amount of tin solder recovered are not available.

Metal Recovery Industries Ltd. (formerly M & T Products of Canada Limited) Hamilton, Ontario, recovers a secondary tin product by de-tinning industrial scrap. Small quantities of municipal scrap are also processed. The product is potassium stannate, which contains 37.5 per cent tin and is used directly in electroplating applications. An equivalent of 120 to 140 t of tin is thus recovered annually.

Malaysia is Canada's main source of tin, and most of the tin destined for this country is brought into New York and trucked from there to Toronto, Hamilton, and Montreal, the major centres of tin consumption. As a result, Statistics Canada's methods of defining country of origin show the United States as the source of most Canadian tin imports. Shipments of Malaysian (straits) tin directly from Malaysia to Canada amounted to 178 t in 1978. Brazil and Bolivia are other significant suppliers of tin to Canada.

Two Canadian mining operations produce tin concentrate. Byproduct tin is recovered from the milling of the Sullivan Mines' lead-zinc ores at Kimberley, British Columbia, and Cominco Ltd. shipped 262 ** t from this operation in 1978. Besides the tin concentrate recovered at Kimberley, Cominco also recovers about 600 t of a lead-tin alloy each year from treatment of lead bullion dross in the indium circuit of its Trail smelter. The tin content of this alloy is about 8 per cent. The company also produces, from purchased commercial-grade metal, small quantities of *Tadanac* high-purity tin (99.9999 per cent) and special research grade (99.999 per cent) tin.

Texasgulf Canada Ltd., a subsidiary of Texasgulf Inc., operates a tin-recovery circuit at its base metal concentrator at Timmins, Ontario. During 1978 Texasgulf shipped 238 t of tin concentrate.

Fine-grained cassiterite is a mineralogical component of sulphide ores at several Canadian mines but its economic recovery is possible only at the Sullivan mine of Cominco and the Kidd Creek mine of Texasgulf. Ore grades at these mines are between 0.12 and 0.25 per cent SnO_2. Tin is present in small quantities in the zinc-lead orebodies of Brunswick Mining and Smelting Corporation Limited, New Brunswick and in the South Bay, Ontario mine of Selco Mining Corporation Limited.

Brunswick Tin Mines Limited has a multi-mineral deposit in southwestern New Brunswick. Reserves for the Fire Tower Zone (FTZ) as reported in 1973 are 29.5 million t with an average grade of 0.20 per cent tungsten, 0.09 per cent molybdenum, 0.08 per cent bismuth, 0.04 per cent tin, 0.07 per cent copper, 0.35 per cent zinc, 0.08 per cent lead, 4 per cent fluorspar and about 30 grams of indium per t. A second deposit, about a half-mile north of the FTZ, contains 12 500 000 t grading 0.241 per cent WO_3, 0.08 per cent MoS_2, 0.08 per cent bismuth and some tin. Of this tonnage, 2 300 000 t grades 0.42 per cent tin, 0.077 per cent WO_3, 0.03 per cent MoS_2 and 0.06 per cent bismuth. The company continues to look for partners to bring the property into production.

The principal use of tin in Canada, accounting for over 50 per cent of the total consumption, is in the production of tinplate. There are two producers of electrolytic tinplate: Dominion Foundries and Steel, Limited (Dofasco) and the Steel Company of Canada, Limited (Stelco), both at Hamilton, Ontario. It is estimated that in 1978,2 300 t of tin were used to produce 261 300 t of tinplate.

Dofasco and Stelco each operate three electrolytic tinplate lines. Stelco's third line, with a capacity of 175 000 t of tinplate a year, can be converted to produce steel with other types of coatings, notably chrome-coated steel. Dofasco's third line is also dual purpose. These dual purpose lines allow the tinplate producers flexibility in the face of higher prices for tin.

The second largest use for tin is in the manufacture of solders which generally absorb 1 600 to 2 000 t of tin annually. Important Canadian tin solder producers are The Canada Metal Company, Limited, Federated Genco

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

** Tonnage differences between annual production and annual shipments may be accounted for by additions to, and deductions from, concentrate inventories.

Table 1. Canada, tin production, imports and consumption 1977-78

	1977		1978p	
	(tonnes)	($)	(tonnes)	($)
Production				
Tin content of tin concentrates and lead-tin alloys	328	3 546 189	375	6 054 000
Imports				
Blocks, pigs, bars				
United States	3 927	44 458 000	3 726	53 875 000
Brazil	419	4 762 000	437	5 836 000
Bolivia	570	5 962 000	246	3 503 000
Malaysia	65	755 000	178	2 818 000
Singapore	20	286 000	173	2 399 000
Indonesia	—	—	25	345 000
Other countries	27	304 000	19	142 000
Total	5 028	56 527 000	4 804	68 918 000
Tinplate				
United States	1 671	980 000	1 158	832 000
United Kingdom	45	66 000	275	364 000
Other countries	6	3 000	—	—
Total	1 722	1 049 000	1 433	1 196 000
Tin, fabricated materials, nes				
United States	573	484 000	255	769 000
United Kingdom	35	70 000	34	71 000
Belgium and Luxembourg	1	1 000	14	19 000
Other countries	14	40 000	17	28 000
Total	623	595 000	320	887 000
Exports				
Tin in ores, concentrates and scrap				
Mexico	—	—	501	2 376 000
United States	72	36 000	301	863 000
United Kingdom	759	2 661 000	124	488 000
Sweden	—	—	17	73 000
Spain	45	251 000	—	—
Total	876	2 948 000	943	3 800 000
Tinplate scrap				
United States	4 999	324 000	2 396	184 000
Singapore	—	—	519	108 000
Peru	35	5 000	—	—
Thailand	15	4 000	—	—
Total	5 049	333 000	2 915	292 000
Consumption				
Tinplate and tinning	2 806		2 465	
Solder	2 032		2 021	
Babbit	182		204	
Bronze	88		73	
Other uses (including collapsible containers, foil, etc.)	177		159	
Total	5 285		4 922	

Source: Statistics Canada.
p Preliminary; — Nil; nes Not elsewhere specified.

Limited, Cramco Alloy Sales Limited, Kester Solder Company of Canada Limited, Tonolli Company of Canada Ltd., Toronto Refiners and Smelters Limited, and Metals & Alloys Company Limited.

Bronze, a copper-lead-tin alloy, is also produced in Canada, chiefly by Noranda Metal Industries Ltd., Anaconda Canada Limited, Federated Genco Limited, Metals & Alloys Company Limited, and The Ingot Metal Company Limited.

Table 2. Canada, tin production, exports, imports and consumption, 1965, 1970 and 1975-78

Year	Production[1]	Exports[2]	Imports[3]	Consumption[4]
		(tonnes)		
1965	171	219	5 073	4 970
1970	120	268	5 111	4 565
1975	319	1 052	4 487	4 315
1976	274	796	4 224	4 849
1977	328	876	5 028	5 285
1978[p]	375	943	4 804	4 922

Source: Statistics Canada.
[1] Tin content of tin concentrates shipped plus tin content of lead-tin alloys produced. [2] Tin in ores and concentrates and tin scrap, and after 1969 also re-exported primary tin. [3] Tin metal. [4] Current coverage exceeds 90 per cent, whereas until 1972 coverage was in the order of 80 to 85 per cent.
[p] Preliminary.

The Fifth International Tin Agreement*

Tin is the only metal for which there is an international agreement between consuming and producing countries, with provisions for a buffer stock. The Fifth International Tin Agreement, which came into force on July 1, 1976 and is effective until June 30, 1981, is designed primarily to limit fluctuations in the price of tin, to help increase export earnings from the commodity and to secure an adequate supply of tin at prices fair to consumers and remunerative to producers.

The governing body of the agreement – the International Tin Council – is made up of both producing and consuming countries which are members.

The main concerns of the International Tin Council are short-term problems of supply, demand and pricing. Decisions affecting supply and price, however, are made with regard to long-term trends. Consumer and producer members form separate groups in the Council and each group has an equal number of votes in the governing body. Canada is a signatory to the Fifth Agreement and, in proportion to its consumption, has 29 out of the total of 1 000 votes allocated to consumers. The 23 consumer members and seven producer members accounted for 82.7 per cent of recorded world consumption in 1978. The total does not include consumption in the U.S.S.R., which does not make data available, even though it is a member country. The United States was the main non-member country among Western consuming countries until July 1, 1976, when it decided to join the Agreement. Norway became a consumer member in 1978.

Producer members are Australia, Bolivia, Indonesia, Malaysia, Nigeria, Thailand and the Republic of Zaire. Together, producer and consumer members of the Council account for 87 per cent of the non-communist production of tin-in-concentrate, but the seven producer members alone account for 85 per cent.

The Fifth Agreement incorporates two main operational mechanisms; the use of a buffer stock, and the application of export controls, when necessary, to adjust supply to demand. Floor and ceiling prices are established from time to time by the Tin Council, taking into account current market prices. The range between the floor and ceiling prices is divided into low, middle and upper sectors. When tin prices are in the lower sector, the buffer stock manager tends to buy tin to support the price; when tin prices are in

Table 3. Estimated world[1] production of tin in concentrates, 1968 and 1977-78

	1968	1977	1978
		(tonnes)	
Malaysia	76 274	58 703	62 650
Bolivia	29 568	30 782	30 881
Thailand	23 980	24 205	28 003
Indonesia	16 940	25 921	27 231
Australia	6 642	10 694	11 716
Brazil	1 865	6 400	8 500
Zaire	6 742	3 560	3 450
South Africa	1 866	2 876	2 886
United Kingdom	1 827	3 851	2 831
Nigeria	9 804	3 267	2 751
Total, including countries not listed	183 100	185 700	195 300

Source: International Tin Council, Statistical Bulletin.
[1] Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary. The People's Republic of China and U.S.S.R. are large tin producers.

*Details of previous International Tin Agreements are given in the 1976 Tin Review.

the upper sector the manager may try to exert a depressing force by selling from the buffer stock. The floor and ceiling prices are expressed in Malaysian ringgit or in any other currency the International Tin Council may decide on.

Contributions by producing countries to the buffer stock must amount to the equivalent of 20 000 t of tin in the form of cash or tin metal, or a combination thereof as determined by the council. The equivalent of 7 500 t is due upon entry into force of the agreement, with the remainder due at times determined by the council. An important change introduced in the Fifth Agreement regarding valuation of contributions to the buffer stock is that cash contributions made after the entry into force of the agreement will be at the floor price prevailing at that time and not, as under the Fourth Agreement, at the floor price on the entry into force of the agreement, This will reduce any erosion of the authorized size of the buffer stock that might otherwise result from increases in the floor price during the life of the agreement.

The Fifth Agreement provides for additional voluntary contributions to the buffer stock over and above those required from producing countries. As in the Fourth Agreement, contributions may be made by any country invited to the conference; such voluntary contributions were made under the Fourth Agreement by France and the Netherlands. However, a major innovation in the Fifth Agreement is that an amount up to the equivalent of 20 000 t of tin metal is an implied overall target for contributions from the participating consuming countries. After the agreement has been in operation for two and a half years the council must review the results obtained in regard to these additional contributions. In the light of its review it may decide that a conference be convened within six months to renegotiate the agreement.

To date, the response to the request for additional voluntary contributions by consumers has been good; in addition to France and The Netherlands, other countries which have made contributions to the buffer stock are Belgium, Canada, Denmark, Japan, Norway and the United Kingdom. The United States administration proposed bills to Congress that would allow the country to make a voluntary contribution in the form of approximately 5 000 t of tin from the General Services Administration (GSA) stockpile. However, none of the bills was approved.

The Fifth Agreement also provides that the council may borrow for the purposes of the buffer stock on the security of the tin it holds. Furthermore, in the event of any other financial resources becoming available to the council (for example, directly from international financial organizations), the council may modify the arrangements concerning the size and financing of the buffer stock.

At the expiration of the five-year agreement, the mandatory contributions by producers and the voluntary contributions by consumers are subject to refund, plus or minus profits or losses from sales. To date, all contributors receive appreciable profits, since on principle the buffer stock manager buys low and sells high.

Tin council activities in 1978

The Tin Council reviewed the price range during its sessions in January and April but no changes were made. However, after another review in July, and based on the findings of the Economic and Price Review Panel (established in March 1977 to make an assessment of data relevant to the review of floor and ceiling prices at six-month intervals) the council revised the price range, effective July 14, as follows: floor, M$ 1350/picul*; lower sector, M$ 1350 to M$ 1450/picul; middle sector, M$ 1450 to M$ 1600/picul; upper sector, M$ 1600 to M$ 1700/picul and ceiling, M$ 1700/picul.

The council initiated two major studies, one on the outlook for the tinplate and soldering industries and the second on the economics of development and production investment. It also established a Preparatory Committee to write a working draft of a Sixth Agreement, for submission at the Geneva Negotiating Conference on tin to be held in the spring of 1980.

World developments

Total non-communist world output of tin in concentrates in 1978 is estimated at 195 120 t by the International Tin Council. This estimate includes some 6 300 t of tin of unspecified origin that is being smuggled out of some producing countries, mainly to avoid taxes, and offered for processing to various custom smelters around the world.

World tin metal production in 1978 is estimated at 189 400 t compared to 179 400 t in 1977. Consumption of primary tin metal is estimated at over 185 300 t, leaving a surplus in the supply-demand balance of about 4 000 t, excluding tin released from noncommercial stocks. During 1978, the United States sold 330 t from the GSA stockpile, compared with 2 679 in 1977. The government held over 203 000 t of stockpiled tin at year-end, of which 171 000 t were in excess of the stockpile goal. None of the bills submitted to Congress for additional sale authority was approved. Indonesia's output increased by about 5 per cent, and that country's dredging capacity is expected to be greater in 1979. P.T. Tambang Timah took delivery in the fall of 1978 of a dredge with a bucket capacity of 0.62 m^3 and a throughput capacity of 6.5 million m^3 per year, equivalent to some 1 500 tonnes per year (tpy) of tin in concentrate. Exploration Maatschappij Indonesia, B.V. took delivery of a dredge capable of producing 2 000 tpy of tin in concentrates in early 1979. The Government of Thailand now requires maximum foreign participation in Thai tin mining to be decreased to 40 per cent. In Australia, Renison Ltd. added 2.17 million t of probable reserves averaging 1.06% Sn. The company plans to expand its output by 33 per cent by 1980. The Wheal Jane tin mine in the United Kingdom closed due to higher costs and lower ore grades.

Smelting operations began at two new smelters in Singapore, while other smelter construction is being carried out in Bolivia, South Africa, Taiwan and Thailand.

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* 1 picul equals 133.33 lb: 1 ringgit (M$) equals approximately $U.S.0.42.

Prices

The following table shows price increases and fluctuations over the year 1978.

TIN PRICES, 1978

	NM Can.	NM U.S.	*Metals Week* N.Y. Market
	¢/lb.	¢/lb.	¢/lb.
January	659.2	587.0	549.0
February	667.4	593.4	549.833
March	635.6	557.5	518.478
April	624.2	539.6	499.188
May	645.2	570.0	531.591
June	682.2	600.9	555.227
July	690.9	507.4	563.350
August	736.8	638.7	592.087
September	795.1	674.8	633.500
October	882.35	739.2	710.333
November	875.06	745.0	693.050
December	824.36	696.8	650.000
Average	726.5	629.2	587.136

Statistics by Mineral Policy Sector, Department of Energy, Mines and Resources.

Occurrence and recovery

About 80 per cent of the world's tin output is derived from alluvial deposits. The principal production method is bucket-line dredging which can be used to water depths as great as 50 metres. Suction dredges are also used, but in most places they are less efficient than the bucket-line method. Other methods are gravel pumping, hydraulicking and dulang washing. Tin is recovered as cassiterite (SnO_2) and at times is associated with other metals such as wolframite (tungsten).

A typical economic grade of a placer deposit is about 240 g per m^3 of sand (approx. 1 800 kg) or a tenor of only 0.013 per cent tin. Leaders in placer tin production are Malaysia, Thailand, Indonesia and Nigeria. The industry is labour-intensive, employing some 150 000 people in these four countries.

Lode mining, though far less common than alluvial mining, still accounts for most of the tin output of Bolivia, Australia, Britain and South Africa. Countries of the communist and socialist blocks, notably The People's Republic of China and the U.S.S.R., are also important producers. Lode deposits usually have a minimum tin content of 0.4 per cent and many mines in Bolivia, Australia and Britain have grades of about 1 per cent. Silver, tungsten, bismuth and lead are common byproducts of lode mines. Cassiterite is also the predominant tin-bearing mineral of lode deposits but stannite, a copper-tin-iron-bearing sulphide, is of some importance.

Concentrating processes for alluvial and most lode tin are based on relatively simple gravity separation methods that produce concentrates ranging from 50 to 76 per cent tin. Magnetic and electrostatic separation are also used. Lode mining companies in Australia, South Africa and Britain have recently installed flotation cells in their beneficiating plants to complement gravity separation and improve the recovery of tin and other metals.

Table 4. Estimated world[1] production of primary tin metal, 1968, 1977 and 1978

	1968	1977	1978
		(tonnes)	
Malaysia	89 600	66 305	71 953
Thailand	24 826	23 102	28 095
Indonesia	4 630	24 005	25 055
Bolivia	60	13 048	16 180
Brazil	1 743	7 400	9 500
United Kingdom	25 333	10 114	8 445
Australia	3 751	5 561	5 129
Spain	2 361	5 307	4 472
United States	3 553	6 724	3 873
Belgium	4 876	3 520	3 295
West Germany	1 528	2 897	3 241
Nigeria	10 001	3 315	2 698
Netherlands	8 111	2 100	1 800
Total, including countries not listed	187 800	179 400	189 400

Source: International Tin Council, Statistical Bulletin.
[1]Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary.

Uses

The manufacture of tinplate* represents the largest world market for tin, averaging about 40 per cent of world consumption. Approximately 90 per cent of tinplate is used in container manufacturing. The major non-packing uses of the product are in the automobile and electronic industries. Typically, an efficient operation uses 4.3 kg of tin per t of tinplate. In 1978, about 110 electrolytic tinning plants around the world used 75 900 t of tin for the production of 13.8 million t of tinplate.

The second-largest tonnage use of tin is in the manufacture of solder, estimated at 28.0 per cent of consumption in the United States, 32.6 per cent in Japan and 15.5 per cent in West Germany. Solders commonly consist of 40 to 70 per cent tin. For soldering galvanized metal, solders with somewhat less than 60 per cent tin content possess the best "wetting" characteristics. Uses for tin solders (60 to 63 per cent tin) in the electronic industry are growing rapidly, but consumption of solder per unit of manufactured product is being reduced through economies in printed circuitry and the use of "tailor-made" preforms. The latter are fluxed and soldered in an automatic process called wave soldering. This soldering method is based on passing the printed circuits across the crest of a standing wave of continuously circulating molten solder. Solder is also used to join the side seams of tinplate cans. Solder has been used in plumbing applications for many years. One of the recent developments is the preplaced solder collar or ring as part of the fitting. The ring holds enough solder to

*Tinplate is a low-carbon steel sheet or strip coated with a very thin layer of tin.

form the join when heated by an acetylene torch. Solder is also widely used in the manufacture of car radiators and in filling seams and welds in car bodies.

Tin is used along with silver in low-temperature soldering applications. Comparisons of mechanical properties of 95 per cent tin-5 per cent silver solders with 80 per cent lead-20 per cent tin solders, show that both the ultimate tensile strength and the shear strength of the silver-tin solders are approximately twice that of lead-tin products. The solder is also 30 per cent harder.

Tin-containing bearing alloys are mainly white metals, aluminum-tin alloys and tin bronzes. Babbits (white metals) are generally high-tin alloys, a typical composition being 90 per cent tin, 7 per cent antimony and 3 per cent copper. They are used in bearings, as are aluminum-tin alloys, which have a higher fatigue strength. Newer bearing materials include chromium and beryllium-inoculated, tin-base alloys offering markedly improved mechanical properties. Copper-tin alloys such as bronze and gunmetal have an average tin content of about 10 per cent and are used for valves and fittings for water and steam pipelines.

Titanium-tin alloys containing 2 to 11 per cent tin are used increasingly in the structural and engine components in the aerospace industry, including engine components in supersonic jets such as the Concorde.

Terneplate, an alloy of 80 to 88 per cent lead and 12 to 20 per cent tin, is a durable roofing material that shows signs of revival in the United States. Other applications for terneplate are in automotive oil filters, outdoor signs, fire doors, and oil stoves and heaters.

Pewter is gaining popularity for tableware and ornamental castings such as commemorative beakers, plaques, and plates. Modern pewter contains no lead and is composed of about 92 per cent tin, 6 per cent antimony and 2 per cent copper.

Fusible alloys of tin, bismuth, lead, cadmium and sometimes gallium and indium, are used in safety devices such as heat fuses. Diecasting alloys of tin, antimony and copper have applications in the production of jewellery.

Lead-calcium-tin alloys are being introduced in battery manufacturing, a market long served almost exclusively by antimonial lead. The tin content in this alloy is as high as to 1.3 per cent. There are forecasts that such maintenance-free, lead-acid batteries may capture up to one-third of the U.S. battery market by 1980.

A relatively new application is the use of small quantities of tin (approximately 0.1 per cent) in cast iron for engine blocks, crankshafts and rear-axle assemblies. Adding tin assures a uniformly hard, wear-resistant and thermally stable perlitic structure in the castings.

Pure tin is used in collapsible tubes, especially for pharmaceutical products. Tin is used in conjunction with the manufacture of plate glass, through the "float process", in which a continuous ribbon of glass floats along a bath of molten pure tin to impart a very flat surface.

Tin oxide is a chemical used in the manufacture of conductive glass and glass resistors.

Tin is used in organotin compounds which find industry applications in diorganotin and triorganotin compounds. The main uses of diorganotin compounds are as stabilizers and catalysts in the plastics and polyurethane foam industry. Triorganotin compounds are used as wood preservatives, marine antifouling paints, fungicides and disinfectants.

The foregoing covers some of the major uses of tin; the 1976 review gave a much more extensive coverage. The reader is also referred to *A Guide to Tin* by the International Tin Research Institute.

Outlook

The tin market in 1978 was preoccupied with anticipated large releases of tin from the GSA stockpile but none of the bills submitted to the United States Congress for additional sales authority was approved. It is likely that Congress will approve the disposal of 35 000 long tons of tin (of which up to 5 000 t may be contributed to the buffer stock) in 1979. For 1979, the continuing growth in tin production in Malaysia, Indonesia, Thailand and Australia should increase tin-in-concentrate production by some 2 000 to 5 000 t. Consumption may also increase, but marginally, by about 1 000 to 2 000 t. This forecast, however, may be upset by higher demand or other actions on the part of those countries which do not publish tin production or consumption figures. Market prices in 1979 are expected to continue upward, and will probably continue to be above the ceiling established under the Tin Agreement.

It should be noted that higher prices are not only prompting new tin supplies and increased exploration, but more efficient use of tin. However, significant results from this trend will not be evident until some time after 1980. Moreover, excessive price increases may begin to trigger irreversible substitution, particularly in the tinplate industry.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
32900-1	Tin in ores and concentrates	free	free	free	free
33507-1	Tin oxides	free	15%	25%	free
33910-1	Collapsible tubes of tin or lead coated with tin	10%	17½%	30%	10%
34200-1	Phosphor tin	5%	7½%	10%	5%
34300-1	Tin in blocks, pigs, bars or granular form	free	free	free	free
34400-1	Tin strip waste and tin foil	free	free	free	free
38203-1	Sheet or strip, iron or steel, corrugated or not, coated with tin	10%	12½%	25%	8%
43220-1	Manufactures of tinplate	15%	17½%	30%	11½%

United States

Item No.		Most Favoured Nation
601.48	Tin ore and black oxide of tin	free
608.91	Tinplate and tin-coated sheets, valued at not over 10¢ per pound	8%
608.92	Tinplate and tin-coated sheets, valued at over 10¢ per pound	0.8¢ per pound
622.02	Unwrought tin other than alloys of tin	free
622.04	Unwrought tin, alloys of tin	free
622.10	Tin waste and scrap	free
622.15	Tin plates, sheets and strips, not clad	6%
622.17	Tin plates, sheets and strips, clad	12%
622.20	Tin wire, not coated or plated with metal	6%
622.22	Tin wire, coated or plated with metal	6%
622.25	Tin bars, rods, angles, shapes and sections	6%
622.40	Tin pipes, tubes and blanks	6%
644.15	Tin foil	17.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1978), USITC Publications 843.

Titanium and Titanium Dioxide

D.G. LAW-WEST

The titanium minerals, ilmenite and rutile, are processed mainly into pigments or titanium metal. Canada produces only pigment-grade titanium dioxide (TiO_2) from ilmenite. The pigment industry consumes virtually all of the ilmenite and about 85 per cent of the rutile produced in the world. Most of the remainder goes to the titanium metal industry. Ilmenite is the most widely used and represents about 90 per cent of the world's titanium mineral production. In 1978 the world's production of ilmenite was an estimated 4.4 million tonnes* with Australia, the United States, Canada and Norway being the main producers. Australia produced most of the 324 000 tonnes of the world's rutile.

Canada

Quebec Iron and Titanium Corporation (QIT), two-thirds owned by Kennecott Copper Corporation and one-third by New Jersey Zinc Company, is the only company that mines and processes ilmenite ore in Canada. The ore is mined by open-pit methods in the Lac Tio-Lac Allard region of eastern Quebec and is crushed at the site to minus 7.5 centimetres (cm) in diameter. After a short haul by rail to the port of Havre St-Pierre, it is loaded aboard ore carriers for transportation via the St. Lawrence River to the company's upgrading plant and smelter at Sorel, about 90 kilometres (km) from Montreal.

Processing at the Sorel plant involves upgrading the ilmenite from an average content of 86 per cent iron and titanium to 93 per cent using heavy media separation techniques such as spirals and cyclones. The upgraded ore is calcined in a rotary kiln to reduce the sulphur content, then cooled, mixed with powdered anthracite and smelted in electric arc furnaces. *Sorelslag*, a titanium slag containing 70 to 72 per cent TiO_2 and *Sorelmetal*, a pig iron with a low manganese content, are produced. The titanium slag is used in the production of TiO_2 pigment by the sulphate process and the pig iron is principally used by manufacturers of ductile iron, but it is also used in powder metallurgy and as a scrap iron substitute. A third product, *Sorelflux*, or unprocessed ilmenite ore with a grain size of between 6.4 and 38.0 millimetres (mm), is used as a metallurgical flux. Ilmenite ore from QIT is also sold as a heavy aggregate, but the tonnage is relatively small.

During the year the demand for titanium slag produced by QIT was very strong. One of the principal reasons for the strength of the market was the low pollution aspect of producing TiO_2 pigments from slag rather than directly from ilmenite. With no labour disruptions during the year, production of titanium slag rose sharply from 692 000 tonnes to about 850 000 tonnes. About 90 per cent of the titanium slag was exported, principally to the United Kingdom, western Europe and the United States. The remainder went to two Canadian TiO_2 pigment producers: Canadian Titanium Pigments Limited of Varennes, Quebec, a subsidiary of NL Industry, Inc. of the United States, and Tioxide Canada Inc., of Tracy, Quebec, a subsidiary of British Titan Products Company Limited of England.

The two domestic producers of TiO_2 pigment have a combined production capacity of approximately 72 000 tonnes per year. About 90 per cent of the Canadian consumption of 60 000 tonnes per year is supplied from domestic sources. This consumption is distributed between the paint industry, 65 per cent; the paper industry, 15 to 20 per cent; and others, including rubber, plastics and textiles, 15 to 20 per cent. In 1978 the demand for TiO_2 pigment was fairly good, and the two Canadian producers operated at close to full capacity.

At the present time, the two Canadian producers of titanium dioxide pigments are actively concerned with problems of pollution. They have received notices from the Government of Quebec directing them to limit, by 1980, the dumping of waste acids and solids into the St. Lawrence River. Both producers use the sulphate process which involves the digestion of QIT titanium slag by sulphuric acid and the consequent hydrolysis of the purified titanium sulphate to give titanium dioxide. However, the process generates dilute acid and solid wastes, which are released into the river. To meet this problem both companies are considering neutralizing the waste acids with limestone. A byproduct of this process would be gypsum, which could be sold to the cement and wallboard industries.

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, titanium production and trade, 1977 and 1978

	1977		1978[p]	
	(tonnes)	($)	(tonnes)	($)
Production (shipments)				
Titanium dioxide, slag	..	77 821 440	..	110 667 000
Imports				
Titanium dioxide, pure				
United States	2 635	2 817 000	3 601	4 218 000
West Germany	582	577 000	1 400	1 543 000
United Kingdom	523	552 000	831	1 027 000
Belgium and Luxembourg	738	697 000	659	667 000
Other countries	—	—	104	95 000
Total	4 478	4 643 000	6 595	7 550 000
Titanium dioxide, extended				
United Kingdom	161	185 000	286	348 000
United States	189	354 000	135	228 000
West Germany	144	78 000	56	46 000
France	—	—	20	21 000
Switzerland	2	6 000	1	3 000
Total	496	623 000	498	646 000
Titanium metal				
United States	289	4 039 000	559	6 754 000
United Kingdom	58	1 354 000	43	947 000
Belgium and Luxembourg	12	557 000	7	328 000
Other countries	13	96 000	22	345 000
Total	372	6 046 000	631	8 374 000
Exports[1] to the United States				
Titanium metal, unwrought including waste and scrap	173	392 607	293	882 784
Titanium metal, wrought	58	691 838	481	3 744 965
Titanium dioxide	14 185	12 246 274	15 642	13 847 302

Source: Statistics Canada, except where noted.
[1] U.S. Department of Commerce, U.S. General Imports, Report F.T. 135. Canadian export statistics do not provide separate categories.
[p] Preliminary; — Nil; .. Not available.

Table 2. Canadian titanium production, trade and consumption, 1965, 1970 and 1975-78

	Production		Imports			Consumption	
	Ilmenite[1]	Titanium Dioxide Slag[2]	Titanium Dioxide Pure	Titanium Dioxide Extended[3]	Total Titanium Dioxide Pigments	Titanium Dioxide Pigments	Ferro-titanium[4]
				(tonnes)			
1965	1 195 990	495 220	1 420	8 649	10 069	35 999	59
1970	1 892 290	766 300	2 523	7 415	9 938	40 290	24
1975	1 543 480	749 840	2 467	241	2 708	. .	25
1976	1 702 900	814 060	4 965	276	5 241	. .	14
1977	1 442 280	692 330	4 478	496	4 974	. .	25
1978[p]	1 809 990	850 030	6 595	498	7 093	. .	. .

Sources: Statistics Canada and company reports.
[1]Ore treated at Sorel, from company reports. [2]Slag with 70 to 72 per cent TiO_2, from company reports. [3]About 35 per cent TiO_2. [4]Ti content.
[p]Preliminary; . . Not available.

Table 3. Titanium slag and iron production, Quebec Iron and Titanium Corporation, 1965, 1970 and 1975-78

	Ore Treated	Titanium Slag	Iron
		(tonnes)	
1965	1 195 990	495 220	338 130
1970	1 892 290	766 300	539 720
1975	1 543 480	749 840	499 890
1976	1 702 900	814 060	551 100
1977	1 442 280	692 330	459 250
1978	1 809 990	850 030	595 000

Source: Kennecott Copper annual report.

World developments

Australian production of rutile decreased by about 20 per cent in 1978, notwithstanding the fact that exports were up by about 50 per cent. The shortfall in supply resulted in a sharp reduction of producer stocks during the year. In contrast, production of ilmenite increased by nearly 10 per cent, while exports were down slightly from the year before. In the United States, the production of titanium dioxide pigments increased by 6 per cent from 1977. However, ilmenite production decreased by 5 per cent, mainly because of the closure of SCM Corporation mining and concentrating operations in New Jersey. The U.S. titanium industry suffered a further set back when the synthetic rutile plant owned and operated by Kerr-McGee Corporation was placed on standby while improvements and additions were being made to equipment.

The new South African heavy minerals project at Richard Bay experienced technical difficulties and did not reach expected production rates during 1978. There was also a problem achieving the quality specifications for the final products, which include titanium minerals, zircon, titanium slag and low-manganese pig iron. Quebec Iron and Titanium Corporation has a 32 per cent interest in the Richards Bay project.

Processing and uses

Nearly 90 per cent of all the titanium ore produced is used in the production of titanium dioxide pigments. The demand for titanium dioxide relates to its high index of refraction which gives pigments their extreme whiteness and opacity. Titanium dioxide can be won from titanium ores by two processes, the sulphate method, which uses ilmenite or ilmenite slag, or the chloride method, which uses natural or synthetic rutile.

In the sulphate process, ilmenite is digested in concentrated sulphuric acid to produce a solution that is then clarified to remove heavy metals and materials. After cooling, the iron is precipitated in the form of hydrated iron sulphate. After leaching and concentration, the liquid is hydrolyzed to form insoluble hydrated titanium dioxide, which precipitates with the addition of seed crystals. The precipitate is then washed and calcined to obtain titanium dioxide. In the chlorine process, rutile is chlorinated in the presence of carbon to produce titanium tetrachloride. After the tetrachloride is separated from other chloride products, it is purified by distillation, then vaporized and oxidized to produce titanium dioxide and chlorine. The chlorine is recovered and recycled.

Table 4. Salient titanium statistics, United States, 1977 and 1978

	Ilmenite		Rutile		Titanium[1]	
	1977	1978^e	1977	1978^e	1977	1978^e
	(tonnes)					
Production	579 691	553 000	. .	. .	. .	. .
Imports	440 892[2]	390 000[2]	112 491	227 000	2 165	1 630
Consumption	921 700[2]	912 000[2]	167 829	254 000	14 729	17 200
Price/pound	. .	. .	. .	. .	$2.98	$3.28
Price/ton	$55.00[3]	$50.00[3]	$360.00[4]	$340.00[4]	. .	. .

Source: U.S. Bureau of Mines, Mineral Commodity Summaries, January 1979.
[1] Tonnes of sponge metal. [2] Includes titanium slag from Canada. [3] 54 per cent TiO_2, fob Atlantic seaboard, long ton. [4] fob Atlantic and Great Lakes ports, short ton.
^{e} Estimated; . . Not available.

Table 5. Consumption of titanium concentrate in the United States, by product, 1977

Product	Ilmenite[1] Gross Weight	Ilmenite[1] Estimated TiO_2 Content	Titanium Slag Gross Weight	Titanium Slag Estimated TiO_2 Content	Rutile Gross Weight	Rutile Estimated TiO_2 Content
	(tonnes)					
Pigments	777 386	466 682	135 582	96 344	131 989	123 550
Welding-rod coatings	x[2]	x[2]	. .	. .	7 816	7 425
Alloys and carbides	x[2]	x[2]	x[3]	x[3]	x[2]	x[2]
Miscellaneous[4]	8 693	6 137	. .	. .	28 404	26 730
Total	786 079	472 819	135 582	96 344	168 209	157 705

Source: U.S. Bureau of Mines, Minerals Yearbook Preprint, 1977.
[1] Includes mixed products containing rutile, leucoxene and ilmenite. [2] Included with "Miscellaneous" to avoid disclosing confidential data. [3] Included with "Pigments" to avoid disclosing confidential data. [4] Includes ceramics, chemicals, glass fibers and titanium metal.
. . Not available; x Confidential.

More than one-half of TiO_2 pigment produced is consumed by the paint industry and an additional one-quarter by the paper industry. The remainder of the production is consumed in the manufacture of plastic, rubber, textiles, floor-coatings, ceramics and inks. In addition to having favourable properties of whiteness and opacity, titanium dioxide pigments are resistant to chemical attack, thermally stable, resistant to ultraviolet degradation and nontoxic.

Some 10 per cent of the titanium ore produced is used in the production of titanium metal. The demand for titanium metal is closely linked to the aerospace industry, which requires titanium metal and its alloys because of their high strength-to-weight ratio.

Titanium sponge metal is produced by reducing purified titanium tetrachloride obtained from the chloride process with sodium or magnesium in an inert atmosphere. Residual chlorides are removed then the sponge metal is compacted and melted into metal ingots. The production of 1 kilogram (kg) of titanium sponge metal requires approximately 2.2 kg rutile, 3.5 kg chlorine, 1.3 kg magnesium or 2.1 kg sodium, 0.3 kg petroleum coke and 8 495 cubic centimetres (cm^3) of inert gas, as well as about 465 mega joules (MJ) of energy per kilogram of sponge metal; included is the energy needed to produce the magnesium and chlorine. An additional 49 to 61 MJ per kilogram of titanium ingot (United States Bureau

Table 6. Production of ilmenite concentrate by country, 1976-78

	1976	1977^p	1978^e
	(000 tonnes)		
Australia	995	1 081	1 180
Norway	767	828	862
Canada[1]	823	711	850
United States	592	579	553
U.S.S.R.^{e}	380	400	. .
Malaysia	180	154	. .
India^e	90	140	136
Finland	123	125	. .
Sri Lanka	56	60^e	. .
Other countries	18	16	853
Total	4 024	4 094	4 434

Sources: U.S. Bureau of Mines, Minerals Yearbook Preprint, 1977; U.S. Bureau of Mines, Mineral Commodity Summaries, January 1979.
[1] Titanium slag containing 70 to 71% TiO_2.
^{p} Preliminary; ^{e} Estimated; . . Not available.

of Mines (USBM) figures) are required for the conversion of sponge metal to titanium ingot. The titanium metal demand from the aerospace industry and for use in water desalination, chemical processing, electrical equipment and underwater-craft construction is increasing. The growth in demand for titanium metal by the aerospace industry has by far out-paced the growth in supply, and at present the backlog in deliveries is two years. As demand for titanium metals is expected to increase, an increase in capacity will be needed to cover shortfalls in supplies.

Table 7. Production of rutile concentrate by country, 1976-78

	1976	1977	1978[e]
		(tonnes)	
Australia	395 343	324 370	272 000
United States	. .	. .	. .
U.S.S.R.[e]	27 000	27 000	27 000
India[e]	4 000	6 000	6 000
Sri Lanka	1 040	1 100[e]	. .
Brazil	128	132[e]	. .
Republic of South Africa	—	—	18 000
Total	427 511	358 602	323 000

Sources: U.S. Bureau of Mines, Minerals Yearbook Preprint, 1977; U.S. Bureau of Mines, Mineral Commodity Summaries January, 1979.
[e]Estimated; . . Not available; — Nil.

Outlook

The short-term outlook for paint, the largest consumer of titanium pigments, is closely linked to the construction industry, where there is expected to be little real growth. Little growth is also expected for the paper industry, the second-largest consumer of titanium dioxide pigments. Plastics and synthetic products have increased the use of TiO_2 and in fact, titanium pigments are now the standard white pigment in plastics and floor coverings. However these products are also primarily consumed by the construction industry.

The long-term outlook for titanium dioxide pigments is not clear. If the construction industry becomes more active the demand for paint could increase, but this may be offset by the use of more durable precoated wood and metal sidings. However, increased housing construction would require large amounts of floor coverings and plastic sheeting for insulation purposes. The demand for titanium pigments by the paper industry should increase to match the usage of paper products such as containers, books and duplicating paper, but introduction of electronic storage and display technologies, especially in the industrial sector, may be an offsetting factor.

At present titanium metal accounts for only 10 per cent of the consumption of titanium ores, but there is indication that this percentage will increase significantly as the aerospace and chemical industries need more titanium metal. The present two-year delivery time for titanium metal airplane structures is not expected to ease until some time in the early 1980s, when additional ingot and manufacturing facilities come on stream. Use in other industrial applications should increase because of the long

Table 8. United States titanium metal data, 1974-78

	1974	1975	1976	1977	1978
			(tonnes)		
Sponge metal					
Imports for consumption	6 317	3 801	1 613	2 165	1 667
Industry stocks	3 467	5 143	3 281	3 217	2 397
Government stocks (total inventory)[1]	28 217	28 750	29 328	29 328	29 328
Consumption	24 400	15 990	12 079	14 729	18 011
Scrap metal consumption	9 615	7 544	8 356	9 878	11 175
Stocks	5 005	5 563	5 229	6 193	5 849
Ingot[2]					
Production	32 778	23 188	19 608	23 861	28 472
Consumption	28 633	22 213	19 055	22 898	27 892
Stocks	. .	936	1 661	1 722	1 955
Net shipments of mill products[3]	15 824	14 177	13 152	14 031	14 062

Sources: U.S. Bureau of Mines, Mineral Industry Surveys; U.S. Bureau of Mines, Minerals Yearbook Preprint, 1977.
[1]Total inventory as of December, 31 of each year. [2]Includes alloy constituents. [3]Bureau of the Census and Business Administration, Current Industrial Report Series D1B-991.
. . Not available.

service life of the metal, an important prerequisite for heat exchangers and water desalination equipment. The high strength-to-weight ratio of titanium metal and its corrosion resistance in salt water will become increasingly important in the construction of underwater craft and equipment required for the development of mineral and food resources from the sea. Cost is the most significant factor in the substitution of titanium for other materials.

Table 9. Chemical composition of titanium concentrates

	Ilmenite	Rutile	Titanium Slag		Ilmenite	Rutile	Titanium Slag
		(%)				(%)	
TiO_2	37.0 - 65.0	94.0 - 98.0	71.4	CaO	0.1 - 1.0	0.02 - 0.08	0.8
Fe				MgO	0.05 - 4.0	0.02 - 0.09	5.0
($FeO + Fe_2O_3$)	30.0 - 55.0	0.2 - 1.5	16.3	Cr_2O_3	0.01 - 0.5	0.1 - 0.3	0.19
SiO_2	0.5 - 3.0	0.2 - 2.0	3.8	V_2O_5	0.05 - 0.5	0.4 - 0.8	0.58
Al_2O_3	0.2 - 1.5	0.2 - 0.5	4.6	ZrO_2	0.1 - 2.0	0.04 - 0.4	—

Source: Roskill Information Services Ltd.
— Nil.

Prices

Prices of selected titanium commodities, in United States currency, 1978

	($)
Titanium ore, fob cars Atlantic and Great Lake ports[1]	
Rutile, 96%, per short ton, delivered within 12 months	325.00-350.00
Ilmenite, 54%, per long ton, shiploads	50.00
Slag, 70%, per long ton, fob Quebec	110.00
Titanium metal, sponge, per lb, max.	
115 Brinell, 99.3%, 500-lb lots[1]	3.28
Mill products, per lb delivered, 4 000-lb lots[1]	
Billet, Ti – 6 AL-4V (8 in. diameter, rotating grade)	5.24
Bar, Ti – 6AL-4V (2 in. diameter, random lengths)	7.48
Titanium dioxide, anatase, dry milled, Canadian prices[2]	
Bags, carlots, delivered East, per kilogram	1.036
Bags, carlots, rutile, per kilogram	1.146

[1]*Metals Week* of December 29, 1978. [2]*Canadian Chemical Processing* of December 1, 1978.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
				(%)	
32900-1	Titanium ore	free	free	free	free
34715-1	Sponge and sponge briquettes, ingots, blooms, slabs, billets, and castings in the rough, of titanium or titanium alloys for use in Canadian manufactures (expires June 30, 1980)	free	free	25	free
34735-1	Tubing of titanium or titanium alloys for use in Canadian manufactures (expires February 28, 1981)	free	free	25	free
34736-1	Sheet, strip or plate of titanium or titanium alloys, cold-rolled, not more than 0.2015 inch in thickness, for use in the manufacture of tubes	free	free	25	free
34745-1	Bars, rods, plate sheet, strip, foil wire, coated or not, forgings and mesh of titanium or titanium alloys, for use by Canadian manufactures	$7^1/_2$	$7^1/_2$	25	5
37506-1	Ferrotitanium	free	5	5	free
92825-1	Titanium oxides	free	$12^1/_2$	25	free
93207-6	Titanium whites, not including pure titanium dioxide	free	$12^1/_2$	25	free

United States

422.30	Titanium compounds	7.5
473.70	Titanium dioxide	7.5
601.51	Titanium ore, including ilmenite, ilmenite sand, rutile and rutile sand	free
607.60	Ferrotitanium and ferrosilicon titanium	5
629.15	Titanium metal, unwrought, waste and scrap	18
629.20	Titanium metal, wrought	18

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States, Annotated (1978) ITC Publication 843.

Tungsten

D.G. LAW-WEST

Canada Tungsten Mining Corporation Limited (Cantung), the only producer of tungsten concentrates in Canada, had a record year in 1978, increasing its production of tungsten trioxide (WO_3) by nearly 27 per cent.

World tungsten prices were strong at the beginning of the year at $U.S. 170 per metric ton unit* (mtu) WO_3, but during the first three quarters of the year prices gradually fell to $ U.S. 133 per mtu WO_3. However, by the end of the year the price of tungsten concentrates had strengthened to about $U.S. 155 per mtu WO_3.

Canadian developments

The record production for Cantung was primarily due to a higher recovery rate in the mill and a better grade of ore from the mine. During 1978 the company mined and milled 176 700 tonnes** of scheelite ore, grading 1.96 per cent WO_3 and produced 288 562 mtu WO_3. In the previous year 216 815 mtu WO_3 was produced from 168 400 tonnes of ore grading 1.65 per cent WO_3. At the end of 1978 mineable ore reserves for Cantung were 3.8 million tonnes with an average grade of 1.55 per cent WO_3.

Cantung's program to double capacity continued on schedule throughout the year. In mid-year Amax Securities Inc., a unit of AMAX Inc. of New York, increased its interest in Cantung from 49 to 65 per cent by purchasing an additional 895 000 shares of the company.

Billiton Exploration Canada Limited, a wholly-owned subsidiary of Billiton B.V. of the Netherlands, entered into a joint venture with the Sullivan Mining Group Ltd. to study the feasibility of bringing into production the tungsten-molybdenum property of Brunswick Tin Mines Limited. Sullivan owns 89 per cent of Brunswick, and Mount Pleasant Mines Limited the remainder. The agreement involves the mining and milling of a 10 000-tonne sample and a program to research processing at Billiton's facilities in the Netherlands. Given positive results, Billiton will undertake to finance, develop and operate the mining complex as well as market the concentrates.

Highland-Crow Resources made a significant discovery of high-grade tungsten in the Yukon and Northwest Territories. More detailed exploration is continuing while previous data are being assessed. The cost of the program is being equally shared by Highland-Crow, Union Carbide Canada Limited and Cassiar Asbestos Corporation Limited.

AMAX Inc. has obtained the required water and land use permits needed to proceed with plans for long-range development of its MacTung prospect on the Yukon-Northwest Territory border. MacTung contains an estimated 30 million tonnes of ore with an average grade of 0.96 per cent WO_3.

International developments

The startup of Stage 2 of the Mt. Carbine wolframite mine in Queensland, Australia was completed early in the year. The mill capacity is now 1 000 tonnes per year as opposed to the 550 tonnes per year of tungsten concentrate achieved under Stage 1.

In Thailand, the production of tungsten concentrate in 1978 amounted to 6 182 tonnes, compared with 4 276 tonnes in the previous year. An additional 275 tonnes of concentrates per year are expected to be produced by a joint venture between Thailand and several South Korean interests. Tungsten production in the country is being hampered by illegal miners who often stampede mining areas and smuggle out tungsten ores.

Beralt, the major tungsten producer in Portugal, made large capital investments to increase the efficiency of its Panasqueica and Borralba mines. The U.S. company Union Carbide Corporation and the Belgium company Geomines are carrying out separate tungsten exploration programs in Portugal.

Uses

Tungsten materials can be divided into several major classes, depending on uses: tungsten carbides, tungsten-bearing steels, superalloys and nonferrous alloys, mill products made essentially from pure metal, and chemicals.

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* A metric ton unit (mtu) contains 10 kilograms, or 22.04 pounds.

**The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, tungsten production, imports and consumption, 1977 and 1978

	1977		1978p	
	(kilograms)	($)	(kilograms)	($)
Production[1] (WO_3)	2 284 409	. .	2 885 619	. .
Imports				
Tungsten in ores and concentrates				
United States	—	—	1 000	8 000
Total	—	—	1 000	8 000
Ferrotungsten[2]				
France	—	—	46 000	777 000
United Kingdom	90 000	1 557 000	24 000	434 000
Other countries	13 000	216 000	5 000	93 000
Total	103 000	1 773 000	75 000	1 304 000
Metallic carbide tips or blanks				
United States	. .	572 000	. .	428 000
Sweden	. .	7 000	. .	70 000
Other countries	. .	54 000	. .	65 000
Total	. .	633 000	. .	563 000
Metallic carbide inserts				
United States	. .	3 234 000	. .	3 193 000
Sweden	. .	826 000	. .	1 055 000
Other countries	. .	913 000	. .	569 000
Total	. .	4 973 000	. .	4 817 000
Metallic carbides, nonagglomerated				
United States	633 000	6 328 000	592 000	6 899 000
Sweden	37 000	1 014 000	74 000	1 508 000
Other countries	3 000	70 000	49 000	1 746 000
Total	673 000	7 412 000	715 000	10 153 000
Consumption (W content)				
Tungsten metal and metal powder	280 833	. .	. .	. .
Tungsten wire	3 186	. .	. .	. .
Others[3]	165 346	. .	. .	. .
Total	449 365	. .	. .	. .

Source: Statistics Canada.
[1] Producers' shipments. [2] Gross weight. [3] Includes tungsten ore and tungsten carbide.
p Preliminary; . . Not available; — Nil.

Tungsten carbide (WC) is one of the hardest materials known and is the preferred metalworking material for cutting edges of machine tools subject to intense wear and abrasion, and for metal surfaces in forming and shaping dies. It is produced by the chemical combination of tungsten metal powder and finely divided carbon. Tungsten carbide is compacted to the desired form using cobalt as a binder and sintered to produce cemented tungsten carbide. Cutting tools of cemented tungsten carbide are used in machining steel, cast iron and nonferrous metals and for shaping in the woodworking and plastics industries. In the more-abrasive applications, cemented tungsten carbide is used to make dies for wire and tube drawing, punches and dies for metal forming, and bits and tools for drilling equipment and wear-resistant parts. With the addition of tantalum, titanium and columbium carbides, the coefficient of friction of the cemented carbides is lowered, thereby, producing grades better suited to the machining of specific products, particularly steel. Other uses of tungsten carbide are in tire studs, spikes for golf shoes, armour-piercing projectiles and welding electrodes.

As an alloy constituent, tungsten is used primarily in the production of high-speed steels and tool and die steels. Tungsten is added to steels either as ferrotungsten (80 per cent W), melting base (30-35 per cent W), scheelite ($CaWO_4$) or as tungsten-bearing scrap. The tungsten-bearing steels are used for the same applications as carbides, especially where lower operating temperatures are encountered. However, tungsten is also used for certain stainless steels for application in high-temperature environments.

Tungsten is an important constituent in a wide variety of superalloys and nonferrous alloys. Tungsten-containing superalloys are being used increasingly in high-temperature applications or in highly corrosive environments because of their high-temperature strength and oxidation resistance. In making the alloys, tungsten is usually added in the form of tungsten metal powder, although tungsten scrap can be used to satisfy part of the tungsten requirements. Superalloys can be classified into three principal types: nickel base, iron base and cobalt base. The most important from the standpoint of usage of tungsten are the cobalt-base or "Stellite" superalloys. Only small amounts of tungsten are used in the nickel- and iron-base superalloys, but several companies are developing new superalloys containing larger amounts of tungsten, a factor which could mean a larger market for tungsten.

Mill products made from pure or substantially pure tungsten metal powder are used in significant quantities by the electric and electronic industries. The most important properties of tungsten in its metallic form are its high-melting point, low-vapour pressure, high hardness, good electrical conductivity and low coefficient of thermal expansion. Tungsten mill products such as rods, wire and flat products are made by compressing tungsten metal powder into the desired shape and then sintering.

Table 2. Canada, tungsten production, trade and consumption, 1965, 1970 and 1975-78

	Production[1] WO_3 Content	Imports		Consumption W Content
		Tungsten Ore[2]	Ferro-tungsten[3]	
	(kilograms)			
1965	1 734 837	162 114	160 572	398 079
1970	1 690 448	82 645	90 718	446 687
1975	1 477 731	953	45 359	451 336
1976	2 168 153	—	77 111	337 345
1977	2 284 409	—	103 000	449 365
1978[p]	2 885 619	1 000	75 000	. .

Source: Statistics Canada.
[1]Producer's shipments of scheelite (WO_3 content). [2]W content. [3]Gross weight.
[p]Preliminary; — Nil; . . Not available.

Discs cut from tungsten rods are used as electrical contacts to improve resistance to heat deformation resulting from sparking and associated high temperatures. Pure tungsten contacts are used principally in ignition circuits of automobiles and aircraft, but the trend to electronic ignition systems without tungsten contacts will mean a decline in the use of tungsten for this application. Tungsten discs are also used as heat sinks in semiconductor applications and, in combination with other elements, as electrical contacts and breakers for industrial use.

Tungsten wire is used for filaments in incandescent lamps and heating elements in fluorescent lamps and vacuum tubes. The overall demand for tungsten wire is increasing to reflect the upward trend in the manufacture of lamps and new uses such as heating elements in deicing and defogging equipment in automobile windshields.

Flat products are used for various parts of electron tubes and radiation shields as well as for very high temperature applications in reducing or inert atmospheres.

Tungsten is used for counterweights and balances, especially by the aircraft industry, but it is being replaced by depleted uranium, which has about the same density.

Tungsten is used in minor amounts to make chemicals and compounds for nonmetallurgical applications. Some of the end-uses include dyes, toners, phosphors, chemical reagents, corrosion inhibitors and catalysts.

Price stabilization

The United Nations Committee on Trade and Development (UNCTAD) continued to discuss ways and means of stabilizing the world tungsten market. At the third and final meeting of the *ad hoc* Intergovernmental Group of Experts on Tungsten, the positions of the majority of producers and most of the consumers with respect to an agreement on tungsten remained polarized. Generally, the producer group supported a full International Agreement (ICA) with full economic provision on tungsten, while the consumer group favoured a producer-consumer consultative forum (PCCF). As a result of the lack of progress, the Secretary-General of UNCTAD called for the formation of a Preparatory Workers Group (PWG) to seek some basis of agreement.

The first meeting of the PWG was characterized by continued impasse, but France proposed a compromise arrangement whereby an ICA would be established to include a commitment to examine and introduce gradually certain economic provisions. However, this proposal was rejected firmly by the major producers – United States, Japan, Federal Republic of Germany, Sweden and Britain – which collectively proposed a work program aimed at improving the data base of the tungsten market.

Prices

Over the year world tungsten prices declined approximately 15 per cent below the high prices of 1977. The average annual price in 1978 as quoted in *Metal Bulletin* was \$143.79/mtu WO_3; the *Metals Week* average price quotation, which reflects U.S. transactions, was \$141.39/mtu WO_3.

The International Tungsten Indicator (ITI), published for the first time in July, has replaced the former Tungsten Users' Index. The ITI combines price information from ten producing companies as well as 23 consuming companies and publishes the results twice a month. By the end of the year the indicator represented almost 50 per cent of the total Western consumer purchases.

Outlook

The short-term outlook for 1979 is for continued stability in the price of tungsten concentrates. The demand for tungsten metal may increase slightly because of its substitution for increasingly expensive molybdenum.

Long-term stability in the tungsten market may depend on the outcome of UNCTAD talks between consuming and producing countries. Should the talks break down permanently, it is highly likely that those countries within the producers group will form an international commodity agreement with binding economic conditions.

Tungsten prices according to "Metals Week" for December 1977 and 1978

	1977	1978
	($U.S.)	
Tungsten ore, 65% minimum WO_3 per short ton unit (20 lb.) of WO_3	effective Oct. 28, 1977	effective Dec. 8, 1978
G.S.A. Domestic, duty excluded	155.448	129.610
G.S.A. Export	154.750	effective Aug. 1, 1978 117.350
L.M.B. ore quoted by *London Metal Bulletin*, cif Europe	effective Dec. 8, 1977 150.595-159.666	effective Dec. 21, 1978 122.010-127.910
Ferrotungsten, per pound W, fob shipping-point, low-molybdenum	effective Dec. 1, 1977 12.100	effective Dec. 1, 1978 11.100
Tungsten metal, per pound, fob shipping point	effective Dec. 1, 1977	effective Dec. 1, 1977
Hydrogen red, depending on Fisher No. range	13.900-15.500	13.900-15.500

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)			
32900-1	Tungsten ores and concentrates	free	free	free	free
34700-1	Tungsten metal in lumps, powder, ingots, blocks or bars and scrap of tungsten alloy metal, for alloying purposes	free	free	free	free
34710-1	Tungsten rod and tungsten wire	free	free	25	free
35120-1	Tungsten and alloys in powder, pellets, scrap, ingots, sheets, strips, plates, bars, rods, tubing, wire, for use in Canadian manufactures (expires June 30, 1979)	free	free	25	free
37506-1	Ferrotungsten	free	5	5	free
37520-1	Tungsten oxide in powder, lumps and briquettes, for use in the manufacture of iron and steel	free	free	5	free
82900-1	Tungsten carbide in metal tubes for use in Canadian manufactures	free	free	free	free

United States

Item No.		
422.40	Tungsten carbide, on W content	21¢ per lb + 12.5% ad val.
422.42	Other tungsten compounds, on W content	21¢ per lb + 10% ad val.
601.54	Tungsten ore, on W content	25¢ per lb
607.65	Ferrotungsten and ferrosilicon tungsten, on W content	21¢ per lb + 6% ad val.
629.25	Tungsten metal waste and scrap, not over 50% tungsten, on W content	21¢ per lb + 6% ad val.
629.26	Tungsten metal waste and scrap, over 50% tungsten, on W content	10.5% ad val.
629.28	Tungsten metal, unwrought, other than alloys: lumps, grains and powders, on W content	21¢ per lb + 12.5% ad val.
629.29	Tungsten metal, unwrought, other than alloys: ingots and shot	10.5% ad val.
629.30	Other unwrought tungsten metal	12.5% ad val.
629.32	Unwrought tungsten alloys, not over 50% tungsten, on W content	21¢ per lb + 6% ad val.
629.33	Unwrought tungsten alloys, over 50% tungsten	12.5% ad val.
629.35	Wrought tungsten metal	12.5% ad val.

Sources: Customs and Tariff Amendments, Department of National Revenue Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1978) ITC Publication 843.

Uranium

R.M. WILLIAMS

Prospects for the uranium industry remained buoyant throughout 1978 despite continued uncertainty about projections of nuclear power growth. Exploration activity was again at record levels in many countries and several discoveries of potential importance were reported. Programs continued which would expand production to meet contracted commitments in the early 1980s and positive steps were taken to clear the way for further development projects to proceed. All indications were that the uranium industry would be able to expand to meet needs, provided that the exploration and development momentum could be maintained.

Few orders for new nuclear power plants were recorded in 1978, however, and projections for nuclear power growth in the medium-term continued to be modified downward, particularly in the United States. The introduction by the United States Department of Energy (USDOE) of new and more flexible enrichment contracting procedures in early 1978, contributed to this downward pressure on projections of uranium requirements. Long-term projections continued to be clouded by uncertainties about the future role of plutonium and those advanced fuel cycles requiring reprocessing. These and other uncertainties about the future of nuclear power became the subject of a major international study, the International Nuclear Fuel Cycle Evaluation (INFCE), on which attention was focussed during 1978 in the hope that the role of nuclear energy in the world's future pattern of energy supply would be clarified.

In Canada, uranium discoveries were reported in New Brunswick, Saskatchewan and the Northwest Territories, although the bulk of exploration activity continued to be in northern Saskatchewan. The final report of the Cluff Lake Board of Inquiry was released and, based on its recommendations, the government of Saskatchewan announced that Phase I of the Cluff Lake production project could proceed. Perhaps the most important stimulus to the industry, however, was the approval by the Government of Ontario of two major long-term sales contracts to Ontario Hydro which will permit uranium operations to continue in the Elliot Lake area of that province well into the next century. With continued growth in Canada's export markets it was expected that uranium could once again become one of Canada's leading export commodities.

Production and development

Production of uranium in 1978 was 6 803 tonnes (t) of uranium (U)*, compared to 5 794 t U in 1977, the increase being attributable to expanded production at all of Canada's six existing producing operations. Shipments of uranium made by these producers from production and inventory amounted to 8 211 t U, valued at $618 million, some 54 per cent of which was from four Ontario producers, the remainder coming from two producers in Saskatchewan; final shipments for 1977 were reported at 5 787 t U, valued at $349 219 143 (Table 1).

Production at Agnew Lake Mines Limited's new *in situ* mining-leaching operation, 90 kilometres (km) east of Elliot Lake, Ontario, did not reach expected levels in 1978; total production amounted to 154 t U. The methods of solution distribution employed in the underground leaching portion of the operation were modified, beginning in mid-1978, to incorporate "flood-leaching" of selected stopes, in an effort to increase recoveries. Methods of solution distribution in the surface leaching program were also modified early in the year and problems with the ion exchange plant were rectified. It was expected that production levels could gradually be increased, and that full capacity of 385 t U/year could be achieved by 1980.

Denison Mines Limited continued to expand mine production at its Elliot Lake, Ontario operation to supply its 6 440 tonne per day (tpd) mill. Some 2 180 872 t of ore were milled with an average grade of 0.912 kilogram (kg) U per tonne to produce 1 880 t U. Production came from both the No. 2 and the recently rehabilitated No. 1 shafts, and a major development project was under way which would open new production areas in the southwest area of the mine. The hoisting capacity of both shafts is being increased to a combined capacity of some 5 420 tpd

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*1 metric ton elemental uranium (tonne U) = 1.2999 short tons uranium oxide (U_3O_8).

(5-day week) by 1982 to handle projected output at that time. As part of the rehabilitation of the No. 1 shaft mining area, a backfill plant and distribution system was to be constructed during 1978 to permit partial pillar recovery in the area.

A major element of Denison's overall expansion involves the rehabilitation of its adjoining Stanrock/Can-Met properties, scheduled to begin in 1979. A small portion of the Stanrock mill will be rehabilitated to treat the mine water and recover the contained uranium. Rather than rehabilitate the entire mill, however, the Stanrock ore will be trucked to the main Denison mill, beginning in 1981. Production from Stanrock will gradually be increased to 3 810 tpd (5-day week) by 1985. To handle the increased feed, the Denison mill will be expanded to a final capacity of 13 610 tpd, with completion scheduled for late 1980.

Table 1. Uranium output[1] in Canada, by province, 1977 and 1978.

	1977		1978	
	(tonnes)	($000)	(tonnes)	($000)
Ontario	3 628	250 689	4 455	363 845
Saskatchewan	2 159	98 530	3 756	253 683
Total	5 787	349 219	8 211	617 528

Sources: Statistics Canada and Mineral Policy Sector, Energy, Mines and Resources, Canada.
[1]Shipments of uranium (U) in concentrate from ore processing plants; one metric ton of elemental uranium (tonne U) is equivalent to 1.2999 short tons uranium oxide (U_3O_8).

Table 2. Uranium production in Canada, by company, 1977 and 1978

		Production	
		(tonnes U)	
Company	Location	1977	1978
Agnew Lake Mines Limited	Agnew Lake, Ont.	27	154
Denison Mines Limited	Elliot Lake, Ont.	1 539	1 880
Eldorado Nuclear Limited	Eldorado, Sask.	456	494
Gulf Minerals Canada Limited[1]	Rabbit Lake, Sask.	1 939	2 115
Madawaska Mines Limited	Bancroft, Ont.	169	210
Rio Algom Limited	Elliot Lake, Ont.	1 664	1 950[2]
	Total Canada	5 794	6 803

Source: Company Annual Reports.
[1]Joint operation with Uranerz Canada Limited.
[2]Includes preproduction of some 45 t U from Rio Algom's Panel operation.

Part of Denison's overall expansion is being carried out, at an estimated cost of $151 million (1975 dollars), to meet its contract with Ontario Hydro (Markets and Prices section).

The first phase of the expansion of Rio Algom Limited's Elliot Lake operations, the enlargement of its Quirke mill to 6 350 tpd, was completed on schedule (and below the $76 million budget) in late 1978 and the mill was operating at capacity by year-end. A total of 1 964 960 t of ore, with an average grade of 0.975 kg U per t, were treated during the year at an average rate of 5 645 tpd; average mill recovery was 93.7 per cent. Production totalled 1 950 t U, of which about 45 t U was attributable to preproduction from the company's Panel operation. Some 2 085 t U were delivered to domestic and export customers from production and inventory.

Production came primarily from two conglomerate horizons in the Quirke Mine, the C Reef, which still provides the bulk of the ore, and the A Reef, some 45 metres (m) stratigraphically above the C Reef, which has recently been developed using highly mechanized trackless equipment. The focus of production will gradually shift from the C to the A Reef and subsequently, in the mid-1980s, to lower levels (down-dip) of both reefs. Various options of developing the down-dip portions of these reefs are being considered.

Dewatering of Rio Algom's Panel mine took place during 1977, the rehabilitation of the shaft was completed during 1978 and mine development was well advanced. The operation will employ a mixture of the conventional and trackless methods of mining currently in use at Quirke. The major construction effort was associated with the rehabilitation of the Panel mill, which will have a capacity of 2 990 tpd. The mill will use sulphuric acid rather than nitric acid as an eluting agent in its ion exchange circuit and magnesia rather than ammonia for the precipitation of the uranium; both of these changes are in response to concern about the presence of nitrate and ammonia in the effluents from the tailings basins. Production from the $134 million project was expected to begin in October 1979.

Rio Algom will also manage the $188 million (1975 dollars) rehabilitation of the Stanleigh property for an affiliated company, Preston Mines Limited; the property is located on the south limb of Elliot Lake's Quirke Lake syncline. Work was to begin on this project in 1979 with the objective of being in production at the rate of 4 540 tpd in 1983 or 1984 to meet Preston's Ontario Hydro contract (Markets and Prices section). Finally, Rio Algom is conducting feasibility studies related to its Milliken, Lacnor and Nordic properties which adjoin Preston's to the south and which the company hopes to bring back into operation, together with the Milliken mill, once markets and financing can be arranged.

Output from Madawaska Mines Limited's operation in the Bancroft area of Ontario continued to increase throughout 1978 as it entered its second full year of production after being rehabilitated in 1976. Production had fallen short of expectations in 1977 due primarily to difficulties in providing enough good-grade ore to the 1 360 tpd mill. A total of 340 678 t of ore were treated during 1978, with an average grade of 0.653 kg U per tonne, to produce 210 t U; average recovery was about 95 per cent.

Table 3. Uranium production by major producing countries, 1960, 1965, 1970, 1975-78

	United States	Canada	France[1]	South Africa	Namibia	Australia	Other[2]	Total[3]
				(tonnes U)				
1960	13 663	9 807	1 061	4 930	—	1 000	1 116	31 577
1965	8 033	3 418	1 700	2 263	—	285	138	15 837
1970	9 822	3 157	1 694	3 169	—	254	232	18 328
1975	8 924	4 679	4 061	2 488	—	—	368	20 520
1976[r]	9 770	5 438	4 193	2 759	593	358	464	23 575
1977	11 463	5 787	4 630	3 360	2 340	356	393	28 329
1978	14 232	8 211	5 242	3 962	2 693	516	458	35 314

Sources: Statistics Canada; U.S. Bureau of Mines Minerals Yearbooks for "Other" data prior to 1975; Mineral Trade Notes; South African Chamber of Mines, Analysis of Working Results; 1978 Annual Reports of Commissariat a l'Energie Atomique; Rio Tinto Zinc Corporation Limited.

[1] Includes Gabon, Malagasy Republic (until 1965) and Niger (from 1970). [2] Includes Argentina, Congo (1960), Finland (1960), Germany (from 1977), Italy (until 1976), Japan (from 1977), Portugal, Spain and Sweden (until 1976). [3] Totals are of listed figures only.

— Nil; [r] Revised.

In Saskatchewan, near Uranium City, Eldorado Nuclear Limited advanced its production expansion program during 1978 despite a chronic shortage of skilled workers. However, the program was still behind schedule and full production of some 690 t U/year was not expected until 1980 or 1981. The 1 630 tpd mill operated at about 1 000 tpd; some 20 per cent of the mill feed came from open pits and the remainder came in about equal amounts from the Fay and Verna mines. Exploration and development effort was being concentrated in the deeper portions of both these mines and it was anticipated that the Fay shaft would be deepened beyond its then-current 1 645 m depth, beginning in 1979. A total of 278 142 t of ore with an average grade of 1.951 kg U per tonne were treated during 1978 to produce 494 t U.

A significant aspect of the Eldorado mill renovation was the installation of a 910 tpd custom ore-receiving plant, in anticipation of toll-milling ore for smaller producers in the Uranium City area. The first of these, Cenex Limited, commenced underground development of its property in late 1978 and planned to be in operation early in 1979. Cenex had an agreement with Eldorado whereby it could ship a reported 360 t of ore a day to the Eldorado mill through 1981.

The joint venture of Gulf Minerals Canada Limited and Uranerz Canada Limited at Rabbit Lake, Saskatchewan, operated above its 1 500 tpd capacity during 1978. By year-end the limits of the open pit were well defined and the depth had reached some 80 m. A total of 2 215 t U were produced during the year, of which Gulf's share was about 1 077 t U. With a view to extending the ultimate life of the mill, Gulf continued to evaluate its Raven and Horseshoe deposits, some 5.5 km southwest of Rabbit Lake and its Collins Bay deposit, about 11 km north of Rabbit Lake. Of particular importance was the announcement in early 1978 that the company had identified yet another deposit of significance 1.6 km southeast of Collins Bay (Exploration section).

Following the release of the Cluff Lake Board of Inquiry's final report in mid-1978 the government of Saskatchewan indicated that the development of the first phase of Amok Ltd.'s Cluff Lake project could proceed (Government Affairs section). It was expected that the $130 million operation could be in operation by mid-1980 at an initial rate of 1 000 t U, increasing eventually to 1 500 t U per year. A surface lease agreement was signed in October between Amok and the provincial government which stipulated several conditions relating to stringent environmental protection measures, health and safety of workers, and employment and business opportunities for northerners.

At Key Lake, Saskatchewan, Uranerz Exploration and Mining Limited continued the evaluation of the Gaertner and Deilmann uranium-nickel deposits on behalf of its joint venture partners. Early in 1978, Saskatchewan Mining Development Corporation (SMDC) exercised its right to buy Inexco Mining Company (Canada) Ltd.'s one-third interest in the deposits, matching an offer of $U.S. 158.5 million made earlier by Denison Mines Limited. Under a cooperative agreement signed in 1977 between SMDC and Eldorado Nuclear Limited, SMDC resold the Inexco interests to Eldorado, retaining an option to buy back 50 per cent. This option was subsequently exercised, leaving Eldorado with a one-sixth interest in the venture, SMDC with one-half and Uranerz with one-third. Eldorado consummated its acquisition in November, through a wholly-owned subsidiary, Eldor Resources Limited (Markets section). Feasibility and engineering studies also continued with the objective that the estimated $200 million project could be in operation as early as 1983, with an annual output of up to 2 300 t U. As part of the feasibility exercise, Sherritt Gordon Mines Limited was engaged to develop an environmentally acceptable process for recovering the uranium and nickel.

British Newfoundland Exploration Limited (Brinex), together with Urangesellschaft Canada Limited, continued to review the feasibility of developing their Labrador

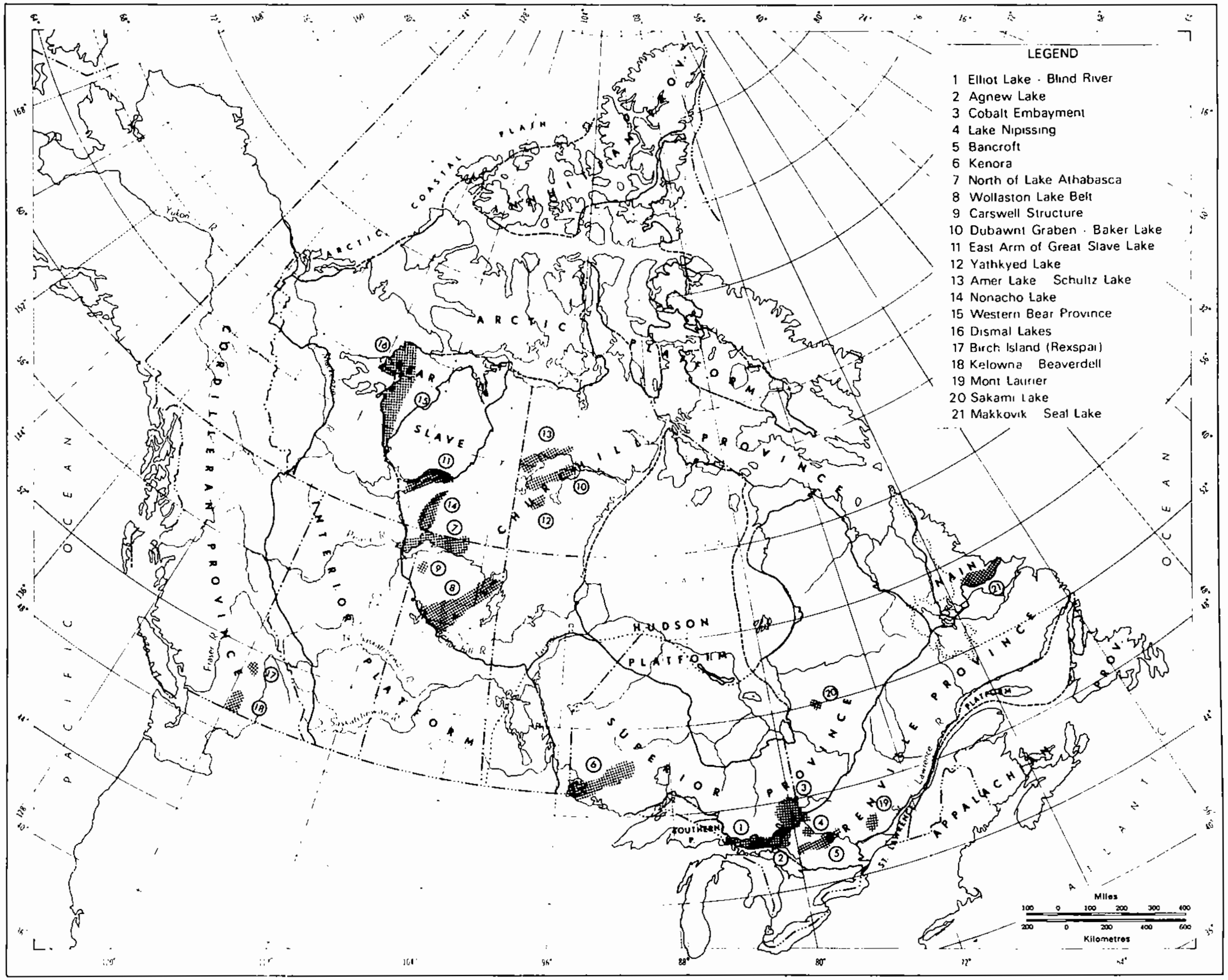


Figure 1. Areas in Canada with uranium resources associated with identified deposits.

uranium project. Various alternative development concepts were being examined and efforts continued to increase reserves. Of possible significance in this latter regard was the discovery in 1978 of some high-grade uraniferous boulders some eight km from the Michelin deposit.

Consolidated Rexspar Minerals & Chemicals Limited also continued to review the feasibility of its project near Birch Island, British Columbia. Further engineering, environmental and metallurgical studies were under way to satisfy the regulatory requirements of the provincial and federal governments.

Finally, in August 1978, Earth Sciences Incorporated (ESI) announced that it had signed a contract with two United States utilities to supply some 40 t U a year from a uranium recovery facility it intended to build adjacent to Western Co-operative Fertilizers Limited's (WCFL) phosphoric acid fertilizer plant near Calgary. Upon receipt of regulatory approvals, it was expected that the $10 million facility could be built in an estimated 15 months. ESI had also proposed a second plant at WCFL's Medicine Hat, Alberta fertilizer plant.

Exploration

Uranium exploration expenditures in Canada continued at a high level in 1978 with activity being reported in all provinces and territories. It was expected that expenditures would exceed those of 1977, which had been reported at $72 million on the basis of a survey of uranium exploration activity conducted by Energy, Mines and Resources Canada, and released in June 1978*. Some 294 000 m of uranium exploratory drilling was reported by the survey for 1977, more than half of which was carried out in Saskatchewan. The survey indicated that, in terms of dollar expenditures, the 10 most active organizations in uranium exploration in Canada during 1977 were Uranerz Exploration and Mining Limited, Saskatchewan Mining Development Corporation (SMDC), Eldorado Nuclear Limited, Gulf Minerals Canada Limited, Noranda Mines Limited, Urangesellschaft Canada Limited, Shell Canada Resources Limited, Imperial Oil Limited, Groupe Minier S.E.S.**, and Conwest Exploration Company Limited.

Three new prospects of potential major significance were reported in Saskatchewan in 1978. In February, Esso Minerals Canada (a subsidiary of Imperial Oil) announced the first results of a major drilling program at Midwest Lake, some 25 km northwest of Rabbit Lake. By late 1978 it was reported that uranium mineralization had been encountered in 81 of 125 holes, that a zone of interest had been defined over a length of 2 130 m and that the zone was open at both ends. The zone, much of which lies beneath the lake, was reported to be 180 m wide at its widest point, with mineralization occurring to a depth of 195 m; total potential uranium content had been variously reported at up to 100 000 t uranium, with similar quantities of nickel, in ore with grades of 1.7 per cent U. Numac Oil & Gas Ltd. and Bow Valley Industries Ltd. held a 25 per cent and a 12-1/2 per cent interest in the project, respectively.

In March 1978, Gulf Minerals Canada announced that exploratory drilling had encountered ore-grade mineralization in a prospect about 1.6 km southeast of its Collins Bay deposit, and 9.5 km northeast of the Rabbit Lake mill. Some 85 holes were reported to contain the mineralization in a zone of interest about 550 m long and 60 m wide; about half of the zone occurs beneath Collins Bay. The company continued to evaluate the prospect throughout the year as part of its effort to expand reserves in the area of the Rabbit Lake mill.

In a joint venture with SMDC, Canadian Kelvin Resources Ltd. and several others, Asamera Oil Corporation Ltd. was engaged in a very encouraging drilling program on a prospect in the Keefe Lake-Henday Lake area just east of Esso Minerals' Midwest Lake property. By year-end, ore-grade mineralization had been encountered in 24 of 38 holes in an area of interest some 240 by 35 metres. Late in the year a second area of interest was identified 0.8 km west of the first, and drilling was continuing to better delineate both.

Other Saskatchewan projects continued to be evaluated during 1978, notably the Maurice Bay deposit, west of Uranium City, being examined by Uranerz together with SMDC; the West Bear project of Gulf Minerals, in joint venture with SMDC and Noranda Exploration Company Limited, 40 km southwest of Rabbit Lake; and the Geike River East property under the guidance of Conwest in a joint venture with Eldorado, Empresa Nacional del Uranio, S.A., Electrowatt Limited and the Central Electricity Generating Board. All of these prospects, as well as the three new ones noted above, are associated with the edge of the Athabasca Basin.

In British Columbia, Norcen Energy Resources Limited continued with its project to evaluate the Blizzard uranium project, 80 km southeast of Kelowna. Mineralization was first identified on the property in 1976, and by late 1978 over 300 holes had been drilled on 30-m centres, which indicated that the deposit could contain 2.7 million t of ore with an average grade of 0.18 per cent U; the zone, not yet fully defined, was about 1 500 m long. Feasibility and open-pit design studies were also under way at year-end. Norcen, as manager-operator of the program, leads a joint venture group, including E & B Explorations Ltd., Campbell Chibougamau Mines Ltd. and Ontario Hydro; the joint venture can acquire a total of 70 per cent interest in the property, originally optioned from Lacana Mining Corporation.

In early 1978 Placer Development Limited signed an agreement with Tyee Lake Resources Ltd. whereby Placer could earn a 55 per cent interest in the latter's Hydraulic Lake property, 22 km southeast of Kelowna by placing it into production. Additional drilling and metallurgical test work were under way at year-end.

Exploratory activity resumed in the Baker Lake area of the Northwest Territories in April 1978 after a one-year hiatus during which a study was carried out to examine the influence of exploration activity on the grazing habits of the region's caribou herds. BP Minerals Limited, Urangesellschaft Canada Limited and Western Mines Limited

*See *1977 Assessment of Canada's Uranium Supply and Demand*, Report EP78-3, EMR Canada, June 1978.

**A special non-incorporated entity representing a joint venture between James Bay Development Corporation, Eldorado Nuclear Limited, and SERU Nuclear (Canada) Limited.

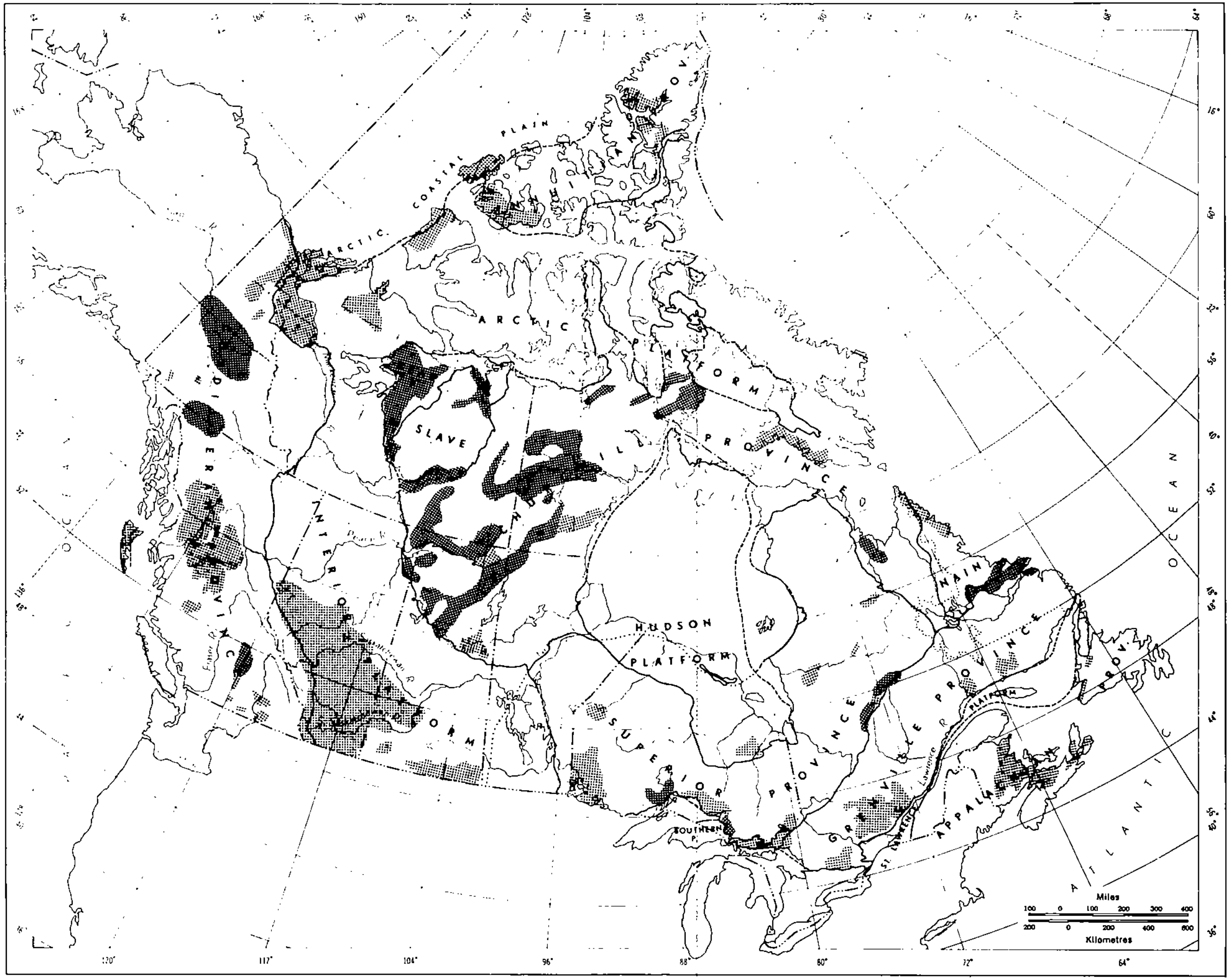


Figure 2. Areas in Canada favourable for the occurrence of uranium deposits.

were subsequently granted permits by the Department of Indian and Northern Affairs to explore in the area subject to certain restrictions (Government Affairs section). A significant indication of the uranium potential in the area was a disclosure by Urangesellschaft late in 1978, that it had intersected uranium mineralization in a drill program on its property 80 km west of Baker Lake. A thickness of about 30 m was encountered averaging better than 0.85 per cent U.

Activity was also reported elsewhere in the Northwest Territories as well as in a number of other areas of Canada. Particularly intriguing, however, was the disclosure late in the year that uranium mineralization had been discovered in the underground workings and surface dumps of Consolidated Durham Mines & Resources Limited's antimony mine 40 km southwest of Fredericton, New Brunswick. The company subsequently signed an agreement with Eldorado Nuclear Limited whereby the latter would assist in evaluating the extent of the mineralization and participate in any possible production venture.

A total of $4.2 million was spent on Canada's uranium reconnaissance program during 1978 by the federal government and the participating provinces. Some 449 300 square kilometres (km^2) were covered by airborne gamma ray spectrometry and 211 700 km^2 by regional geochemistry, in areas of five provinces as well as in the Yukon and Northwest Territories. During the year results were released with respect to 481 700 km^2 of airborne work and 251 000 km^2 of regional geochemistry performed in 1977. In August 1978 it was announced that federal funding of contract work associated with the uranium reconnaissance program would be terminated beginning in the fiscal year 1979-80 as part of a general effort to restrain government spending.

Uranium resources

The Uranium Resource Appraisal Group (URAG) of Energy, Mines and Resources Canada (EMR) completed its fourth annual (1977) assessment in early 1978. URAG divides its uranium resource estimates into several separate categories reflecting different levels of confidence in the quantities reported. These categories are further separated into two levels of economic exploitability related to the current market price of uranium. In the 1977 assessment, the lower price category was bounded by the uranium market price estimated at $110/kg U in September 1977 and the higher price category spanned the $110-$160/kg U interval. Results of URAG's 1977 uranium resource assessment were published in June 1978 and are summarized in Table 4. Areas in Canada in which these resources occur are illustrated in Figure 1.

Allowing for 1977 production and taking into account processing recoveries which averaged 93.8 per cent in 1977 for existing mines, resource estimates in all but the measured category increased over those reported a year earlier. The increases amounted to 8.1 per cent, 3.6 per cent and 10.0 per cent for the indicated, inferred and prognosticated categories, respectively; there was no appreciable change in the measured category. While these changes were partly a result of reassessments in the case of a few properties, most of the increase was a reflection of continued evaluation work associated with recent exploration successes in Saskatchewan and of encouraging results of exploration programs in several areas of the Northwest Territories.

Table 4. 1977 estimates of Canada's mineable uranium resources

Resource Category	Mineable at prices up to $110/kg U[1]	Mineable at prices up to $160/kg U[2]
	(tonnes U contained in mineable ore)[3]	
(1) Measured	78 000	82 000
(2) Indicated	94 000	107 000
(1) + (2) = Reasonably Assured[4]	*172 000*	*189 000*
(3) Inferred	243 000	318 000
(4) Prognosticated	161 000	388 000
(3) + (4) = Estimated Additional[4]	*404 000*	*706 000*

Source: *1977 Assessment of Canada's Uranium Supply and Demand*; Report EP78-3, June 1978, Energy, Mines and Resources Canada.
[1]$110/kg U (Canadian dollars) was the estimated uranium market price in September 1977, at the commencement of the assessment. [2]Includes resources mineable at up to $110/kg U. [3]1 tonne (metric ton) U = 1.2999 short tons U_3O_8. [4]International resource terms employed by the Nuclear Energy Agency of OECD and the International Atomic Energy Agency; for purposes of international comparison, Canada equates its high and low "price" categories to the NEA/IAEA's high and low "cost" categories, respectively.

As in its previous assessments, URAG made a projection of uranium production that could be supported by these resources assuming adequate availability of manpower, equipment, capital financing and the existence of base load contracts. Barring such constraints it was estimated that 1978 production could reach 6 400 t U, rising to 7 600 and 12 500 t U per year by 1980 and 1985, respectively. As noted earlier, 1978 production was higher than expected by some 5 per cent.

In its 1977 assessment URAG reported the results of its first study of Speculative Resources (resources that are thought to exist in virgin uranium areas or in areas where only uranium occurrences are known). Based on then-current geological knowledge, Speculative Resources, additional to the Reasonably Assured and Estimated Additional Resource categories, were judged to be approximately 700 000 to 800 000 t U. The areas delineated by URAG that are favourable for such uranium mineralization are shown in Figure 2.

Early in 1978, the Organization for Economic Co-operation and Development (OECD) released the results of the sixth in a series of world uranium supply assessments conducted jointly by the Nuclear Energy Agency (NEA) of OECD and the International Atomic Energy Agency (IAEA)*. The study showed that Canada accounted for some 10 per cent of the world's** "low-cost" Reasonably Assured Resources, ranking fourth behind Australia, South Africa, and the United States. Perhaps more important, in terms of Canada's future capability as a uranium supplier, was its position with respect to Estimated Additional Resources. Of the world total of 2.1 million t U reported in this category, in deposits mineable at "costs" † up to $U.S. 130/kilogram U, Canada accounts for 31 per cent, ranking second behind the United States ‡.

Government affairs

In January 1978 Canada and the European Economic Community (EEC) officially signed an agreement providing for revised nuclear safeguards arrangements with respect to Canadian exports of uranium and nuclear technology to EEC countries, thus formalizing negotiations which had been completed in December 1977. Japanese and Canadian government officials successfully completed similar negotiations in January 1978, thereby enabling uranium shipments to be resumed to Japanese customers. Shipments to Switzerland, however, continued to be embargoed throughout 1978 pending the completion of negotiations providing for revised nuclear safeguards arrangements between Canada and Switzerland.

In April 1978 the federal Department of Indian Affairs and Northern Development lifted a year-long ban on uranium exploration activity in the Baker Lake area of the Northwest Territories. Land-use permits were subsequently issued to exploration companies subject to restricted utilization of certain areas for specified periods. The restricted areas include land used by caribou for migration, calving and post-calving assembly, and critical wildfowl nesting and molting areas. Also, land known to be used by caribou for water crossings, and land adjacent to these crossings, was withdrawn from further disposition. Since caribou movements can change from year to year, there was provision for redesignation of such areas should the need arise. These restrictions were in line with conditions set out in an interim injunction granted by the Federal Court at the request of the native people in the area. At issue was an aboriginal claim seeking to prevent further uranium exploration activity in a 70 000 km^2 area around Baker Lake. The case was to be heard before the Federal Court early in 1979.

Following the release of the final report of the Cluff Lake Board of Inquiry in June 1978, the government of Saskatchewan announced that Phase I of the Cluff Lake uranium project could proceed, subject to strict occupational health, safety and environmental regulations. The government also agreed in principle with the general expansion of the uranium industry in the province and committed itself to an in-depth review of the Board's recommendations. A surface lease agreement was subsequently reached in October 1978 with Amok Ltd., which included specific recommendations of the board in respect to environmental protection measures, the health and safety of workers, and employment and business opportunities for northerners. It was expected that these arrangements would serve as a model for subsequent developments.

Several other provincial actions were of interest, beginning with an announcement early in 1978 by the Government of Manitoba that it would suspend its own mineral exploration program and that it would no longer insist on being equal partners in exploration projects conducted by private companies. In October, the Government of British Columbia indicated that, beginning in 1979, a provincial inquiry would be held to recommend standards for uranium mining, following which new guidelines would be established for approval of uranium development projects. Finally, in late 1978 an interim report on nuclear power in Ontario was released by the Royal Commission on Electric Power Planning (the Porter Commission). While the report endorsed the continued growth of nuclear power in Ontario, it expressed the preliminary opinion that Ontario Hydro's projected installation rate was somewhat ambitious. Commission hearings were to continue, but no date was set for its final report.

Rules governing foreign ownership of Canada's uranium producing industry were contained in a bill introduced to Parliament in June 1978 by the Minister of EMR. The Uranium and Thorium Mining Review Bill (C-64) drew heavily on policy principles limiting foreign ownership in the uranium industry that were first announced by the Prime Minister and the Minister of EMR in 1970, except that additional provisions were included to permit nonresident ownership as high as 50 per cent. The bill would be complementary to the Foreign Investment Review Act, Parts I and II of which were promulgated in 1974 and 1975, respectively. The bill would be administered by the Minister of EMR, and the Foreign Investment Review Agency (FIRA) would act as an adviser to the minister to ensure harmony between ownership and control principles.

The bill would require that in order to produce uranium in Canada a company must apply for an extraction permit issued by the Minister of EMR. An applicant would automatically be qualified, provided that shares held in the company by or for nonresidents did not exceed 33 per cent; that three-quarters of the company directors were Canadian citizens; and that the holding of working interests, royalty interests, or managerial contracts by nonresidents did not exceed limits prescribed by the Governor in Council. The applicant company could, however, be owned up to 50 per cent by nonresidents, if it was able to demonstrate that it was Canadian controlled. In cases where an applicant firm was not qualified under the above requirements, it could be granted a permit if its level of foreign ownership did not exceed 50 per cent, and if its proposed project was deemed to be of significant benefit to Canada.

On the international scene, the International Nuclear Fuel Cycle Evaluation (INFCE) was well under way by the end of 1978. More than 60 countries were participating in the study, in which all aspects of the future role of nuclear power in the world were being examined in an effort to

*Uranium Resources, Production and Demand, NEA/IAEA, December 1977.

**Excluding the U.S.S.R., Eastern Europe and China.

†See footnote 4, Table 4.

‡URAG's 1976 uranium data were incorporated into this world assessment.

arrive at an internationally acceptable system to permit the expansion of nuclear power while minimizing the risk of nuclear weapons' proliferation. Eight INFCE working groups were established:

1. Fuel and Heavy Water Availability
2. Enrichment Availability
3. Assurances of Long-Term Supply
4. Reprocessing, Plutonium Handling and Recycle
5. Fast Breeders
6. Spent Fuel Management
7. Waste Management and Disposal
8. Advanced Fuel Cycle and Reactor Concepts

Canada was participating in all but Working Group 5, and was co-chairing Working Group 1, together with Egypt and India. It was anticipated that the working groups would complete their assignments in mid-1979 and that the final INFCE report would be available in early 1980.

Table 5. Uranium under export contracts reviewed* since September 5, 1974 (as of December 1978)

	Short tons U_3O_8	tonnes U
Belgium	1 100	850
Finland	2 300	1 770
France	2 000	1 540
Italy	1 800	1 380
Japan	22 048	16 960
South Korea	300	230
Spain	6 250	4 810
Sweden	875	670
Switzerland	1 050	810
United Kingdom	10 000	7 690
United States	24 000	18 460
West Germany	8 085	6 220
Total	79 808	61 390

Source: Atomic Energy Control Board.
*Reviewed and found to be consistent with Canadian uranium export policy.

Markets and prices

In February 1978 the Government of Ontario passed an Order in Council approving the purchase by Ontario Hydro of some 76 160 t U from Denison Mines Limited and Preston Mines Limited over the period 1980 to 2020. The Denison contract calls for delivery of 48 465 t U over the period 1980 to 2011 under a pricing formula that provides for a cost-related base price, plus one-half the difference between the base price and the world price, but no lower than the base. Ontario Hydro will also provide Denison's estimated $151 million (1975 dollars) expansion costs, interest free. The Preston contract calls for the delivery of 27 695 t U over the period 1984 to 2020, under a pricing formula which provides for a cost-related base price, plus one-third of the difference between the base price and the world price, but no lower than the base. Ontario Hydro will fund the total estimated $188 million (1975 dollars) cost of rehabilitating Preston's Stanleigh property, interest free.

The Ontario Hydro contracts were unprecedented in the world's uranium industry with respect to both the size of the sales and the length of the delivery periods. It was anticipated that they might have a significant influence on uranium prices in general and on Canadian export prices in particular. For example it was estimated* that Denison's initial deliveries could carry a base price in 1980 dollars from $101 to $109/kilogram U ($39 to $42/lb U_3O_8), including the value for interest on the "front-end" money. In Preston's case the comparable figure for deliveries in 1984 could be $156/kg U ($60/lb U_3O_8). A second significant indication of possible future uranium market prices was a February 1978 ruling by an arbitrator chosen by Rio Algom Limited and the Tennessee Valley Authority (TVA) that prices for 1979 deliveries under the Rio Algom-TVA contract should be $U.S. 118.09/kg U ($U.S. 45.42/lb U_3O_8). This price, which converts to about $Cdn. 140/kg U ($Cdn. 54/lb U_3O_8) under year-end exchange rates, was subsequently approved by Canada's Atomic Energy Control Board (AECB). Later, in December 1978,

*O.J.C. Runnalls, *Canada's Role as a Uranium Supplier*, April 1978.

Table 6. Exports of uranium concentrates[1] from Canada, 1960, 1965, 1970 and 1975-78

	United States[2]	Britain	Japan	West Germany	Others	Total
			($000)			
1960	236 594	25 905	147	294	601	263 541
1965	17 140	39 573	179	426	1 941	59 259
1970	20 148	9 482	266	103	3 982	33 981
1975	97 725	23 096	1 773	304	10 578	133 476
1976	198 277	24 327	1 068	288	29 128	253 088
1977	224 717	2 946	288	384	8 268	236 603
1978	433 814	77 708	1 808	6 918	137 891	658 139

Source: Statistics Canada.
[1]Exports of radioactive ores and concentrates, and radioactive elements and isotopes which cleared customs. [2]Almost entirely destined for a third country, primarily West Germany and Japan, following enrichment, for years 1970 to 1978.

it was reported that prices for 1980 deliveries under the same contract were set by another arbitrator's ruling at \$U.S. 133.90/kg U (\$U.S. 51.50/lb U_3O_8), which converts to some \$Cdn. 159/kg U (\$Cdn. 61/lb U_3O_8).

Although there was some minor activity in the marketplace during 1978 on the part of Canadian producers, very little of the market data was released. Early in the year Cenex Limited announced that it had agreed to deliver 92 t U to the Public Service Electric and Gas Co. of New Jersey in 1979 at an average price greater than \$U.S. 117/kg U (\$U.S. 45/lb U_3O_8). Subsequently, the company announced a second contract with the Power Authority of the State of New York whereby Cenex agreed to deliver up to 192 t U from February 1979 to March 1981 at a reported price of about \$U.S. 114/kg U (\$U.S. 44/lb U_3O_8). Finally, in the event that the latter contract was not approved by the AECB, Cenex was reported to have agreed to sell the Swedish Nuclear Fuel Supply Co., 115 t U at a price of some \$U.S. 118/kg U (\$U.S. 45.40/lb U_3O_8).

In June 1977 it was announced that Madawaska Mines Limited and Italy's AGIP SpA had agreed on a price of \$Cdn. 109.20/kg U (\$Cdn. 42/lb U_3O_8) for uranium concentrates shipped in 1977 and 1978 and the same price, plus escalation, for 1979 shipments. Escalation was to be calculated using June 1978 Canadian labour and commodity indices.

Also, in June 1978 it was reported that Eldorado Nuclear Limited's wholly owned subsidiary, Eldor Resources Limited, intended to finance its purchase of a one-sixth interest in the Key Lake joint venture in northern Saskatchewan by borrowing up to 770 t U from the Canadian government's uranium stockpile and selling the uranium at current world market prices. Eldor would pay interest on any uranium borrowed and would be required to repay the loan with material from Key Lake production. Eldor's acquisition and development costs were estimated to be about \$126 million.

Early in 1979 the AECB released data which, by comparison with data released in late 1977, indicated that, during 1978, export contracts covering deliveries of some 2 500 t U to France, Japan and the United States were reviewed by the federal government and found to be consistent with Canadian uranium export policy. A total of 36 contracts had been reviewed by the federal government since September 5, 1974, as summarized in Table 5, covering commitments made by Agnew Lake Mines, Amok, Cenex, Denison, Eldorado, Gulf Minerals, Madawaska, Rio Algom and Uranerz Canada. As of December 1978 outstanding export commitments of all Canadian producers were approximately 63 000 t U.

Refining

Output of uranium hexafluoride (UF_6)* at Eldorado's Port Hope, Ontario refinery fell below target in 1978, dropping 17 per cent to 3 219 t U as UF_6. The decline was largely a result of production difficulties encountered following a seven-week strike during the second half of the year. Although the program to expand the UF_6 circuit to 5 440 t U a year was completed in early 1978, commissioning difficulties were still being encountered at year-end. As one of five commercial uranium refiners in the world, Eldorado converts uranium concentrates to UF_6 for a variety of customers in Europe, Japan and the United States.

Output of Eldorado's other principal product, natural ceramic-grade uranium dioxide (UO_2), increased by 14 per cent in 1978, reaching 966 t U as UO_2. This total represented 23 per cent of the total volume of uranium refined during the year, the highest in the company's history, despite the interruption caused by the strike. Following resumption of production, the UO_2 circuit was operated at maximum capacity for the remainder of the year and a second continuous-reduction unit was installed late in the year. In anticipation of the increased UO_2 requirements of Canadian utilities forecasted for the mid-1980s, Eldorado continued with plans for the construction of an additional processing circuit to be installed in 1979.

Both the UO_2 and the UF_6 circuits are fed by a solvent extraction circuit which converts mine concentrates to nuclear-pure uranium trioxide (UO_3). Expansion of Eldorado's UO_3 plant which had begun in 1974 continued throughout 1978 with the objective of increasing its nominal capacity from 4 540 t U a year to some 6 800 t U a year by 1979.

Following Eldorado's conversion of uranium concentrates to natural UO_2 powder, the powder is then pelletized for fabrication into fuel elements for Canada's nuclear power program as well as for some CANDU reactor exports. Three companies have capabilities in this area: Westinghouse Canada Limited with a plant at Port Hope, Ontario; Canadian General Electric Company Limited with a pelletizing facility in Toronto and a fuel-fabrication plant in Peterborough, Ontario; and Combustion Engineering-Superheater Ltd., with a plant at Moncton, New Brunswick.

In February 1978 a federal environmental assessment review panel recommended to the Minister of the Environment that Eldorado not be granted permission to construct an integrated waste-disposal and refinery complex at its site near Port Granby, Ontario. The site had been the company's preferred choice after a detailed study of 17 possible sites in Ontario. The choice was rejected by the Minister on the grounds that it represented an inappropriate use of agricultural land and that it lacked support from people living in the immediate vicinity.

Eldorado proceeded to examine three alternative Ontario sites, involving nonagricultural land, near Port Hope, Blind River and Sudbury, where local governments were supportive of the proposed plant. Environmental impact statements were prepared and submitted in September 1978 to a federal environmental assessment panel constituted by the Federal Environmental Assessment Review Office of the Department of the Environment. Public hearings were conducted late in the year and the decision of the panel was expected early in 1979.

The company also continued to assess the feasibility of constructing a second new UF_6 conversion plant at a site at Warman, near Saskatoon, Saskatchewan. It is envisaged that additional Canadian UF_6 capacity will be required for

*Uranium hexafluoride is the required feed material for the uranium enrichment process.

the 1980s to refine Saskatchewan's growing uranium production for the export market. Eldorado expected to complete an environmental impact statement on the Warman proposal during 1979.

Nuclear power developments

As of the end of 1978, some 100 000 electrical megawatts (MWe) of nuclear power capacity was operating throughout the world (excluding China, USSR and Eastern Europe). It was projected that some 255 000 to 280 000 MWe would be in operation by 1985 and possibly more than 1 000 000 MWe by the year 2000. Within Canada, 10 CANDU reactors with an aggregate capacity of 4 774 MWe were operating by the end of 1978 and a further 15 reactors with an aggregate capacity of some 10 500 MWe were either under construction, committed or planned (Table 7).

By the end of 1978, units of Ontario Hydro's Pickering (A) Generating Station had been operating for eight years and had a lifetime capacity factor of 80 per cent. One Pickering unit had a capacity factor* of 95 per cent for the year 1978 and all four of the Pickering units and one of the Bruce units were in the top ten in performance by world power reactors over 500 MWe. Despite major outages during 1978 the four-unit Pickering A station had an average capacity factor of 88 per cent. Pickering and Bruce

*Amount of electricity produced as a percentage of the theoretical maximum.

Table 7. Nuclear power plants in Canada, December 1978

Reactors	Owner	Net Output	In-Service Dates
		(MWe)	
Operating			
Nuclear Power Demonstration	Atomic Energy of Canada Ltd.	22	1962
Douglas Point	Atomic Energy of Canada Ltd.	208	1968
Gentilly 1	Atomic Energy of Canada Ltd.	250	1971
Pickering 1 to 4	Ontario Hydro	2 056	1971-73
Bruce 1, 2 and 3	Ontario Hydro	2 238	1977-78
Subtotal		4 774	—
Under Construction or Committed			
Bruce 4	Ontario Hydro	746	1979
Pickering 5 to 8	Ontario Hydro	2 064	1981-83
Gentilly 2	The Quebec Hydro-Electric Commission	637	1980
Point Lepreau	New Brunswick Electric Power Commission	630	1981
Bruce 5 to 8	Ontario Hydro	3 076	1983-86*
Subtotal		7 153	—
Planned			
Darlington 1 to 4	Ontario Hydro	3 400	1985-88*
Subtotal		3 400	—
Grand Total		15 327	—

Sources: *1977 Assessment of Canada's Uranium Supply and Demand*, Energy, Mines and Resources, Canada, Report EP78-3, June 1978; Atomic Energy of Canada Limited, Annual Report 1978-79.
*Projected in-service dates revised as of February 1979 to 1983-87 for Bruce B, and 1987-90 for Darlington.

together supplied some 31 per cent of Ontario Hydro's electricity during the year at about half the cost of the utility's coal-burning stations. For the first time nuclear-electric generators surpassed coal-fired units as a source of electricity for the Province of Ontario.

Aside from the continued excellent performance of Ontario Hydro's operating reactors, the principal event of 1978 was the integration of the last two units of Bruce A into the Ontario Hydro system. The third unit started up in November 1977, produced its first electricity by December, 1977, and was declared in-service on February 1, 1978. The fourth unit started up late in 1978 and was declared in-service in January 1979.

Design work was well advanced on Pickering B and Bruce B, which will essentially be duplicates of Pickering A and Bruce A. At Pickering B, mechanical installation had started on the first unit, while Bruce B was in the civil construction phase. Site preparation had also been completed at Darlington. Early in 1979, however, Ontario Hydro rescheduled the in-service dates for Bruce B and Darlington to bring capacity into phase with projected electricity demands.

Ontario Hydro's Douglas Point Generating Station continued to provide some 65 per cent of its output as process heat to the Bruce Heavy Water Production Plant, and the NPD Generating Station operated primarily as a training facility in nuclear power plant operations. Atomic Energy of Canada Limited's (AECL) Gentilly 1 Station (a CANDU-Boiling Light Water prototype) remained inoperative throughout 1978. At Gentilly 2* most of the civil engineering construction work had been completed by the end of 1978, and electrical and instrumentation work was to be stepped-up in 1979. A manufacturing fault in the steam generators, however, was expected to delay the construction schedule, although the extent of the delay remained uncertain. Finally, despite a 10-week strike at Point Lepreau during the summer of 1978, civil engineering work was essentially completed at year-end.

In November 1977, the Minister of EMR released a report *The Management of Canada's Nuclear Wastes*, prepared by an independent panel which he had asked to examine the issues in an effort to promote public discussion. The release of the report led to its discussion in the House of Commons' Committee on National Resources and Public Works. In its interim report (June 1978), the Committee recommended that an intensive research and development program into all facets of nuclear waste management be pursued on an urgent basis.

In June 1978 a two-year agreement was reached between the Ontario Ministry of Energy, and the federal Department of Energy, Mines and Resources (EMR) defining the roles for the different parties in pursuing a nuclear waste management research and development program in Ontario. The agreement resulted in the formation of a four-party (EMR, AECL, the Ontario Ministry of Energy and Ontario Hydro) coordinating committee to approve the program of field work. An important element of this work is a program to verify the concept of using stable geological formations for the disposal of nuclear waste. This program is being carried out by AECL with the assistance of EMR's Science and Technology Sector.

*Gentilly 2 will use a conventional CANDU-Pressurized Heavy Water reactor.

Outlook

Differing views about the future of the uranium industry developed during 1978 in the face of continuing uncertainty about the role that nuclear energy is expected to play. The outlook for uranium supply showed clear signs of strengthening, particularly in Australia and Canada, and prospects seemed good for a continuation of this trend. On the other hand, projections of the growth of nuclear power were revised downward in several countries, few new nuclear plant orders were recorded, and the United States introduced new uranium enrichment contract criteria which were expected to have a significant downward influence on near-term uranium demand. These diverging factors of supply and demand resulted, predictably, in forecasts of short-term uranium surpluses and declining prices.

Other observers, however, emphasized the facts that the uranium industry would not likely proceed with major development projects without first acquiring markets; that developments in Australia, Canada and elsewhere would take time, would not be without difficulty and would likely be sequential in nature; that development projects in general, and in North America in particular, would continue to be hampered by environmental and regulatory restrictions; that there was varying political stability in certain of the exporting countries; and that there had in fact been no demonstrable weakening of price. Such observers predicted that major uranium surpluses would likely not develop and that prices would either continue to remain stable or increase in line with increasing costs of labour and supplies.

On the global scale, the need for nuclear energy to play a prominent role in future energy supply was clearly demonstrated in the concluding report of the World Energy Conference (WEC) Conservation Commission's two-year study of world energy supply to 2020, released in September 1978*. The Commission believed that by 2020 the world's total annual primary energy supply could be expanded to about three times that produced in 1977, but that to achieve this objective nuclear energy would need to take over an increasing share of the burden. It was the Commission's view that by 2020 nuclear energy could provide some 30 per cent of primary energy supply, that oil and gas production would peak about 1990 and 2000, respectively, and that, even with a fourfold expansion, renewable energy (solar, geothermal, biomass) could supply no more than 10 per cent of the world's total primary energy by 2020. In conclusion, the Commission expressed the opinion that, if the world is to avoid energy shortages, "it must search for oil and develop synthetic fuels from

**World Energy – Looking Ahead to 2020*, Report by the Conservation Commission of the World Energy Conference, IPC Science and Technology Press, 1978.

coal; search for uranium and develop more efficient nuclear power systems; develop new energy sources and promote the wise and efficient use of all (of these) resources''.

While there may indeed be some risk of uranium surpluses in the short-term, there is the greater risk that the industry might lose its momentum and then not be in a position to provide uranium on an appropriate time-scale to meet long-term requirements. In view of the lengthening lead-times associated with uranium exploration and development, and the relative shortness of the projection periods in question, it seemed essential that the momentum of resource development be maintained. It also seemed clear that a decline in uranium prices, and the loss in the confidence of the market that would likely result, could severely jeopardize these longer-term objectives. It was hoped that these longer term interests would prevail and the uranium industry would be able to look forward to the future with increasing confidence.

Zinc

D.H. BROWN

Canadian developments

Canada is the world's largest producer and trader of zinc, and some 25 per cent of all zinc consumed in the western world originates from Canadian mines. In turn, this makes Canada's zinc industry over 90 per cent reliant on foreign markets.

Metal refining capacity in Canada is currently sufficient to process 50 per cent of domestic zinc mine production to refined metal, but this potential has not been achieved in recent years due to recessionary world market conditions.

In 1978, there were 27 mine-mill operations in Canada producing zinc-in-concentrate. The zinc content of this production was 1 245 299 tonnes*, compared with 1 300 228 tonnes the previous year. No new capacity came on stream during the year and two projects which were scheduled to do so were deferred due to the poor investment climate. The only zinc mine closed during the year was the H.B. mine at Salmo, British Columbia, owned by Cominco Ltd. Its closure reduced Canadian productive capacity by about 13 000 tonnes of zinc-in-concentrate annually. The mill capacity of zinc-producing mines in Canada was 93 200 tonnes per day until September 1978, when the 1 100 tonne-per-day mill at the H.B. mine was closed down. There were no significant production disruptions in 1978 due to either transportation or labour strikes but some companies made use of vacation shutdowns as a means of inventory control.

During the year mill capacity utilization at these operations averaged about 81 per cent and the average recovery of zinc from ores was 83.5 per cent for zinc in zinc and bulk concentrates, and 89 per cent for zinc in all concentrates. The zinc content of ore milled totalled 1 469 361 tonnes, of which 1 227 233 tonnes reported to zinc and bulk concentrates. Canada's reported zinc mine production is slightly higher than this figure because a few mines report some quantities of zinc in other concentrates as being destined for recovery.

Zinc metal production in Canada for 1978 was 495 420 tonnes, virtually unchanged from the prior year. There is no secondary metal production in Canada and accordingly all production is derived from four electrolytic refineries. The two largest plants in the world are located in Canada, and operated by Cominco Ltd. and Canadian Electrolytic Zinc Limited, respectively. Collectively, Canada's refining capacity, at 633 000 tonnes of zinc metal per year, is second only to Japan in the western world.

After 20 years of basic research, Sherritt Gordon Mines Limited has concluded a successful pilot scale process for the pressure-leaching of zinc concentrates. The Sherritt process produces elemental sulphur and eliminates atmospheric emissions of sulphur-dioxide gas. In addition, the process can achieve extractions as high as 98 per cent so that residue treatment is not necessary. In 1977, Cominco Ltd. and Sherritt conducted a joint venture pilot-plant program to further develop the process. The favourable results of the program indicate high potential for commercial application. Cominco Ltd. is currently evaluating the feasibility of incorporating the process into its modernization program at Trail, British Columbia which will eventually expand the plant's capacity by 25 000 tonnes per year. Additionally, the Province of New Brunswick is hopeful that either this process or a sulphation-roast process developed by the Research and Productivity Council of New Brunswick will provide economic incentive for the mining and refining of fine-grained, lead-zinc ores in that province.

The availability in Canada of zinc in scrap metal has traditionally been modest and until last year only small quantities of about 5 000 tonnes were consumed directly in the manufacture of copper alloys, zinc oxides and dusts. In late-1977, Fers et Métaux Recyclés Ltée started up its Auto-Metal Reclamation System which currently recovers about 5 000 tonnes per year of zinc diecast alloy, mainly from shredded automobiles. The plant's capacity to process the nonferrous portion of scrapped automobiles currently exceeds the automotive scrapping rate in Canada, and accordingly further units are not likely to be built in Canada in the near future, given the small size of our domestic market. The system was developed and constructed in Canada and it is Canada's first heavy media separation, metal-recycling plant. The recovered alloy contains about 92 per cent zinc and is sold to Canadian consumers to produce zinc dust for the paint industry.

* The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Canada, zinc production, trade and consumption, 1977 and 1978

	1977		1978ᵖ	
	(tonnes)	($)	(tonnes)	($)
Production				
All forms[1]				
Ontario	295 419	231 409 401	254 873	195 299 000
Northwest Territories	159 709	125 104 245	194 172	148 786 000
New Brunswick	188 198	147 419 873	171 604	131 494 000
British Columbia	103 781	81 294 016	102 035	78 185 000
Yukon	102 847	80 562 287	98 506	75 481 000
Quebec	99 606	78 023 672	93 853	71 916 000
Manitoba	61 523	48 192 408	57 310	43 915 000
Newfoundland	51 908	40 660 642	53 655	41 113 000
Saskatchewan	7 524	5 894 134	6 350	4 866 000
Total	1 070 515	838 560 678	1 032 358	791 055 000
Mine output[2]	1 300 228	. .	1 245 229	. .
Refined[3]	494 888	. .	495 420	. .
Exports				
Zinc blocks, pigs and slabs				
United States	207 374	159 232 000	259 400	190 485 000
United Kingdom	44 511	32 904 000	52 956	36 524 000
Brazil	—	—	11 380	8 544 000
India	—	—	12 175	8 431 000
Philippines	1 291	919 000	10 794	7 693 000
Taiwan	1 799	1 138 000	8 232	4 676 000
Venezuela	4 949	3 488 000	6 617	4 176 000
Italy	1 211	958 000	5 711	4 174 000
Singapore	2 730	1 854 000	6 666	4 154 000
West Germany	2 693	1 992 000	5 771	3 701 000
Thailand	1 594	1 067 000	5 253	3 286 000
Other countries	27 206	19 014 000	54 313	35 602 000
Total	295 358	222 566 000	439 268	311 446 000
Zinc contained in ores and concentrates				
Belgium and Luxembourg	274 102	101 212 000	194 639	57 208 000
United States	60 126	21 921 000	133 847	42 831 000
Japan	139 919	49 736 000	149 426	31 427 000
West Germany	44 061	13 426 000	75 312	16 751 000
Netherlands	—	—	29 290	11 984 000
France	10 635	3 845 000	23 843	6 104 000
Italy	7 199	2 236 000	15 645	5 548 000
United Kingdom	11 101	3 810 000	24 389	5 341 000
India	9 791	2 626 000	20 664	2 625 000
U.S.S.R.	15 741	5 707 000	10 113	2 411 000
Other countries	25 776	8 280 000	9 064	1 179 000
Total	598 451	212 799 000	686 232	183 409 000

Table 1. (cont'd)

	1977		1978^p	
	(tonnes)	($)	(tonnes)	($)
Exports (cont'd)				
Zinc alloy scrap, dross and ash[4]				
United States	14 934	2 682 000	13 507	3 698 000
United Kingdom	2 728	780 000	2 764	891 000
Spain	282	164 000	295	122 000
West Germany	413	41 000	564	107 000
Taiwan	108	49 000	304	105 000
India	—	—	504	98 000
Other countries	672	84 000	1 235	157 000
Total	19 137	3 800 000	19 173	5 178 000
Zinc dust and granules				
United States	3 419	3 614 000	3 980	3 843 000
Venezuela	94	105 000	187	219 000
United Kingdom	—	—	35	9 000
Colombia	—	—	3	4 000
Other countries	9	11 000	1	1 000
Total	3 522	3 730 000	4 206	4 076 000
Zinc fabricated material, nes				
United States	1 788	1 782 000	1 189	1 778 000
United Kingdom	12	30 000	44	44 000
Hong Kong	149	104 000	69	37 000
France	—	—	2	13 000
West Germany	1	2 000	3	10 000
Other countries	75	64 000	1	7 000
Total	2 025	1 982 000	1 308	1 889 000
Imports				
In ores, concentrates and scrap	6 048	2 822 000	6 145	2 048 000
Dust and granules	156	181 000	272	327 000
Slabs, blocks, pigs and anodes	3 330	2 386 000	2 405	1 840 000
Bars, rods, plates, strip and sheet	433	759 000	386	567 000
Zinc oxide	4 037	1 848 000	2 067	1 647 000
Zinc sulphate	1 510	562 000	1 950	755 000
Zinc fabricated materials, nes	1 139	2 747 000	917	2 145 000
Total	16 653	11 305 000	14 142	9 329 000

Table 1. (cont'd)

	1977			1978^p		
	Primary	Secondary	Total	Primary	Secondary	Total
	(tonnes)					
Consumption[5]						
Zinc used for, or in the manufacture of:						
Copper alloys (brass, bronze, etc.)	6 134^r	5 795^r	74 851	6 823	7 173	83 883
Galvanizing: electro	1 175			1 295		
hot dip	61 747			68 592		
Zinc diecast alloy	11 686	—	11 686	14 184	x	x
Other products (including rolled and ribbon zinc, zinc oxide)	16 902	1 973	18 875	21 924	x	x
Total	97 644^r	7 768^r	105 412	112 818	10 659	123 477
Consumer stocks on hand at end of year	8 328^r	1 030^r	9 358	12 028	1 371	13 398

Source : Statistics Canada.
[1]New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2]Zinc content of ores and concentrates produced. [3]Refined zinc produced from domestic and imported ores. [4]Gross weight. [5]Consumer survey does not represent 100 per cent of Canadian consumption and is therefore consistently less than apparent consumption.
^{p}Preliminary; . . .Not available; — Nil; nes Not elsewhere specified; ^{r}Revised; x Confidential.

Domestic zinc metal consumption increased to 145 000 tonnes in 1978, compared with 125 000 tonnes in 1977. This consumption strength appeared to be broadly-based and was prompted in part by the ability of zinc consumers to be more competitive in foreign markets due to the devalued Canadian dollar. Typically, Canadian usage is broken down into: protective coatings on steel, 49 per cent; alloy for diecast parts, 20 per cent; brass, 11 per cent; and a general category, including zinc oxide as the major component, 20 per cent.

At the present time, Canada has 98 000 tonnes of new zinc mine capacity under construction and scheduled to come into production during the period 1979-82. Additionally, another 476 000 tonnes of potential new zinc mine capacity is known to be under active consideration for the 1982-85 period. The firm projects are: the No. 12 mine expansion by Brunswick Mining and Smelting Corporation Limited (40 000 tonnes per year (tpy), 1980); Mattagami Lake Mines Limited's Lyon Lake Division (28 000 tpy, 1980) and F Zone (12 000 tpy, 1981) developments; and the Gays River property held by Esso Minerals Canada (18 000 tpy, 1979). The potential 1982-85 projects consist of: the West MacDonald zinc mine (19 000 tpy) held by Les Mines Gallen Limitée; the Polaris zinc-lead deposit (80 000 tpy) held by Arvik Mines Ltd.; the Grum zinc-lead deposit (100 000 tpy) held by Cyprus Anvil Mining Corporation; the Goldstream copper-zinc deposit (6 000 tpy) held by Noranda Mines Limited; the Detour River copper-zinc-silver deposit (60 000 tpy) held by Selco Mining Corporation Limited; and the Howard's Pass zinc-lead deposit (200 000 tpy) held by Placer Development Limited and United States Steel Corporation.

Table 2. Canada, mine output, zinc, 1977 and 1978

	1977	1978
	(tonnes)	
Newfoundland	60 977	63 620
New Brunswick	232 102	246 764
Quebec	123 920	113 040
Ontario	351 958	276 436
Manitoba and Saskatchewan	82 328	82 500
British Columbia	109 242	93 430
Yukon Territory	122 678	134 038
Northwest Territories	217 023	235 401
Total	1 300 228	1 245 229

Source: Statistics Canada.

The Grum deposit had been jointly held by Kerr Addison Mines Limited and Canadian Natural Resources Limited; however, in November 1978 the two companies announced that they had agreed in principle to sell the property to the Cyprus Anvil Mining Corporation. Cyprus Anvil's plans for the property are not yet known.

As far as zinc metal capacity is concerned, there are no firm projects in Canada but there is both a potential expansion by Cominco Ltd. at Trail (25 000 tpy) and the possibility of a new electrolytic refinery by Brunswick Mining and Smelting Corporation Limited (100 000 tpy), which are under consideration for the early- and mid-1980s, respectively.

Western world developments

For the first time in four years, zinc producers began to witness some improvement in the world's supply-demand balance for zinc last year. The accumulation of zinc stocks in both metal and concentrate throughout the 1975-77 period finally came to an end in 1978, as world demand exceeded supply by about 237 000 tonnes. Under these conditions, eroding metal prices and concentrate terms bottomed out in the first half of 1978 and then began to improve over the balance of the year.

The principal factors behind this recovery were increased metal demand, increased exports to socialist countries, and individual restraint by those producers who brought their mounting inventories of zinc under control. At the same time, disparate currency exchange rates precluded the recovery being shared equally among world producers.

According to the International Lead and Zinc Study Group, zinc mine production declined 21 000 tonnes to 4 804 000 tonnes in 1978. Compared to prior years, relatively few mines commenced production in 1978 and any additions to existing capacity were completely off-set by a record number of mine closures. New zinc mine capacity from four projects during the year totalled 102 000 tonnes, while 17 mine closures removed 153 000 tonnes of annual zinc production.

Australia's Woodlawn zinc-lead-copper mine, at 70 000 tonnes of annual zinc production, was the largest zinc-producing mine to commence operation in 1978. The mine closures took place predominantly in the United States where nine mines producing a total of 93 000 tonnes of zinc annually were either closed or placed on a care-and-maintenance basis. Additionally, the Balmat Edwards division of St. Joe Minerals Corporation, the largest zinc mine in the United States, remained idle for the second half of the year due to a labour disagreement. Overall, these factors not only reduced U.S. mine production by 25 per cent last year but also contributed to the normalization of concentrate inventories in North America, which should continue this year as well. Labour strikes by zinc miners in Ireland and Peru were a further factor in reducing world mine supply last year.

In the forthcoming period 1979-82, there are 19 projects scheduled for production in various parts of the world that will add some 472 000 tonnes of new zinc mine capacity to existing totals; however, a substantial number of these mines will undoubtedly require further price improvement before they will be firmly committed to production as planned.

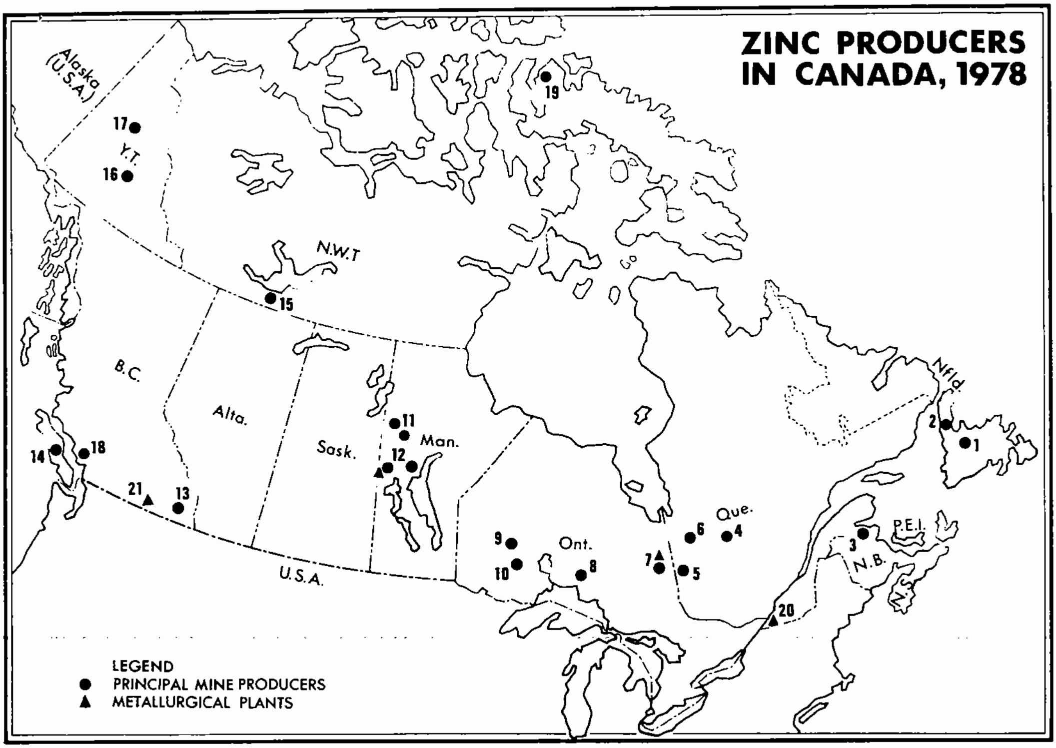
Zinc metal consumption increased nearly 4 per cent in 1978 to 4 383 000 tonnes. Additional demand resulted from Japan acquiring 82 000 tonnes of zinc during the year for its national stockpile and from the exporting of another 27 000 tonnes to socialist countries, resulting in a total metal demand in the western world of 4 492 000 tonnes. By comparison, zinc metal production remained almost unchanged from the prior year at 4 287 000 tonnes and, as such, demand exceeded supply by 203 000 tonnes, which came out of commercial metal stocks. In fact, the decline in producer inventories during 1978 more than doubled this apparent deficit in supply. Some observers doubted that rising consumer inventories could account for the entire difference, thereby creating some speculation that consumption in some parts of the world had been understated.

World smelter capacity, represented by some 72 plants in 1978, is estimated to be 5 647 000 tonnes, of which 1 360 000 tonnes remained idle, as this quantity was surplus to reported metal production. No smelter closures were reported last year, hence this idle capacity represents a reduced utilization of capacity at existing plants to about 76 per cent on average. During the year two new refineries and two expansions to existing refineries came on stream: in the United States, 80 000 tpy; the Republic of Korea, 50 000 tpy; Brazil, 15 000 tpy; and Japan, 4 000 tpy; increasing world smelter capacity by 149 000 tonnes. In the period 1979-82 another 341 000 of electrolytic capacity from seven plants, mainly in Central and South America, is scheduled to come into production.

Table 3. Canada, zinc production, exports and domestic shipments, 1965, 1970 and 1975-78

	Production		Exports			Producers' Domestic Shipments
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total	
			(tonnes)			
1965	745 738	325 224	442 203	239 678	681 881	94 892
1970	1 135 714	417 906	809 248	318 834	1 128 082	106 405
1975	1 055 151	426 902	705 088	247 474[r]	952 562	149 214
1976	982 057	472 316	653 371[r]	352 071[r]	1 005 442	133 561
1977	1 070 515	494 888	598 451	295 358	893 809	130 641
1978[p]	1 032 358	495 420	686 232	439 268	1 125 000	144 740

Source: Statistics Canada.
[1] New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2] Refined zinc produced from domestic and imported ores.
[p] Preliminary; [r] Revised.



Principal producers
(numbers refer to numbers on map above)

1. ASARCO Incorporated (Buchans Unit)
2. Newfoundland Zinc Mines Limited
3. Brunswick Mining and Smelting Corporation Limited
   Heath Steele Mines Limited
4. Lemoine Mines Limited
5. Falconbridge Copper Limited, Lake Dufault Division
   Louvem Mining Company Inc.
6. Mattagami Lake Mines Limited
   Orchan Mines Limited
7. Texasgulf Canada Ltd.
8. Noranda Mines Limited (Geco Division)
9. Selco Mining Corporation Limited
10. Mattabi Mines Limited
    Falconbridge Copper Limited (Sturgeon Lake Joint Venture)
11. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake, Osborne Lake, Stall Lake, Ghost Lake, Anderson Lake, Westarm, Flin Flon, White Lake, Centennial)
12. Sherritt Gordon Mines Limited (Fox Lake mine and Ruttan mine)
13. Cominco Ltd. (Sullivan mine and H.B. mine)
    Teck Corporation (Beaverdell mine)
    Silvana Mines Inc. (Silmonac mine)
14. Western Mines Limited
15. Pine Point Mines Limited
16. Cyprus Anvil Mining Corporation
17. United Keno Hill Mines Limited
18. Northair Mines Ltd.
19. Nanisivik Mines Ltd.

Metallurgical plants

7. Texasgulf Canada Ltd., Hoyle
11. Hudson Bay Mining and Smelting Co. Limited, Flin Flon
20. Canadian Electrolytic Zinc Limited, Valleyfield
21. Cominco Ltd., Trail

Table 4. Principal zinc mines in Canada, 1978 and (1977)

Company and Location	Daily Mill Capacity	Zinc	Lead	Copper	Silver	Ore Produced	Zinc Concentrates Produced	Zinc Concentrates Zinc Grade	Zinc Content of all Concentrates	Destination of Zinc Concentrate
	(tonnes ore)	(%)	(%)	(%)	(grams/ tonne)	(tonnes)	(tonnes)	(%)	(tonnes)	
Newfoundland										
ASARCO Incorporated	1 000	10.78	6.07	1.04	104.9	183 251	27 663	56.23	18 452	6,11
Buchans	(1 150)	(10.76	(6.12)	(0.99)	(107.0)	(174 180)	(26 232)	(55.81)	(17 338)	(6,11)
Newfoundland Zinc	1 500	9.10	—	—	—	516 946	74 395	62.30	46 348	3,6
Mines Limited	(1 350)	(9.40)	(—)	(—)	(—)	(492 552)	(71 291)	(62.6)	(45 270)	(3,6)
Daniel's Harbour										
New Brunswick										3,6,7,9,
Brunswick Mining and	9 050	8.88	3.56	0.29	93.9	3 058 300	410 361	53.37	227.964	10,11,12
Smelting Corporation	(8 950)	(7.83)	(3.12)	(0.37)	(84.8)	(3 134 419)	(354 135)	(51.91)	(210 097)	(3,7,9,10)
Limited										
Bathurst										
Heath Steele Mines	3 200	4.43	1.53	1.03	77.5	1 137 767	76 144	47.77	38 676	6,8,9,12
Limited	(3 200)	(3.90)	(1.53)	(1.22)	(68.2)	(1 150 338)	(69 181)	(47.78)	(35 474)	(8,10,12)
Newcastle										
Quebec										
Falconbridge Copper	1 400	3.85	—	3.36	43.5	372 722	22 208	51.97	13 456	3,6,8
Limited	(1 400)	(3.74)	(—)	(3.27)	(38.7)	(389 967)	(22 152)	(52.59)	(11 650)	(12)
Lake Dufault Division										
Noranda										
Lemoine Mines Limited	300	11.18	—	4.97	94.6	105 611	17 498	53.41	10 855	12
Lemoine mine	(300)	(10.60)	(—)	(4.67)	(100.8)	(110 306)	(16 516)	(52.84)	(8 685)	(12)
Chibougamau										
Louvem Mining	900	5.33	0.29	0.15	87.8	248 073	20 811	55.14	11 901	2,6
Company Inc.	(900)	(5.95)	(. .)	(. .)	41.8	(277 837)	(30 334)	(53.14)	(16 120)	(12)
Val d'Or										
Mattagami Lake Mines	3 500	7.56	—	0.52	32.6	878 484	116 102	53.03	62 175	3,6
Limited	(3 500)	(6.64)	(—)	(0.52)	(30.9)	(946 343)	(108 518)	(53.33)	(58 518)	(3,6)
Matagami										

Table 4. (cont'd)

Company and Location	Daily Mill Capacity	Zinc	Lead	Copper	Silver	Ore Produced	Zinc Concentrates		Zinc Content of all Concentrates	Destination of Zinc Concentrate
							Produced	Zinc Grade		
	(tonnes ore)	(%)	(%)	(%)	(grams/ tonne)	(tonnes)	(tonnes)	(%)	(tonnes)	
Quebec (cont'd)										
Orchan Mines Limited Matagami	2 200 (1 700)	5.89 (6.35)	— (—)	0.61 (0.54)	34.3 (29.1)	368 602 (508 273)	36 719 (54 787)	50.70 (51.53)	18 618 (28 259)	3 (3)
Ontario										
Falconbridge Copper Limited Sturgeon Lake Joint Venture Sturgeon Lake	1 100 (1 100)	9.14 (10.44)	1.17 (1.26)	2.73 (3.46)	171.8 (206.4)	370 087 (383 883)	54 800 (57 805)	53.00 (53.22)	32 220 (30 755)	3,6 (12)
Mattabi Mines Limited Sturgeon Lake	2 700 (2 700)	6.49 (8.40)	0.67 (0.84)	0.83 (1.01)	93.3 (121.7)	871 675 (938 427)	91 713 (127 707)	54.57 (54.88)	51 880 (72 443)	3,12 (3)
Noranda Mines Limited Geco Division Manitouwadge	4 550 (4 550)	2.19 (2.62)	0.12 (0.11)	1.54 (1.94)	38.7 (41.8)	1 572 458 (1 591 682)	50 565 (60 309)	50.78 (51.93)	30 802 (37 981)	3 (3)
Selco Mining Corporation Limited, South Bay Division Uchi Lake	450 (450)	12.20 (9.87)	— (—)	1.43 (1.68)	75.8 (76.8)	121 635 (164 792)	24 807 (27 442)	53.05 (53.62)	13 354 (15 073)	6 (3,6,12)
Texasgulf Canada Ltd., Kidd Creek	9 050 (9 050)	6.12 (7.26)	0.22 (0.22)	1.62 (1.84)	78.9 (104.0)	3 002 148 (3 299 033)	313 348 (395 782)	50.69 (52.59)	169 955 (220 497)	5,6,12 (5,6,7,12)
Manitoba and Saskatchewan										
Hudson Bay Mining and Smelting Co., Limited Flin Flon	7 250 (7 250)	3.16 (2.80)	0.13 (0.20)	2.26 (2.20)	20.6 (20.6)	1 679 001 (1 652 919)	72 899 (63 764)	49.80 (47.80)	42 684 (35 844)	2 (2)
Sherritt Gordon Mines Limited, Fox mine Lynn Lake	2 700 (2 700)	1.73 (1.93)	— (—)	1.24 (1.46)	4.8 (. .)	874 935 (807 688)	22 368 (22 051)	51.12 (51.10)	13 291 (13 162)	2 (2)

Ruttan mine	9 050	1.53	—	1.15	5.7	2 307 069	53 810	51.63	29 792	2,6
Ruttan Lake	(9 050)	(1.95)	(—)	(1.13)	(. .)	(2 261 227)	(70 244)	(50.63)	(37 664)	(2,7)
British Columbia										
Cominco Ltd.	9 050	3.31	4.64	—	62.1	2 107 876	119 163	49.52	64 228	1
Sullivan mine	(9 050)	(3.83)	(3.74)	(—)	(47.6)	(2 198 840)	(150 420)	(48.60)	(77 594)	(1)
Kimberley										
H.B. Mine,	1 100	4.87	1.10	—	5.1	200 889	15 364	50.01	8 434	1
Salmo	(1 100)	(3.86)	(0.67)	(—)	(. .)	(357 258)	(22 561)	(54.2)	(12 716)	(1)
Silvana Mines Inc.,	100	4 34	5.81	—	508.8	15 966	970	51.23	634	6
Silmonac mine	(100)	(6.04)	(7.15)	(—)	(594.0)	(15 877)	(1 405)	(49.78)	(892)	(6)
Sandon										
Northair Mines Ltd.,	250	1.96	1.30	0.20	70.6	93 397	2 161	45.96	1 613	1
Brandywine area	(250)	(2.03)	(1.54)	(—)	(126.5)	(92 167)	(2 347)	(53.90)	(1 265)	(1)
Teck Corporation	100	0.60	0.35	—	323.7	35 280	403	26.10	148	1
Beaverdell mine	(100)	(0.41)	(0.36)	(—)	(353.1)	(34 434)	(245)	(32.5)	(154)	(1)
Beaverdell										
Western Mines Limited,	900	8.24	1.33	1.25	139.9	269 035	35 581	51.47	20 667	1,12
Lynx and Myra Falls	(900)	(7.58)	(1.34)	(1.14)	(147.1)	(269 071)	(31 247)	(52.67)	(18 608)	(6,12)
Yukon Territory										
Cyprus Anvil Mining	9 050	5.14	3.17	0.20	19.9	3 280 660	246 376	50.41	143 940	6,7,8
Corporation	(9 050)	(4.88)	(2.74)	(0.19)	(22.5)	(3 116 035)	(220 831)	(50.29)	(128 276)	(7,8)
Faro										
United Keno Hill Mines	450	0.79	5.50	—	1 224.7	81 721	30	38.32	487	12
Limited	(450)	(1.12)	(4.57)	(—)	(1 216.8)	(82 995)	(454)	(. .)	(676)	(2)
Elsa										
Northwest Territories										
Pine Point Mines Limited	10 000	5.91	2.62	—	—	2 985 072	273 705	58.52	161 948	1,2,7,8,12
Pine Point	(10 050)	(5.29)	(2.14)	(—)	(—)	(3 123 307)	(264 801)	(56.66)	(152 574)	(1,8,11,12)
Nanisivik Mines Ltd.	2 200	13.24	1.44	—	61.7	574 314	116 548	56.82	66 417	8,12
Baffin Island	(1 350)	(13.27)	(2.00)	(—)	(50.0)	(546 000)	(116 500)	(57.60)	(67 000)	(12)

Sources: Company reports in response to survey by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.

Destination of concentrates: (1) Trail; (2) Flin Flon; (3) Valleyfield; (4) Belledune; (5) Timmins; (6) United States; (7) Japan; (8) Germany; (9) Belgium; (10) France; (11) Britain; (12) Unspecified and other countries.

— Nil; . . Not available.

East-West trade

A significant and unexpected factor in the recovery of zinc in 1978 was the importation by communist countries such as Bulgaria, U.S.S.R., Romania, North Korea, China, Czechoslovakia, Hungary and East Germany of substantial amounts of zinc metal and zinc-in-concentrate from the West. By contrast, in prior years Poland had accounted for the majority of all East-West trade in zinc.

With the increased number of Eastern countries participating in East-West trade, it is estimated that traditional zinc-in-concentrate exports to the East almost tripled to about 220 000 tonnes and zinc metal was also now being imported, about 27 000 tonnes in 1978, whereas traditionally, these countries had exported zinc metal to the West.

At present, the full extent of these trends and the reasons behind them are not obvious because, except for Poland, the COMECON countries stopped publishing nonferrous trade statistics two or three years ago at about the same time they began to change their historical pattern of trade with the West. Assessments of future trade are accordingly speculative, but in the interim it is expected that 1979 will realize a continuation of last year's trade, with exports of both metal and concentrate at slightly increased levels.

International trade

On December 20, 1977 the Lead-Zinc Producers Committee in the United States filed a petition with the International Trade Commission (I.T.C.) which requested the establishment of quotas and tariffs under Section 201 of the Trade Act of 1974 to restrict zinc metal imports to the United States for the 1978-82 period. The petition requested an annual import quota for zinc of 317 500 tonnes, with a special tariff of $154.32 per tonne levied against imports above the quota. The petition would have had an adverse effect on the orderly rehabilitation of the zinc industry in the rest of the world, and Canada, which has traditionally been the leading supplier of concentrates and metal to the United States, accounting for about 50 per cent of its import requirements, would have had to face the greatest degree of restricted access. However, commissioners on the I.T.C. decided against the petition by a five to one vote on June 1, 1978. Had the I.T.C. decided otherwise, there was the additional concern that the European Economic Community would have found it necessary to invoke restrictive measures to protect its industry against the dislocated trade surpluses that would have amassed outside United States borders.

International price developments

In recent years, international zinc price movements have closely followed a world supply-demand balance for zinc that deteriorated throughout the period 1975-77 but improved sharply in 1978. During this same time, shifting currency values acted to exacerbate an already difficult situation.

In Europe, and elsewhere outside of North America, the Gob (good ordinary brand) Producer Basis price for zinc dropped from $U.S. 600 to $U.S. 550 per tonne in February 1978. In the second half of the year this quotation, in U.S. dollars, was successively increased to $625 in August, then to $675 in September, and finally to $720 in October, where it remained through year-end.

Table 5. Canada, primary zinc metal production, 1978

	Refined Zinc Production	Annual Rated Capacity	Utilization
	(tonnes)	(tonnes)	(%)
Canadian Electrolytic Zinc Limited Valleyfield, Quebec	159 850	205 000	78.0
Cominco Ltd. Trail, British Columbia	195 190	245 000	79.7
Hudson Bay Mining and Smelting Co. Ltd. Flin Flon, Manitoba	64 650	74 400	86.9
Texasgulf Canada Ltd. Hoyle, Ontario	72 850	108 900	66.9
Total	492 540	633 300	77.8

Sources: 1978 Company annual reports; *Metallurgical Works in Canada: Nonferrous and Precious Metals*, Operators List 3, January 1977; Department of Energy, Mines and Resources, Ottawa.

Table 6. Canada, producers' domestic shipments of refined zinc, 1976-78

	1976	1977	1978p
	(tonnes)		
1st Quarter	30 656	33 607	42 492
2nd Quarter	40 251	35 844	33 439
3rd Quarter	31 858	28 640	30 806
4th Quarter	30 796	32 550	38 003
Total	133 561	130 641	144 740

Source: Statistics Canada.
p Preliminary.

In the United States and Canada, 1978's price trends were much the same as in Europe except that producer prices became split temporarily during the recovery phase. It should also be noted that North American prices are quoted on a delivered basis whereas delivery costs in the Gob Producer Basis quotations appear to be negotiable; hence the price levels reported reflect these differences. United States producer prices for zinc declined from 30.5¢ to 29¢ per pound in February, following the decline in Europe but then increased to 31¢ per pound in June. They were subsequently increased again to 33¢ per pound in August and to 34.5¢ per pound in October, and remained firm to year-end. Canada's producer prices moved in unison with price changes in the United States but on a currency-equivalent basis which took into consideration the devalued Canadian dollar. On this basis, domestic prices declined from 32.5¢ per pound to 31.0¢ per pound in February and then increased successively to 34.5¢ per pound in June, 37¢ per pound in September, and 39¢ per pound in December.

The price effects of shifting currency exchange rates was not unique to Canada and, more generally, they became a factor that has had an impact upon most of the world's zinc industry. So far in this decade, two major realignments have taken place; the Smithsonian Agreement of December 1971, and the U.S. dollar devaluation in February/March 1973, which was subsequently followed by a regime of floating currencies that has continued to the present. Traditionally, the Gob Producer Basis quotation for zinc outside North America was quoted in the pound sterling; however, this currency was abandoned in favour of the U.S. dollar at year-end 1974 because continuing erosion in the pound eroded the value of the zinc quotation for producers outside the sterling area. Throughout the world recession which followed, the U.S. dollar similarly weakened with the result that the effect of these continuing currency shifts upon zinc trade has generally been favourable for exporting countries but unfavourable for importing countries.

In the period December 1975 to October 1978, when the last price increase took place, the principal zinc producing nations saw their currencies devalue vis-a-vis the U.S. dollar whereas the principal consuming countries saw their currencies revalue against the U.S. dollar. On a global basis, the impact of these currency shifts has been less than beneficial to the concept of an international price for zinc. The shifts have depressed prices realized by the mines and reduced operating margins for custom smelters in the strong currency areas, with the opposite being the case for the weak, devalued currencies. Rampant inflation and currency devaluation have gone hand-in-hand for some countries to

Table 7. International zinc metal prices, 1978

Month	Canada	U.S.A.	Producers Outside North America	London Metal Exchange
	(¢/lb)	(¢/lb)	($U.S./tonne)	(£/tonne)
January	32.5	30.5	600.0	276.6
February	32.5	30.1	582.5	246.2
March	31.0-32.5	29.0	550.0	266.5
April	31.0	29.0	550.0	299.8
May	31.0	29.0	550.0	308.8
June	31.0-35.4	29.0	550.0	314.4
July	31.0-34.5	29.8	550.0	308.1
August	31.0-34.5	31.2	602.3	318.5
September	34.0-37.0	32.4	629.8	323.4
October	34.0-39.0	32.8	681.4	355.1
November	39.0	34.4	720.0	350.6
December	39.0	34.5	720.0	346.0
1978 Average	34.0	31.0	607.2	309.5
1977 Average	35.1	34.4	719.7	338.5

Source: International Lead Zinc Study Group Bulletin.

ZINC PRICES-MONTHLY AVERAGE

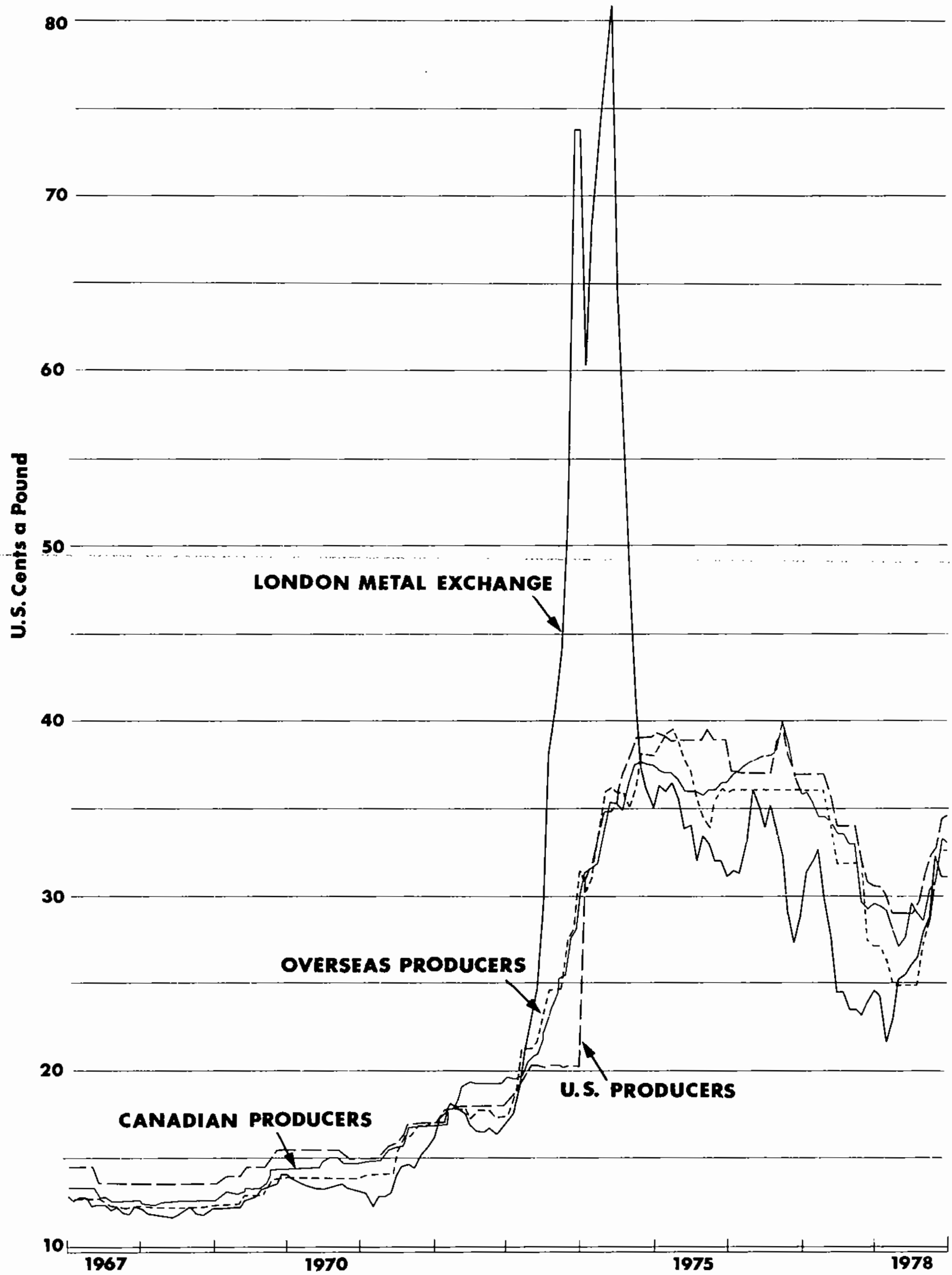


Table 8. Western world primary zinc statistics, 1976-79

	1976	1977	1978^p	1979^e
	(000 tonnes)			
Mine production (Zn content)	4 548	4 825	4 724	4 600
Metal production	4 135	4 280	4 287	4 680
Metal consumption	4 148	4 224	4 383	4 520

Source: International Lead and Zinc Study Group, March 1979.
^{p} Preliminary; ^{e} Estimated by the Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.

the extent that the apparent currency gains have been consumed by domestic cost inflation. At the same time, some consuming countries are currently faced with very depressed domestic zinc prices since their currencies have been revalued in the range of 10 to 35 per cent during the past three years. Japan, for example, has been among the countries most severely disadvantaged by currency revaluation. To keep its zinc industry afloat, Japan approved a massive mine subsidization scheme last year and domestic zinc prices have also been raised above world levels.

The action taken by Japan points out a potentially serious problem for other strong-currency countries and the world zinc industry in general. The monetary system has created compelling economic incentives for strong-currency countries to raise domestic prices above world levels; however, zinc is also a homogenous product worldwide and as such there is little basis for price discrimination between market areas. Furthermore zinc demand is relatively insensitive to price changes and despite the fact that zinc prices are a bargain in many strong-currency countries there is little hope for rapid self-correction based upon price-inspired consumer demand. This general concern may become more apparent if the supply-demand balance for zinc continues to improve while currency disparities remain unchanged or deteriorate further.

Tariffs

The following tariffs apply for zinc in its various forms.

Canada

Item No.		British Preferential	GSP[1]	GATT[2]	General
32900-1	Zinc in ores and concentrates	free	free	free	free
34505-1	Zinc spelter, zinc and zinc alloys containing not more than 10% by weight of other metal or metals, in the form of pigs, slabs, blocks, dust or granules	free	free	free	2¢/lb
34500-1	Zinc dross and zinc scrap for remelting, or for processing into zinc dust	free	free	free	10%
35800-1	Zinc anodes	free	free	free	10%

United States

TSUS Number		GSP	GATT
602.20	Zinc ores and concentrates, on zinc content	free	0.67¢/lb[3]
	Unwrought zinc		
626.02	Unalloyed	0.7¢/lb	0.7¢/lb
626.04	Alloys of zinc	19%	19%
626.10	Zinc waste and scrap	0.75¢/lb[3]	0.75¢/lb[3]

European Economic Community

Brussels Tariff Nomenclature (BTN) Number		GSP	GATT
26.01	Zinc ore and concentrates	free	free
79.01	Unwrought zinc	3.5%	3.5%
	Zinc waste and scrap	free	free

Japan

Brussels Tariff Nomenclature (BTN) Number		GSP	GATT
26.01	Zinc ores and concentrates	free	free
79.01	Unwrought zinc, 97% zinc	free	12 yen/kg[4]
	Zinc waste and scrap	free	2.5%[5]

Sources: Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States (TSUS) Annotated, 1978, ITC Publication 843; Official Journal of the European Communities, Volume 21, No. L 335, 1978; Customs Tariff Schedules of Japan, 1978.

[1]GSP Generalized System of Preferences extended to all beneficiary developing countries. [2]GATT General Agreement on Tariffs and Trade (most favoured nation treatment). [3]Duty temporarily suspended. [4]Temporarily reduced to 8 yen/kg. [5]Temporarily reduced to 2 per cent.

Zirconium

MICHEL A. BOUCHER

Canada imports all of its zirconium needs, mostly in the form of finished products. Some finished zirconium products are produced from imported semifinished, zirconium-alloy material.

Canada requires all forms of zircon: zircon concentrates mainly for the foundry industry; ferrozirconium for the steel industry and zirconium alloys for the nuclear industry. In line with this demand Canada imported, in 1978, 4 500 tonnes* of zircon concentrates from Australia and 326 257 kilograms (kg) of zirconium alloys mainly from the United States. Consumption of ferrozirconium was 444 tonnes.

Ontario Hydro, with a large nuclear capacity, is Canada's largest consumer of zirconium alloy products. Hydro-Québec and the New Brunswick Electric Power Commission will also become important consumers of zirconium alloy products as their nuclear generating capacity expands. The largest consumer of ferrozirconium in recent years was Dominion Foundries and Steel Limited followed by Esco Limited, Fonderie Magog, Black-Clawson-Kennedy Ltd., Atlas Steels Division of Rio Algom Limited and Hawker Siddeley Canada Ltd.

World production and developments

Zircon. Australia continues to be the largest producer and exporter of zircon, the major mineral of zirconium.

In 1978 world production of zircon concentrates was 448 000 tonnes. Australia accounted for 397 000 tonnes, of which 391 000 tonnes were exported.

In 1978, identified resources of zircon in Australia were 20 million tonnes, of which about 73 per cent is considered to be economic at current prices for zircon, rutile, ilmenite and monazite. However, about 44 per cent of identified economic resources on the east coast, or 19 per cent of total Australian identified economic resources of zircon, are unavailable for mining because of environmental considerations. This means that identified economic and mineable reserves of zircon are equal to 11.7 million tonnes. At current rates of production the remaining reserves are expected to last about 30 years.

South Africa, with the Richards Bay deposit, is the world's second largest producer of zircon. The Richards Bay consortium, which mines the deposit, is owned by Union Corporation Limited, with 30 per cent interest; The Industrial Development Corporation of South Africa, with 20 per cent; Quebec Iron and Titanium Corporation, with 40 per cent; and The South African Mutual Life Assurance Soc. Ltd., with 10 per cent interest. Production began in late 1977 and output is exported mainly to Japan, the European Economic Community (EEC) and the United States. Some 115 000 tonnes of zircon are expected to be produced by 1980, along with 55 000 tonnes of rutile. Also, some 400 000 tonnes of titania slag and 220 000 tonnes of low-manganese pig iron will be produced as coproducts.

Zirconium. Only a small amount of zircon is converted to its metal form; nevertheless, zirconium can be considered to be a strategic metal in that it is an essential component of nuclear reactors.

World production of zirconium metal ingot is controlled by Teledyne Wah Chang (TWCA) in the United States and by Pechiney Ugine Kuhlmann Development, Inc. (PUK) in France. Entry into the zirconium metal ingot market is difficult as the price of sponge is kept high but the price of metal and fabricated zirconium products kept low. This means that consumers buying sponge for melting and sale as metal ingot have difficulty matching the supplier's price of metal ingot.

However, a new entry into the zirconium metal ingot market is expected in late 1979, when Western Zirconium Inc. of Westinghouse Electric Corporation brings on stream a $50 million zirconium metal ingot manufacturing plant near Ogden, Utah in the United States. The plant will have an annual production capacity of 1 400 tonnes of zirconium and will employ some 430 workers.

A new process to be employed in the plant is designed to reduce costs of production and is described as follows. Zircon sand is mixed with coke and chlorine, and heated to an elevated temperature. The product, impure zirconium tetrachloride, is treated chemically to remove hafnium and iron and yield zirconium oxide. Silicon tetrachloride, a byproduct of the process, will be purified and sold. Coke and chlorine react with zirconium oxide and produce pure zirconium tetrachloride. Zirconium tetrachloride is reduced to zirconium sponge with magnesium at an elevated temperature. The sponge is then melted with elements such as tin and chromium to form alloys. The end product, zirconium ingot, measures approximately 65 centimetres

*The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

Table 1. Australia, zircon production, 1965, 1970 and 1975-78

	Zircon Concentrate	Zircon (ZrO_2 SiO_2 content)
	(tonnes)	
1965	230 504	228 259
1970	395 351	390 294
1975	382 217	375 548
1976	420 185	413 655^r
1977	401 842	391 991
1978^p	396 883	. .

Sources: Australian Mineral Industry Quarterly, September 1978; Australian Quarterly Bulletin of Mineral Sands Statistics, March 1979.
^{p} Preliminary; ^{r} Revised; . . Not available.

(cm) in diameter by about 2.5 metres (m) in length and weighs 4 550 kg.

The process buildings have approximately 15 000 square metres (m^2) of enclosed manufacturing area. Mill production capacity of the plant is expected to be reached in the mid-1980s.

Production of zirconium metal at Teledyne Wah Chang was cut back in 1978 because of a slowdown of nuclear power plant construction. TWCA is reported to be studying the possibility of building a new zirconium plant to replace the company's 20-year old zirconium-hafnium separation plant which is apparently obsolete.

Zirconium Industry Inc. of Japan was also expanding in 1978 and Pechiney of France was studying the possibility of increasing production capacity substantially in 1979. These new developments may be the result of the difficulties and delays that Europe and Japan have in obtaining U.S. export licenses for nuclear-grade zirconium. Another problem for U.S. zirconium suppliers stems from the fact that the objective of several countries is to achieve independence from U.S. suppliers. Finally as nuclear power programs expand, domestic production of zirconium will become more economically attractive for various countries.

Table 2. World[1] production of zircon concentrates, 1976-78

	1976	1977^p	1978^e
		(tonnes)	
Australia	420 185	401 842	396 883
Republic of South Africa	11 252	12 293	36 300
India^e	10 300	10 300	. .
Brazil	3 058	3 200	. .
Malaysia	3 129	1 179	. .
Thailand	55	50	. .
Sri Lanka	10	10	. .
Other countries	. .	. .	14 517
Total	447 989	428 874	447 700

Sources: United States Bureau of Mines, Mineral Commodity Summaries, 1979; United States Bureau of Mines, Mineral Trade Notes, August 1978; Australian Quarterly Bulletin of Mineral Sands Statistics, March 1979.
[1] No data are available on production, if any, within the centrally planned economy nations. United States production is withheld.
^{p} Preliminary; ^{e} Estimate; . . Not available.

Table 3. Comparative end-use markets for zircon for major market-based countries (percentage of total zircon production) 1975

	United States	Japan	United Kingdom	West Germany	France	Italy	Overall
Foundry	50	18	30	30	15	20	35
Refractories	21	67	40	15	65	10	37
Ceramics	15	3	15	25	8	65	14
Abrasives	10	2	5	15	5	3	8
Chemicals	2	10	5	—	2	1	5
Metal	2	—	—	—	5	—	1
All other	—	—	5	15	—	1	—
Total	100	100	100	100	100	100	100

Source: Stanford Research Institute, World Minerals Availability, Volume 7, 1976.
— Nil.

Table 4. Australia, exports of zircon concentrates, 1976-78

	1976	1977	1978[p]
		(tonnes)	
Japan	125 421	88 789	109 364
United States	51 923	60 191	56 614
Italy	42 558	32 257	40 348
Netherlands	27 013	38 205	39 185
United Kingdom	9 969	16 930	29 020
France	14 068	18 284	24 501
West Germany	19 792	4 836	17 752
Spain	16 829	26 716	16 971
Belgium and Luxembourg	11 345	13 805	13 915
Canada	5 665	4 856	4 500[e]
Other countries	19 953	22 852	39 105
Total	344 536	327 721	391 275
Value ($000)	54 492	36 157	29 363

Sources: Australian Mineral Industry Quarterly, September 1978; Australian Quarterly Bulletin of Mineral Sands Statistics, March 1979.
[p] Preliminary; [e] Estimated.

Table 5. World production capacity of major zircalloy manufacturers, 1978

Country	Producer	Annual Production Capacity	Type Material	Supplier of Material
		(000 metres)		
Zircalloy tubing				
United States	General Electric	2 000	tubing	Wah Chang, Pechiney Ugine Kuhlmann (PUK)
	Westinghouse	2 000	tubing	Wah Chang, (PUK)
	Sandvik, Inc.	500	tubing	Wah Chang, (PUK)
Canada	Noranda Mines Limited	1 000	tubing	Wah Chang, (PUK)
	Westinghouse	500	tubing	Westinghouse (U.S.)
France	Ballourec	1 000	tubing	PUK
West Germany	N.R.G.	1 200	tubing	PUK, Wah Chang
	Mannessmann	300	tubing	PUK, Wah Chang
Sweden	Sandvik	1 000	sponge	PUK
Japan	Kobe Steel	300	tubing	Wah Chang
	Mitsubishi Metal	300	tubing	Wah Chang
	Sumitomo Metal	300	tubing	Wah Chang

Table 5. (cont'd)

Country	Producer	Annual Production Capacity	Type Material	Supplier of Material
Channel boxes		(no. of units)		
United States	Carpenter	1 500	sheets	Wah Chang, PUK
	General Electric	6 000	sheets	Wah Chang, PUK
Sweden	Asea-Atom	1 500	sheets	PUK, Wah Chang
West Germany	Mannessmann	1 500	sheets	PUK, Wah Chang
Japan	Kobe Steel	1 000	sheets	Wah Chang

Source: Roskill Information Services Ltd., March 1979.

Canadian production and developments

Zircon. Canada does not produce zircon even though the mineral is plentiful in several localities such as the tar sands of Alberta, certain mineral sands in Nova Scotia and some igneous rocks in Quebec and Ontario.

The most promising source of zircon is the tar sands which have the following average analysis:

Element	Per cent by weight
Fe	0.54
Ti	0.21
Mg	0.14
Cu	0.06
Zr	0.05

Material	Tonnes material per thousand tonnes of tar sands to the extraction plant
H_2O	107.79
Light metals	14.23
Other heavy minerals (leucoxene, rutile, anatase)	0.87
Other minerals (Ni, Zn, Fe, Mn, Cr, Si)	0.92
Ilmenite	0.34
Zircon	0.32
Total	124.47

Thus, for every 1 000 tonnes of tar sands processed in an oil recovery plant, some 0.32 tonnes of zircon can be produced and zircon grade is therefore raised to 0.26 per cent (0.32 tonnes/124.47 tonnes).

Currently, Great Canadian Oil Sands Limited (GCOS) extracts 3.3 million tonnes of tar sands annually and Syncrude Canada Ltd. extracts 83 million tonnes annually. This represents 37 000 tonnes of zircon per year. This availability is equivalent to about 10 per cent of world production and could double in the next decade as several other tar sands plants are brought into production.

Several companies and governments are interested in the recovery of zircon and other minerals from the tar sands. These include the Alberta government, Canadian Titanium Pigments Limited and Ontario Hydro.

The Alberta government is working in cooperation with GCOS and Syncrude on a beneficiation process for the recovery of zircon and other heavy minerals. Canadian Titanium Pigments is interested in the recovery of zircon for sale to foundries and abrasive industries, as well as the recovery of leucoxene for sale to the pigment industry.

Table 6. Non-communist consumption of zirconium metal, 1978, 1980 and 1985

	1978	Projected 1980	Projected 1985
		(tonnes)	
Nuclear power plants	3 400	4 300	4 500-5 000
Chemical processing equipment and flash bulb manufacturing	227	275[1]	442[1]
Military projects	1 134	..	..
Total	4 761		

Source: Teledyne Wah Chang, Albany Corp.
[1] At 10 per cent per annum growth rate.
.. Not available.

Table 7. Forecast of world zirconium metal demand, 1973, 1985 and 2000

	1973 Actual Demand	1985	2000	Average Growth per Annum
		(tonnes)		(%)
United States	2 453	5 000	12 000	6
Other	4 000	10 000	32 000	8
Total	6 453	15 000	44 000	7

Source: Roskill Information Services Ltd., March 1979.

Table 8. Canada, imports of zirconium alloys, 1977 and 1978

	1977		1978^p	
	(kilograms)	($)	(kilograms)	($)
United States	208 995	9 930 000	318 785	8 537 000
France	13 567	438 000	6 972	292 000
United Kingdom	—	—	500	3 000
Total	222 562	10 368 000	326 257	8 832 000

Source: Statistics Canada.
^{p} Preliminary; — Nil.

When nuclear grade zircon becomes available from the tar sands Ontario Hydro would be interested in examining, with industry, the possibility of producing zirconium metal in Canada for use in its reactor program.

Zirconium. In the past five years Canadian imports of zirconium alloys have more than doubled. TWCA in the United States continues to be the major supplier of tube reduced extrusions "Trex" to the two Canadian tube producers, Noranda Metal Industries Ltd. and Westinghouse.

Canadian requirements for zirconium products in 1985 are forecast on the basis that:

(a) Canadian nuclear electric generating capacity will be about 10 000 MWe in 1985, or capacity will be growing by about 1 400 MWe annually.
(b) One kg of zirconium alloy makes 6.7 m of fuel cladding with a life expectancy of 1 year, and 15 kg of fuel cladding are required per MWe.
(c) Pressure tubes and calandria tubes each have a life expectancy of 30 years, and 65 kg of these tubes are required initially per MWe.

Table 9. Canada, imports of zirconium alloys, 1973-78

Year	Imports	Value
	(kg)	($)
1973	140 526	5 420 000
1974	222 504	5 981 000
1975	221 939	8 549 000
1976	181 451	8 337 000
1977	222 562	10 368 000
1978	326 257	8 832 000

Source: Statistics Canada.

Canadian zirconium requirements in 1985

Fuel cladding (1 005 000 metres)	10 000 Mw	$\times \frac{15 \text{ kg}}{\text{MWe}} =$	150 000 kg
Pressure tubes and calandria tubes	1 400 Mw	$\times \frac{65 \text{ kg}}{\text{MWe}} =$	91 000 kg
Total			241 000 kg

(The production of zirconium requires about 1 kg magnesium per 1 kg zirconium metal produced.)

Ontario Hydro is by far the largest consumer of zirconium in the form of fuel cladding, pressure tubes and calandria tubes. The major suppliers to Ontario Hydro are Chase Nuclear (pressure tubes), Noranda and Westinghouse (fuel cladding) and Westinghouse and Bristol Aerospace (calandria tubes). Noranda may become a supplier of pressure tubes to Ontario Hydro as it intends to start extruding pressure tubes in the near future.

Prices

At the end of 1978 zircon prices, as quoted in *Metals Week*, were as follows:

	Price per kg
	($U.S.)
Zircon concentrates	
Australia	0.154
United States	0.165
Sponge	22.700
Standard mill products	37.550

Outlook

About 80 per cent of zirconium metal is consumed by the nuclear industry. The future of the metal is uncertain for several reasons: production of sponge is restricted because of the marketing strength of the established producers; entry into the market is difficult because prices are kept low; the technology required to produce zirconium is very sophisticated and consequently restricts the number of producing countries; environmental controls which are already tight, are expected to be tighter in the future; and the objective of several countries is to become independent of the U.S. for their energy-related supplies.

For these reasons the imbalance between supply and demand will continue for several years.

Table 10. Non-communist supply sources, zirconium metal (ingots), 1978 and 1980

Company	Location	Production Capacity 1978	Production Capacity 1980
		(tonnes)	
Teledyne Wah Chang (TWCA)	Albany, Oregon, U.S.	3 500	3 500
Pechiney Ugine Kuhlmann (PUK)	Jarrie, France	1 000	1 400
Zirconium Industry Inc.[1]	Hiratsuka, Japan	250	350
Nippon Mining Co. Ltd.[2]	Toda, Japan	50	350
Western Zirconium Inc.	Ogden, Utah, U.S.	—	1 400
Total		4 800	7 000

Source: Teledyne Wah Chang, Albany Corp.
[1]Converts TWCA reactor-grade zirconium oxide to sponge which is returned to TWCA for the production of ingots and for fabrication. [2]Produces sponge through recycling of scrap.
— Nil.

NUCLEAR CAPACITY IN CANADA FORECAST TO 2000

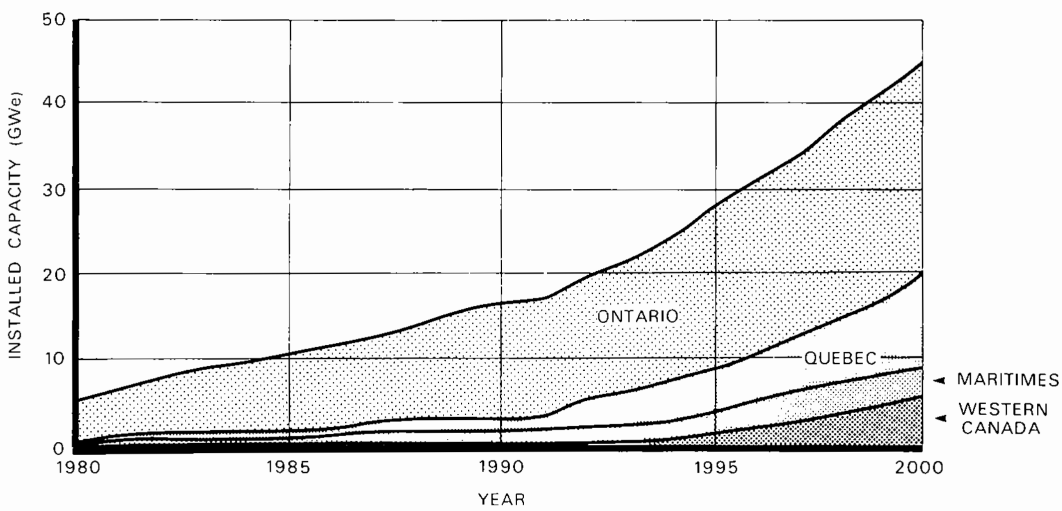


Table 11. Composition of zircalloy

	Zr	Sn	Fe	Ni	Cr
Zircalloy 1	97.50	2.50	—	—	—
Zircalloy 2[1]	98.23	1.50	0.012	0.05	0.10
Zircalloy 3	99.50	0.25	0.250	—	—
Zircalloy 4	98.28	1.50	0.120	—	0.10

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.
[1]The density of Zircalloy 2 is 6.55 grams per cubic centimetre, compared with 6.51 grams per cubic centimetre for zirconium.
— Nil.

Canadian zirconium industry facilities

Refining — nil
Melting — nil

Primary Metal Processing — nil

Fuel Bundle Fabrication and Assembly

Canadian General Electric, Peterborough, Ontario
Westinghouse Canada Ltd., Port Hope, Ontario
Varennes, Quebec
Combustion Engineering Superheater Ltd., Moncton, New Brunswick

Fuel Cladding (Tube) Production

Noranda Metal Industries Ltd., Arnprior, Ontario
Westinghouse Canada Ltd., Port Hope, Ontario

Large Tube Production
(Coolant, Calandria, Reactivity Tubes)

Bristol Aerospace Ltd., Winnipeg, Manitoba
Chase Nuclear (Canada) Ltd., Arnprior, Ontario
Noranda Metal Industries Ltd., Arnprior, Ontario
Westinghouse Canada Ltd., Port Hope, Ontario

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.

Zirconium inventory and replacement demands for different types of reactors

Type of reactor	Initial Core	Annual Replacement
	(tonnes/MWe)	
CANDU (heavy water)	0.08	0.015
U.S. reactors (light water)	0.03-0.06	0.015

Source: Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa.

Zirconium is extensively used in the form of zircalloy for cladding of nuclear fuel. Zirconium has both a high resistance to corrosion and a high transparency to thermal neutrons.

Zircalloy 2 and 4 are the alloys most commonly used; their compositions are shown in the table above.

Tariff Profile (most favoured nation)

	Japan	U.S.A.	Canada (MFN)	EEC
	(%)	(%)	(%)	(%)
Ore	Free	Free	Free	Free
Reactor quality zirconium oxide	8	6	5	4
Sponge	8	6	Free	6
Ingots	8	6	Free	6
Zirconium alloy ingots	8	7.5	Free	6
Fabricated materials	12[1]	9	Free	10

Sources: Official Journal of the European Communities, Common Customs Tariff; Tariff Schedules of the Unites States Annotated (1978) USITC Publication 843; Customs Tariff Schedules of Japan; Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

[1]Zircalloy tubing used in over 260 light water reactors is charged tax at the basic rate of 12 per cent, but is provisionally free of tax by reason of the second Amendment to the enforcement regulations pertaining to provisional customs. Until 1977 zircalloy tubing was provisionally free of tax, but from April 1, 1978, it was excluded from the provisions of the second amendment.

Statistical Summary
Canadian Mineral Industry

This statistical summary of Canadian mining and related activities is as comprehensive as possible, given the availability of data.

The summary is divided into nine sections, each containing a number of statistical tables, and is preceded by a list of tables contained in each section and by a table entitled "Canada, General Economic Indicators, 1964-78".

The sources of Canadian Mining Industry statistics are Statistics Canada, other federal departments and agencies, provincial governments and company annual reports. International mineral statistics are derived from U.S. Bureau of Mines publications, American Bureau of Metal Statistics, World Bureau of Metal Statistics, *Metals Week*, *Engineering and Mining Journal*, the United Nations and the Organization for Economic Cooperation and Development. Where applicable, an explanation of a concept or a term is contained in the footnote to a statistical table. The statistical data are given in Metric (SI) units unless otherwise noted. If further information is required, the source of the information should be consulted.

The statistical summary was prepared by J.T. Brennan and staff, Statistics Section, Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa. Telephone (613) 995-9351, Extension 281.

STATISTICAL TABLES

SECTION 6, EMPLOYMENT, SALARIES AND WAGES

SECTION 7, MINING, EXPLORATION AND DRILLING

SECTION 8, TRANSPORTATION

SECTION 9, INVESTMENT AND FINANCE

		1964	1965	1966	1967	1968
Gross national product, current dollars	$ million	50 280	55 364	61 828	66 409	72 586
Gross national product, constant dollars (1971 = 100)	,,	65 610	69 981	74 844	77 344	81 864
Value of manufacturing industry shipments	,,	30 856	33 889	37 303	38 955	42 062
Value of mineral production	,,	3 365	3 715	3 981	4 381	4 722
Merchandise exports	,,	8 094	8 525	10 071	11 112	13 270
Merchandise imports	,,	7 488	8 633	10 072	10 873	12 358
Balance of payments, current account	,,	− 424	− 1 130	− 1 162	− 499	− 97
Corporation profits before taxes	,,	5 841	6 318	6 714	6 823	7 742
Capital investment, current dollars	,,	10 980	12 935	15 088	15 348	15 455
Capital investment, constant dollars (1971 = 100)	,,	14 259	15 944	17 645	17 571	17 628
Population	000's	19 291	19 644	20 015	20 378	20 701
Labour force	,,	6 933	7 141	7 420	7 694	7 919
Employed	,,	6 609	6 862	7 152	7 379	7 537
Unemployed	,,	324	280	267	315	382
Unemployment rate	%	4.7	3.9	3.6	4.1	4.8
Employment index	1961 = 100	108.2	114.3	120.7	122.6	122.7
Labour income	$ million	25 367	28 201	31 878	35 303	38 444
Index industrial production	1971 = 100	68.0	73.8	79.2	82.3	87.6
Index manufacturing production	,,	69.5	75.8	81.5	83.9	89.1
Index mining production	,,	67.0	70.5	74.1	79.9	86.2
Index real domestic product	,,	69.4	74.5	79.5	82.3	86.9
General wholesale price index	1935-39 = 100	245.4	250.3	259.5	264.1	269.1
Consumer price index	1971 = 100	78.6	80.5	83.5	86.5	90.0

[p] Preliminary; [r] Revised.

indicators, 1964-1978

1969	1970	1971	1972	1973	1974	1975	1976	1977	1978[p]
79 815	85 685	94 450	105 234	123 560	147 528	165 343[r]	191 166[r]	209 379	230 407
86 225	88 390	94 450	100 248	107 812	111 678	113 005[r]	119 116[r]	121 949	126 127
45 930	46 381	50 276	56 191	66 674	82 455	88 427[r]	98 076[r]	109 747	130 353
4 734	5 722	5 963	6 408	8 370	11 754	13 347	15 693[r]	18 473	19 661
14 498	16 401	17 397	19 671	24 838	31 739	32 587	37 651[r]	43 684	51 919
14 130	13 952	15 617	18 669	23 325	31 880	34 830[r]	37 494[r]	42 332	49 938
− 917	+ 1 106	+ 431	− 386	+ 108	− 1 460	− 4 757	− 3 842[r]	− 4 299	− 5 302
8 294	7 699	8 681	10 799	15 417	20 062[r]	19 709[r]	20 281[r]	22 330	26 065
16 927	17 798	20 184	22 218	26 618	32 882	38 216	43 636	46 597	50 238
18 498	18 635	20 184	21 242	23 551	24 927[r]	25 694[r]	26 727[r]	26 527	26 392
21 001	21 297	21 568	21 802	22 043	22 364	22 697	22 993	23 258	23 481
8 162	8 395	8 639	8 897	9 276	9 639	9 974	10 206	10 498	10 882
7 780	7 919	8 104	8 344	8 761	9 125	9 284	9 479	9 648	9 972
382	476	535	553	515	514	690	727	850	911
4.7	5.7	6.2	6.2	5.5	5.3	6.9	7.1	8.1	8.4
127.0	127.1	127.8	129.9	135.9	142.8	141.1	144.1	144.3	146.5
43 065	46 706	51 528	57 570	66 501[r]	79 844[r]	93 289[r]	107 914[r]	119 003	129 885
93.6	94.9	100.0	107.5[r]	118.1[r]	122.2[r]	114.9	121.3[r]	125.2	132.4
95.8	94.5	100.0	107.1[r]	117.6[r]	122.0[r]	114.3[r]	120.8[r]	124.1	133.8
86.9	98.7	100.0	106.5	119.3	117.3	107.1	109.8	114.0	105.3
92.2	94.4	100.0	105.5[r]	113.6[r]	119.0[r]	119.8[r]	126.1[r]	130.1	135.3
282.4	286.4	289.9	310.3	376.9	461.3	491.6	512.4	559.5	610.2
94.1	97.2	100.0	104.8	112.7	125.0	138.5	148.9	160.8	175.2

Table 1. Mineral production of Canada, 1977 and 1978, and average 1974-78

	Unit of Measure	1977		1978[p]		Average 1974-78	
		(Quantity)	($ 000)	(Quantity)	($ 000)	(Quantity)	($ 000)
Metals							
Antimony	t	..	9 159	..	7 647	..	7 642
Bismuth	t	165	2 247	158	1 341	144	2 050
Cadmium	t	1 185	8 232	965	5 940	1 179	8 325
Calcium	t	491	1 802	588	2 708	499	1 572
Cobalt	t	1 485	18 770	1 163	27 140	1 384	16 362
Columbium (Cb_2O_5)	t	2 509	12 870	2 535	13 412	2 025	9 317
Copper	000 t	759	1 162 697	658	1 078 636	740	1 155 103
Gold	kg	53 921	272 331	52 875	375 054	52 735	278 056
Indium	kg	1 120	..	..	..	..	..
Iron ore	000 t	53 621	1 375 566	39 622	1 149 890	48 067	1 078 135
Iron remelt	000 t	..	79 304	..	79 550	..	75 368
Lead	000 t	281	195 000	308	250 301	298	172 723
Magnesium	t	7 633	17 767	8 269	19 638	6 355	13 656
Mercury	t	—	—	—	—	179	..
Molybdenum	t	16 568	150 582	14 068	169 939	14 445	110 414
Nickel	000 t	233	1 212 568	130	652 040	223	1 017 241
Platinum group	kg	14 475	61 988	8 678	55 672	12 100	57 018
Selenium	t	161	6 461	123	4 647	170	6 442
Silver	kg	1 313 685	207 801	1 206 000	238 883	1 273 459	200 158
Tantalum (Ta_2O_5)	t	..	..	..	..	..	..
Tellurium	t	35	1 415	27	1 365	37	1 059
Thorium	t	—	—	—	—	—	—
Tin	t	328	3 546	375	6 054	324	3 283
Tungsten (WO_3)	t	2 284	..	..	..	..	..
Uranium (U)	t	5 787	349 219	8 005	588 657	5 520	..
Zinc	000 t	1 071	838 561	1 032	791 055	1 053	836 733
Total metals			5 987 886		5 519 569		5 050 657
Nonmetals							
Arsenious oxide	t	..	..	—	—	..	..
Asbestos	000 t	1 517	563 532	1 380	601 631	1 426	437 326
Barite	000 t	117	2 836	88	1 850	93	1 964
Feldspar	000 t	—	—	—	—	—	—
Fluorspar	000 t	..	8 685	—	—	..	3 748
Gemstones	t	..	915	..	936	..	785
Gypsum	000 t	7 234	31 376	7 889	36 760	6 814	26 729
Magnesitic dolomite and brucite	000 t	..	6 290	..	6 034	..	5 210
Mica	kg	..	..	..	..	..	..
Nepheline syenite	000 t	575	11 984	579	13 100	544	10 740
Peat	000 t	386	28 257	404	30 145	380	25 276
Potash (K_2O)	000 t	5 764	403 707	6 375	492 963	5 561	383 534
Pyrite, pyrrhotite	000 t	24	197	9	72	27	197
Quartz	000 t	2 317	19 310	1 983	19 743	2 364	16 071
Salt	000 t	6 039	90 076	6 222	104 042	5 765	79 706
Soapstone, talc and pyrophyllite	000 t	72	2 260	67	2 658	72	2 040
Sodium sulphate	000 t	395	20 450	378	19 474	469	20 111
Sulphur in smelter gas	000 t	736	14 164	673	13 635	694	13 167
Sulphur, elemental	000 t	5 207	80 608	5 868	100 168	4 843	82 270
Titanium dioxide	000 t	..	77 821	..	110 667	..	73 870
Total nonmetals			1 362 468		1 553 878		1 182 744

Table 1. (cont'd)

	Unit of Measure	1977		1978^p		Average 1974-78	
		(Quantity)	($ 000)	(Quantity)	($ 000)	(Quantity)	($ 000)
Fuels							
Coal	000 t	28 520	609 517	30 273	733 350	26 176	567 843
Natural gas	000 m^3	91 517 960	3 422 070	87 527 871	3 881 585	88 084 105	2 439 460
Natural gas byproducts	000 m^3	16 703	969 725	14 824	957 168	16 798	832 340
Oil, crude	000 m^3	76 579	4 871 500	74 502	5 660 440	81 652	4 374 266
Total fuels			9 872 812		11 232 543		8 213 909
Structural materials							
Clay products	$ 000	. .	103 361	. .	107 279	. .	91 319
Cement	000 t	9 639	420 086	10 777	481 405	10 142	379 317
Lime	000 t	1 900	64 467	2 069	74 452	1 863	56 935
Sand and Gravel	000 t	262 905	364 881	265 978	375 415	252 898	328 775
Stone	000 t	120 163	296 567	111 997	316 798	100 457	244 787
Total structural materials			1 249 362		1 355 349		1 101 133
Total all minerals			18 472 528		19 661 339		15 548 442

Note: 1. Production statistics for the following are not available for publication: diatomite, helium, nitrogen and yttrium. 2. Nil production for the following between 1974 and 1978: feldspar, grindstone, iron oxide, lithia and thorium. 3. Dollar values only available for publication for the following: antimony, iron remelt, gemstones, fluorspar, magnesitic dolomite and brucite, titanium dioxide and clay products.

^{p} Preliminary; . . Not available; — Nil.

Table 2. Canada, value of mineral production, per capita value of mineral production and population, 1937-78

	Metallics	Industrial Minerals	Fuels	Total	Per capita Value of Mineral Production	Population of Canada
		($ million)			($)	(000)
1937	335	57	66	458	41.48	11 045
1938	324	54	65	443	39.71	11 152
1939	343	61	71	475	42.12	11 267
1940	382	69	79	530	46.55	11 381
1941	395	80	85	560	48.69	11 507
1942	392	83	92	567	48.63	11 654
1943	357	80	93	530	44.94	11 795
1944	308	81	97	486	40.67	11 946
1945	317	88	94	499	41.31	12 072
1946	290	110	103	503	40.91	12 292
1947	395	140	110	645	51.38	12 551
1948	488	172	160	820	63.97	12 823
1949	539	178	184	901	67.01	13 447
1950	617	227	201	1 045	76.24	13 712
1951	746	266	233	1 245	88.90	14 009
1952	728	293	264	1 285	88.90	14 459
1953	710	312	314	1 336	90.02	14 845
1954	802	333	353	1 488	97.36	15 287
1955	1 008	373	414	1 795	114.37	15 698
1956	1 146	420	519	2 085	129.65	16 081
1957	1 159	466	565	2 190	131.87	16 610
1958	1 130	460	511	2 101	122.99	17 080
1959	1 371	503	535	2 409	137.79	17 483
1960	1 407	520	566	2 493	139.48	17 870
1961	1 387	542	674	2 603	142.72	18 238
1962	1 496	574	811	2 881	155.05	18 583
1963	1 510	632	885	3 027	159.91	18 931
1964	1 702	690	973	3 365	174.45	19 291
1965	1 908	761	1 046	3 715	189.11	19 644
1966	1 985	844	1 152	3 981	198.88	20 015
1967	2 285	861	1 235	4 381	214.99	20 378
1968	2 493	886	1 343	4 722	228.10	20 701
1969	2 378	891	1 465	4 734	225.42	21 001
1970	3 073	931	1 718	5 722	268.68	21 297
1971	2 940	1 008	2 015	5 963	276.46	21 568
1972	2 956	1 085	2 367	6 408	293.92	21 802
1973	3 850	1 293	3 227	8 370	379.69[r]	22 043
1974	4 821	1 731	5 202	11 754	525.55	22 364
1975	4 796[r]	1 898	6 653	13 347	588.05	22 697
1976	5 315[r]	2 269[r]	8 109	15 693[r]	682.51	22 993
1977	5 988	2 612	9 873	18 473	794.24	23 258
1978[p]	5 520	2 909	11 232	19 661	837.33	23 481

[p] Preliminary; [r] Revised.

Table 3. Canada, value of mineral production by provinces, territories and mineral classes, 1978[p]

	Metals		Industrial Minerals		Fuels		Total	
	($ 000)	(% of total)	($ 000)	(% of total)	($ 000)	(% of total)	($ 000)	(% of total)
Alberta	—	—	237 893	8.17	9 511 489	84.67	9 749 382	49.58
Ontario	1 989 074	36.04	579 838	19.93	26 440	0.24	2 595 352	13.20
Quebec	780 532	14.14	1 041 732	35.81	—	—	1 822 264	9.27
British Columbia	853 258	15.46	199 305	6.85	765 106	6.81	1 817 669	9.24
Saskatchewan	267 291	4.84	555 320	19.09	730 893	6.51	1 553 504	7.90
Newfoundland	577 568	10.46	33 789	1.16	—	—	611 357	3.11
Manitoba	330 818	5.99	89 541	3.08	43 632	0.39	463 991	2.36
Northwest Territories	274 927	4.98	—	—	32 845	0.29	307 772	1.57
New Brunswick	250 329	4.54	47 387	1.63	8 538	0.08	306 254	1.56
Yukon	195 772	3.55	32 404	1.11	—	—	228 176	1.16
Nova Scotia	—	—	90 117	3.10	113 600	1.01	203 717	1.04
Prince Edward Island	—	—	1 901	0.07	—	—	1 901	0.01
Total Canada	5 519 569	100.00	2 909 227	100.00	11 232 543	100.00	19 661 339	100.00

[p]Preliminary; — Nil.

Table 4. Canada, production of leading minerals

	Unit of Measure	Nfld.	P.E.I.	Nova Scotia	New Bruns-wick	Quebec	Ontario
Oil, crude	000 m³	—	—	—	1	—	94
	$000	—	—	—	46	—	7 246
Natural gas	000 m³	—	—	—	2 351	—	310 700
	$000	—	—	—	42	—	19 194
Iron ore	000 t	15 831	—	—	—	13 798	9 425
	$000	504 973	—	—	—	338 900	295 437
Copper	000 t	11	—	—	11	89	194
	$000	18 211	—	—	17 570	145 515	318 807
Natural gas byproducts	000 m³	—	—	—	—	—	—
	$000	—	—	—	—	—	—
Zinc	000 t	54	—	—	172	94	255
	$000	41 113	—	—	131 494	71 916	195 299
Coal	000 t	—	—	2 504	281	—	—
	$000	—	—	113 600	8 450	—	—
Nickel	000 t	—	—	—	—	—	97
	$000	—	—	—	—	—	489 616
Asbestos	000 t	27	—	—	—	1 216	—
	$000	12 539	—	—	—	509 431	—
Uranium (U)	t	—	—	—	—	—	4 454
	$000	—	—	—	—	—	341 097
Potash (K_2O)	000 t	—	—	—	—	—	—
	$000	—	—	—	—	—	—
Cement	000 t	. .	—	. .	. .	2 956	3 942
	$000	5 440	—	14 341	15 794	117 292	156 420
Sand and gravel	000 t	4 627	885	9 067	5 443	71 776	79 832
	$000	7 650	1 901	18 491	6 600	64 398	132 000
Gold	kg	498	—	—	218	14 463	22 052
	$000	3 610	—	—	1 551	102 515	156 490
Stone	000 t	635	—	2 087	3 175	67 999	30 481
	$000	2 310	—	7 590	10 150	183 588	87 360
Lead	t	8 123	—	—	70 877	227	6 570
	$000	6 595	—	—	57 539	184	5 333
Silver	kg	15 000	—	—	179 000	73 000	421 000
	$000	3 048	—	—	35 429	14 479	83 382
Molybdenum	t	—	—	—	—	813	—
	$000	—	—	—	—	9 270	—
Titanium dioxide	000 t	—	—	—	—	. .	—
	$000	—	—	—	—	110 667	—
Clay products	$000	569	—	4 718	2 306	16 904	57 655
Salt	000 t	—	—	913	—	—	4 674
	$000	—	—	19 234	—	—	66 495
Sulphur, elemental	000 t	—	—	—	—	—	. .
	$000	—	—	—	—	—	7
Iron, remelt	000 t	—	—	—	—	. .	—
	$000	—	—	—	—	79 550	—
Lime	000 t	—	—	—	. .	345	1 387
	$000	—	—	—	2 166	12 525	48 922
Platinum group	kg	—	—	—	—	—	8 678
	$000	—	—	—	—	—	55 672
Total leading minerals	$000	606 058	1 901	177 974	289 137	1 777 134	2 516 432
Total all minerals	$000	611 357	1 901	203 717	306 254	1 822 264	2 595 352
Leading minerals as a per cent of all minerals		99.1	100.0	87.4	94.4	97.5	97.0

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

by provinces and territories, 1978[p]

Manitoba	Saskat-chewan	Alberta	British Columbia	Yukon	N.W.T.	Total Canada
593	9 646	62 147	1 872	—	149	74 502
43 632	688 300	4 784 520	131 086	—	5 610	5 660 440
—	1 643 015	76 329 167	8 723 955	—	518 683	87 527 871
—	15 564	3 557 781	261 769	—	27 235	3 881 585
—	—	—	568	—	—	39 622
—	—	—	10 580	—	—	1 149 890
60	6	—	275	11	1	658
99 378	10 045	—	450 524	18 066	520	1 078 636
—	144	14 350	330	—	—	14 824
—	8 129	928 588	20 451	—	—	957 168
57	6	—	102	98	194	1 032
43 915	4 866	—	78 185	75 481	148 786	791 055
—	4 990	13 063	9 435	—	—	30 273
—	18 900	240 600	351 800	—	—	733 350
33	—	—	—	—	—	130
162 424	—	—	—	—	—	652 040
—	—	—	73	64	—	1 380
—	—	—	47 257	32 404	—	601 631
—	3 551	—	—	—	—	8 005
—	247 560	—	—	—	—	588 657
—	6 375	—	—	—	—	6 375
—	492 963	—	—	—	—	492 963
679	339	1 164	1 132	—	—	10 777
34 447	20 202	60 308	57 161	—	—	481 405
14 969	9 253	24 313	45 813	—	—	265 978
30 195	11 730	46 900	55 550	—	—	375 415
1 524	435	—	6 376	1 026	6 283	52 875
10 740	3 045	—	45 204	7 354	44 545	375 054
3 175	—	272	4 173	—	—	111 997
12 250	—	900	12 650	—	—	316 798
565	—	—	71 251	80 643	70 071	308 327
458	—	—	57 842	65 466	56 884	250 301
28 000	8 000	—	212 000	148 000	122 000	1 206 000
5 509	1 516	—	41 923	29 405	24 192	238 883
—	—	—	13 255	—	—	14 068
—	—	—	160 669	—	—	169 939
—	—	—	—	—	—	..
—	—	—	—	—	—	110 667
2 693	3 092	10 532	8 810	—	—	107 279
10	273	352	—	—	—	6 222
52	9 258	9 003	—	—	—	104 042
1	14	5 767	86	—	—	5 868
31	340	98 318	1 472	—	—	100 168
—	—	—	—	—	—	..
—	—	—	—	—	—	79 550
..	—	141	64	—	—	2 069
3 273	—	5 099	2 467	—	—	74 452
—	—	—	—	—	—	8 678
—	—	—	—	—	—	55 672
448 997	1 535 510	9 742 549	1 795 400	228 176	307 772	19 427 040
463 991	1 553 504	9 749 382	1 817 669	228 176	307 772	19 661 339
96.8	98.8	99.9	98.8	100.0	100.0	98.8

Table 5. Canada, percentage contribution of leading minerals to total value of mineral production, 1969-78

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978^p
Oil, crude	21.4	20.2	22.8	24.5	26.8	30.0	28.2	25.8^r	26.4	28.8
Natural gas	5.5	5.5	5.7	6.2	5.4	6.2	11.4	16.9^r	18.5	19.7
Iron ore	9.6	10.3	9.3	7.6	7.2	6.2	6.9	7.8^r	7.5	5.9
Copper	12.4	13.6	12.7	12.6	13.8	11.9	7.7	7.0^r	6.3	5.5
Natural gas byproducts	2.9	2.8	3.2	3.9	4.2	5.6	5.9	5.1^r	5.3	4.9
Zinc	7.8	7.0	7.0	7.5	7.8	7.4	6.5	5.2^r	4.5	4.0
Coal	1.1	1.5	2.0	2.4	2.1	2.6	4.4	3.9	3.3	3.7
Nickel	10.2	14.5	13.4	11.2	9.7	8.3	8.3	7.3^r	6.6	3.3
Asbestos	4.1	3.6	3.4	3.2	2.8	2.6	2.0	2.9	3.1	3.1
Uranium	...	...	...	...	0.1	...	...	1.5	1.9	3.0
Potash (K_2O)	1.5	1.9	2.3	2.1	2.1	2.6	2.7	2.3	2.2	2.5
Cement	3.4	2.7	3.1	3.3	2.9	2.4	2.5	2.4^r	2.3	2.4
Sand and gravel	2.6	2.3	2.6	2.8	2.6	2.3	2.3	2.1^r	2.0	1.9
Gold	2.0	1.5	1.3	1.9	2.3	2.2	2.0	1.3	1.5	1.9
Stone	1.9	1.5	1.6	1.6	1.5	1.5	1.5	1.5	1.6	1.6
Lead	2.0	2.2	1.8	1.8	1.5	1.1	1.2	0.8	1.1	1.3
Silver	1.8	1.4	1.2	1.2	1.4	1.7	1.3	1.1^r	1.1	1.2
Molybdenum	1.1	1.0	0.6	0.7	0.6	0.5	0.5	0.6	0.8	0.9
Titanium dioxide	0.6	0.6	0.7	0.6	0.6	0.4	0.4	0.5	0.4	0.6
Clay products	1.1	0.9	0.8	0.8	0.7	0.6	0.6	0.6	0.6	0.6
Salt	0.6	0.6	0.7	0.6	0.6	0.5	0.5	0.5	0.5	0.5
Sulphur, elemental	1.3	0.5	0.4	0.3	0.3	0.6	0.7	0.5	0.4	0.5
Iron, remelt	0.6	0.6	0.5	0.7	0.6	0.6	0.6	0.4	0.4	0.4
Lime	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4
Platinum group	0.7	0.8	0.7	0.5	0.5	0.5	0.4	0.3	0.3	0.3
Other minerals	3.4	2.1	1.8	1.6	1.5	1.3	1.2	1.3	1.0	1.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

^{p}Preliminary; ^{r}Revised; ...Amount too small to be expressed.

Table 6. Canada, value of mineral production by provinces and territories, 1969-78

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978[p]
					($ million)					
Alberta	1 205	1 396	1 641	1 979	2 760	4 517	5 750	6 934[r]	8 576	9 749
Ontario	1 222	1 593	1 555	1 536	1 855	2 435	2 354	2 712[r]	2 980	2 595
Quebec	717	803	766	786	936	1 222	1 232[r]	1 493	1 675	1 822
British Columbia	434	490	541	678	978	1 156	1 296	1 606	1 687	1 818
Saskatchewan	345	379	410	410	510	791	862	974[r]	1 208	1 554
Newfoundland	257	353	343	291	374	448	551	745	867	611
Manitoba	246	332	330	323	414	489	530	511[r]	564	464
Northwest Territories	119	134	116	120	165	223	206	225	256	308
New Brunswick	95	105	107	120	164	217	232	239	289	306
Yukon	35	78	93	107	151	171	230	125	210	228
Nova Scotia	58	58	60	57	61	83	102	127[r]	159	204
Prince Edward Island	1	1	1	1	2	1	2	2	2	2
Total	4 734	5 722	5 963	6 408	8 370	11 753	13 347[r]	15 693[r]	18 473	19 661

[p]Preliminary; [r]Revised.

Table 7. Canada, percentage contribution of provinces and territories to total value of mineral production, 1969-78

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978[p]
Alberta	25.5	24.4	27.5	30.9	33.0	38.4	43.1	44.2[r]	46.4	49.6
Ontario	25.8	27.8	26.0	23.9	22.2	20.7	17.6	17.3[r]	16.1	13.2
Quebec	15.2	14.0	12.9	12.3	11.2	10.4	9.2	9.5[r]	9.1	9.3
British Columbia	9.2	8.6	9.1	10.6	11.7	9.8	9.7	10.2[r]	9.1	9.2
Saskatchewan	7.3	6.6	6.9	6.4	6.1	6.7	6.5	6.2[r]	6.5	7.9
Newfoundland	5.4	6.2	5.8	4.5	4.5	3.8	4.1	4.7[r]	4.7	3.1
Manitoba	5.2	5.8	5.5	5.0	4.9	4.2	4.0	3.3	3.1	2.4
Northwest Territories	2.5	2.4	1.9	1.9	2.0	1.9	1.6	1.5	1.4	1.6
New Brunswick	2.0	1.8	1.8	1.9	1.9	1.9	1.7	1.5	1.6	1.6
Yukon	0.7	1.4	1.6	1.7	1.8	1.5	1.7	0.8	1.1	1.1
Nova Scotia	1.2	1.0	1.0	0.9	0.7	0.7	0.8	0.8	0.9	1.0
Prince Edward Island	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[p]Preliminary; [r]Revised.

Table 8. Canada's world role as a producer of certain

	Production Unit	World Production
Nickel (mine production)	t	777 900
	% of world total	
Zinc (mine production)	t	6 601 000
	% of world total	
Asbestos	t	5 696 188
	% of world total	
Potash (K_2O equivalent)	000 t	25 447
	% of world total	
Uranium (U)	t	29 188
	% of world total	
Molybdenum	t	95 184
	% of world total	
Elemental sulphur	000 t	31 217
	% of world total	
Gypsum	000 t	65 661
	% of world total	
Titanium concentrates (ilmenite)	t	4 094 000
	% of world total	
Silver	kg	10 123 404
	% of world total	
Platinum group metals (mine production)	kg	198 510
	% of world total	
Gold (mine production)	kg	1 225 528
	% of world total	
Copper (mine production)	t	7 980 300
	% of world total	
Lead (mine production)	t	3 665 900
	% of world total	
Aluminum (primary metal)	t	14 217 500
	% of world total	
Iron ore	000 t	826 721
	% of world total	
Cadmium (smelter production)	t	17 795
	% of world total	

[p] Preliminary; [e] Estimated.

important minerals, 1977[p]

Rank of Six Leading Countries with % of world total					
1	2	3	4	5	6
Canada 232 512 29.9	U.S.S.R. 135 000 17.4	New Caledonia 115 500 14.9	Australia 85 700 11.0	Cuba 37 000 4.8	Philippine Republic 36 800 4.7
Canada 1 300 228 19.7	U.S.S.R. 1 040 000 15.8	Australia 491 800 7.5	Peru 477 500 7.2	U.S.A. 456 200 6.9	Japan 275 700 4.2
U.S.S.R. 2 458 500[r] 43.2	**Canada** 1 517 359 26.6	Rep. of South Africa 380 164 6.7	Southern Rhodesia 200 000[r] 3.5	People's Rep. of China 200 000[r] 3.5	Italy 154 000[r] 2.7
U.S.S.R. 8 500[r] 33.4	**Canada** 5 764 22.7	East Germany 3 244 12.8	West Germany 2 341 9.2	U.S.A. 2 229 8.8	France 1 580[r] 6.2
U.S.A. 11 385 39.0	**Canada** 5 787 19.8	Rep. of South Africa 3 360 11.5	Territory of S.W. Africa 3 042 10.4	France 2 097 7.2	Gabon 1 600 5.5
U.S.A. 55 523 58.3	**Canada** 16 568 17.4	Chile 11 000[r] 11.6	U.S.S.R. 9 700[r] 10.2	People's Rep. of China 1 500[r] 1.6	Peru 463 0.5
U.S.A. 9 513 30.5	**Canada** 5 207 16.7	Poland 4 825 15.5	U.S.S.R. 3 020 9.7	France 2 020 6.5	Mexico 1 875 6.0
U.S.A. 12 147 18.5	**Canada** 7 234 11.0	Iran 6 700[r] 10.2	France 5 806 8.8	U.S.S.R. 5 200[r] 7.9	Spain 4 300 6.6
Australia 1 080 694 26.4	Norway 828 358 20.2	**Canada** 711 000 17.4	U.S.A. 579 240 14.2	U.S.S.R. 400 000[r] 9.8	Malaysia 153 666 3.8
Mexico 1 462 765 14.5	U.S.S.R. 1 399 700[r] 13.8	**Canada** 1 313 685 13.0	U.S.A. 1 187 095 11.7	Peru 936 215 9.3	Australia 852 982 8.4
Rep. of South Africa 91 755[r] 46.2	U.S.S.R. 90 200[r] 45.4	**Canada** 14 475 7.3	Japan 1 009 0.5	Colombia 809[r] 0.4	U.S.A. 172 0.1
Rep. of South Africa 699 886 57.1	U.S.S.R. 244.162[r] 19.9	**Canada** 53 921 4.4	Papua-New Guinea 40 435[r] 3.3	U.S.A. 34 225 2.8	Southern Rhodesia 18 662 1.5
U.S.A. 1 364 400 17.1	U.S.S.R. 1 100 000 13.8	Chile 1 056 200 13.2	**Canada** 759 423 9.5	Zambia 656 000 8.2	Zaire 481 600 6.0
U.S.S.R. 625 000[r] 17.1	U.S.A. 550 000 15.0	Australia 433 700 11.8	**Canada** 327 593 8.9	Peru 181 500 5.0	Mexico 163 500 4.5
U.S.A. 4 117 500 29.0	U.S.S.R. 2 200 000[r] 15.5	Japan 1 188 200 8.4	**Canada** 973 106 6.8	West Germany 741 800 5.2	Norway 637 000 4.5
U.S.S.R. 237 700 28.8	Australia 97 500 11.8	Brazil 67 000 8.1	U.S.A. 56 275 6.8	**Canada** 53 621 6.5	People's Rep. of China 50 000 6.1
U.S.S.R. 2 900[r] 16.3	Japan 2 844 16.0	U.S.A. 2 188 12.3	Belgium 1 434 8.1	West Germany 1 335 7.5	**Canada** 1 185 6.7

Table 9. Canada, census value added, commodity producing industries, 1970-76

	1970	1971	1972	1973	1974	1975	1976[p]
				($ million)			
Primary industries							
Agriculture	2 869	2 686[r]	2 846[r]	4 421[r]	5 550[r]	5 947	5 978
Forestry	694	698	829	1 109	1 245	1 125	1 348
Fishing	204	205	237	320	293	292	392
Hunting and trapping	13	11	17	28	31	21	31
Mining[1]	3 831	3 826	4 292	6 289	8 930	9 750	11 361
Electrical power	1 707	1 685[r]	1 841[r]	2 137[r]	2 468	2 706	3 134
Total	9 318	9 111[r]	10 062[r]	14 304[r]	18 517[r]	19 841	22 244
Secondary industries							
Manufacturing	21 418	23 188	25 982	30 767	37 654	38 716	42 510
Construction	6 167	7 581	8 244	9 695	11 850	13 718	17 270
Total	27 585	30 769	34 226	40 462	49 504	52 434	59 780
Grand Total	36 903	39 880[r]	44 288[r]	54 766	68 021	72 275	82 024

[1]Cement, lime, clay and clay products (from domestic clays) industries are included under "Manufacturing".
[p]Preliminary; [r]Revised.

Table 10. Canada, census value added, total activity, mining and mineral manufacturing industries, 1972-76

	1972	1973	1974	1975	1976p
			($000)		
Mining					
Metallic minerals					
Placer gold	113				
Gold quartz	75 055	119 192	163 590	149 869	113 749
Copper-gold-silver	449 533	1 026 497	1 028 643	595 410	600 677
Silver-cobalt	3 626	(1)	(1)	(1)	(1)
Silver-lead-zinc	176 263	292 731	382 281	320 776	233 678
Nickel-copper	529 445	820 344	1 049 650	729 656	888 080
Iron	279 610	345 830	403 910	556 710	732 118
Miscellaneous metal mines	96 114	106 713	143 301	211 517	270 105
Total	1 609 759	2 711 307	3 171 375	2 563 938	2 838 407
Industrial minerals					
Asbestos	161 736	176 368	239 816	230 612	373 206
Feldspar, quartz and nepheline syenite	11 069	13 933	15 339	14 707	18 454
Gypsum	14 512	16 748	16 542	14 861	15 753
Peat	11 500	14 216	19 772	20 556	23 726
Potash	112 245	128 957	232 652	298 471	262 052
Salt	32 376	36 731	49 751	45 888	70 671
Sand and gravel	54 864	59 841	83 522	102 305	99 014
Stone	57 898	66 999	92 852	111 031	110 988
Talc and soapstone	1 162	1 456	1 412	(2)	(2)
Miscellaneous nonmetals	11 263	12 400	20 711	25 711	23 899
Total	468 625	527 649	772 369	864 142	997 763
Fuels					
Coal	130 615	166 705	261 246	483 493	474 338
Petroleum and natural gas	2 083 466	2 883 273	4 724 990	5 838 459	7 050 003
Total	2 214 081	3 049 978	4 986 236	6 321 952	7 524 341
Total mining industry	4 292 465	6 288 934	8 929 980	9 750 032	11 360 511
Mineral manufacturing					
Primary metal industries					
Iron and steel mills	921 737	1 169 567	1 398 735	1 364 022	1 498 808
Steel pipe and tube mills	112 947	115 589	152 339	170 265	148 786
Iron foundries	138 758	163 711	222 415	238 117	241 893
Smelting and refining	556 918	590 724	794 193	886 405	812 654
Aluminum rolling, casting and extruding	98 186	94 600	146 721	132 636	149 366
Copper and alloy rolling, casting and extruding	67 075	91 040	91 301	68 282	71 429
Metal rolling, casting and extruding, nes	64 972	83 647	106 108	88 446	113 332
Total	1 960 593	2 308 878	2 911 812	2 948 173	3 036 268
Nonmetallic mineral products industries					
Cement manufacturers	154 787	172 236	190 396	210 342	249 142
Lime manufacturers	12 584	17 871	25 033	24 913	30 041
Concrete products manufacturers	182 476	197 733	248 548	282 131	282 089
Ready-mix concrete manufacturers	163 640	202 110	236 308	282 597	282 614
Clay products (domestic clay)	39 974	41 595	51 531	59 732	65 881
Clay products (imported clay)	27 039	33 802	41 661	41 698	39 078
Refractories manufacturers	22 815	28 075	37 163	45 823	44 393

Table 10. (cont'd)

	1972	1973	1974	1975	1976[p]
			($000)		
Mineral manufacturing (cont'd)					
Stone products manufacturers	9 363	11 002	12 327	13 975	16 282
Glass manufacturers	150 110	162 436	190 028	185 639	205 068
Glass products manufacturers	59 107	73 340	72 378	74 327	87 403
Abrasive manufacturers	33 063	38 038	45 962	43 863	55 076
Other nonmetallic mineral products industries	155 188	171 604	195 228	237 369	270 215
Total	1 010 146	1 149 842	1 346 563	1 502 409	1 627 282
Petroleum and coal products industries					
Petroleum refining	430 520	539 560	925 246	789 680	945 816
Manufacturers of lubricating oil and greases	21 156	22 410	26 289	32 633	32 635
Other petroleum and coal products industries	13 843	18 725	26 717	43 639	45 749
Total	465 519	580 695	978 252	865 952	1 024 200
Total mineral manufacturing	3 436 258	4 039 415	5 236 627	5 316 534	5 687 750
Total mining and mineral manufacturing	7 728 723	10 328 349	14 166 607	15 066 566	17 048 261

(1) Included with "Silver-lead-zinc" mines. (2) Included with "Miscellaneous nonmetals".
[p] Preliminary; .. Not available; nes Not elsewhere specified.

Table 11. Canada, indexes of physical volume of total industrial production, mining and mineral manufacturing, 1964-78 (1971 = 100)

	1964	1965	1966	1967	1968	1969	1970	1971	1972r	1973r	1974r	1975r	1976r	1977	1978p
Total industrial production	68.0	73.8	79.2	82.3	87.6	93.6	94.9	100.0	107.5	118.1	122.2	114.9	121.3	125.2	132.4
Total mining	67.0	70.5	74.1	79.9	86.2	86.9	98.7	100.0	106.5	119.3	117.3	107.1	109.8	114.0	105.3
Metals															
All metals	75.5	78.0	81.5	89.9	95.5	88.4	105.4	100.0	96.1	107.5	106.0	97.7	103.2	105.9	85.1
Placer gold and gold quartz mines	164.6	159.7	150.0	134.1	121.7	118.2	105.3	100.0	90.0	78.7	66.9	67.2	69.3	67.5	64.8
Iron mines	65.6	65.9	82.7	88.8	104.8	91.9	116.1	100.0	83.3	102.6	92.1	88.5	119.6	115.8	82.9
Other metal mines	66.7	76.5	76.5	87.8	92.0	85.3	103.0	100.0	99.6	110.1	111.4	101.4	100.7	105.4	86.7
Fuels															
All Fuels	53.2	56.8	61.3	67.1	73.4	80.8	92.6	100.0	118.5	134.1	128.2	118.6	110.9	113.7	113.6
Coal	74.8	75.1	70.7	70.3	68.7	68.4	87.5	100.0	148.2	158.6	159.1	200.6	184.9	203.4	226.8
Oil, crude natural gas	51.7	55.5	60.7	66.8	73.7	81.7	93.0	100.0	116.1	132.1	125.7	111.9	104.8	106.3	104.3
Nonmetals															
All nonmetals	61.0	65.6	71.8	76.8	83.7	92.8	95.0	100.0	99.4	107.9	123.6	102.8	115.5	127.4	120.6
Asbestos	74.0	71.7	79.5	78.9	82.6	89.8	95.2	100.0	99.0	103.4	108.2	70.1	99.2	102.4	85.5
Mineral manufacturing															
Primary metals	76.8	84.4	87.9	84.5	92.9	94.9	100.9	100.0	101.7	113.2	122.6	109.9	107.7	116.1	123.7
Nonmetallic mineral products	76.0	83.3	86.0	80.7	87.1	90.5	86.6	100.0	107.7	117.6	123.3	116.5	118.5	121.5	133.7
Petroleum and coal products	73.0	75.7	79.2	79.9	88.7	92.1	94.4	100.0	112.8	128.8	132.5	130.8	129.2	135.0	136.7

p Preliminary; r Revised.

Table 12. Canada, indexes of real domestic product by industries, 1968-78 (1971 = 100)

	1968	1969	1970	1971	1972	1973[r]	1974[r]	1975[r]	1976[r]	1977[r]	1978[p]
Real domestic product, all industries	86.9	92.2	94.4	100.0	105.5	113.6	119.0	119.8	126.1	130.1	135.3
Agriculture	85.2	90.6	89.0	100.0	88.5	93.7	89.8	98.0	104.2	108.8	117.8
Forestry	94.4	102.4	103.3	100.0	102.4	123.9	117.8	97.6	112.3	116.4	123.8
Fishing and trapping	115.6	102.6	105.4	100.0	95.5	100.4	89.3	88.3	102.1	106.9	126.5
Mining (including milling), quarries and oil wells	86.2	86.9	98.7	100.0	106.5	119.3	117.3	107.1	109.8	114.0	105.3
Electric power, gas and water utilities	78.2	85.4	93.3	100.0	111.4	120.7	130.2	130.7	142.9	151.0	159.7
Manufacturing	89.1	95.8	94.5	100.0	107.1	117.6	122.0	114.3	120.8	124.1	133.8
Construction	90.1	92.5	90.9	100.0	102.4	107.5	112.6	116.7	122.8	121.8	120.7
Transportation, storage and communication	82.8	89.0	94.2	100.0	107.0	116.3	124.0	126.9	133.7	139.5	145.2
Trade	87.1	91.7	93.2	100.0	109.2	118.9	128.0	128.8	135.1	136.5	140.9
Community, business and personal service	85.7	91.6	95.5	100.0	104.2	108.8	115.0	119.9	125.7	129.9	134.0
Finance, insurance and real estate	86.7	92.4	94.6	100.0	106.0	114.7	120.6	127.8	135.6	143.7	150.5
Public administration and defence	89.1	91.6	95.2	100.0	104.3	109.8	114.0	119.6	123.0	126.1	128.8

[p] Preliminary; [r] Revised.

Table 13. Canada, value of exports of crude minerals and fabricated mineral products, by main groups, 1974-78

	1974	1975	1976[r]	1977	1978[p]
			($ million)		
Ferrous					
Crude material	574.0	721.5	984.4	1 115.0	853.6
Fabricated material	917.7	913.1	1 007.4	1 242.9	1 695.7
Total	1 491.7	1 634.6	1 991.8	2 357.9	2 549.3
Nonferrous					
Crude material	1 801.8	1 519.6	1 528.0	1 614.8	1 549.2
Fabricated material	2 102.7	1 843.5	2 231.4	2 578.5	3 359.7
Total	3 904.5	3 363.1	3 759.4	4 193.3	4 908.9
Nonmetals					
Crude material	799.0	794.9	1 103.4	1 276.0	1 375.8
Fabricated material	178.4	162.7	194.7	253.6	377.2
Total	977.4	957.6	1 298.1	1 529.6	1 753.0
Mineral fuels					
Crude material	4 232.6	4 637.3	4 464.0	4 428.9	4 514.8
Fabricated material	611.3	638.5	562.0	649.1	776.6
Total	4 843.9	5 275.8	5 026.0	5 078.0	5 291.4
Total minerals and products					
Crude material	7 407.4	7 673.3	8 079.8	8 434.7	8 293.4
Fabricated material	3 810.1	3 557.8	3 995.5	4 724.1	6 209.2
Total	11 217.5	11 231.1	12 075.3	13 158.8	14 502.6

[p] Preliminary; [r] Revised.

Table 14. Canada, value of imports of crude minerals and fabricated mineral products, by main groups, 1974-78

	1974	1975	1976[r]	1977	1978[p]
			($ million)		
Ferrous					
Crude material	94.6	179.5	129.8	106.0	223.8
Fabricated material	1 759.8	1 494.7	1 274.0	1 501.0	1 838.9
Total	1 854.4	1 674.2	1 403.8	1 607.0	2 062.7
Nonferrous					
Crude material	302.7	288.9	294.6	409.0	476.0
Fabricated material	816.2	621.8	600.4	662.1	949.7
Total	1 118.9	910.7	895.0	1 071.1	1 425.7
Nonmetals					
Crude material	121.0	183.0	157.9	170.6	222.9
Fabricated material	326.1	358.7	413.5	472.0	537.1
Total	447.1	541.7	571.4	642.6	760.0
Mineral fuels					
Crude material	2 955.5	3 886.8	3 834.1	3 876.4	4 106.8
Fabricated material	373.6	275.8	219.7	299.7	378.3
Total	3 329.1	4 162.6	4 053.8	4 176.1	4 485.1
Total minerals and products					
Crude material	3 473.8	4 538.2	4 416.4	4 562.0	5 029.5
Fabricated material	3 275.7	2 751.0	2 507.6	2 934.8	3 704.0
Total	6 749.5	7 289.2	6 924.0	7 496.8	8 733.5

[p] Preliminary; [r] Revised.

Table 15. Canada, value of exports of crude minerals and fabricated mineral products in relation to total export trade, 1974-78

	1974		1975		1976r		1977		1978p	
	$ Million	% of Total	$ Million	% of Total	$ Million	% of Total	$ Million	% of Total	$ Million	% of Total
Crude material	7 407.4	23.3	7 673.3	23.6	8 079.8	21.5	8 434.7	19.3	8 293.4	16.0
Fabricated material	3 810.1	12.0	3 557.8	10.9	3 995.5	10.6	4 724.1	10.8	6 209.2	12.0
Total	11 217.5	35.3	11 231.1	34.5	12 075.3	32.1	13 158.8	30.1	14 502.6	28.0
Total exports, all products	31 739.5	100.0	32 586.9	100.0	37 650.7	100.0	43 683.9	100.0	51 918.9	100.0

p Preliminary; r Revised.

Table 16. Canada, value of imports of crude minerals and fabricated mineral products in relation to total import trade, 1974-78

	1974		1975		1976		1977		1978p	
	$ Million	% of Total	$ Million	% of Total	$ Million	% of Total	$ Million	% of Total	$ Million	% of Total
Crude material	3 473.8	10.9	4 538.2	13.0	4 416.4r	12.0r	4 562.0	10.8	5 029.5	10.1
Fabricated material	3 275.7	10.3	2 751.0	7.9	2 507.6	6.7	2 934.8	6.9	3 704.0	7.4
Total	6 749.5	21.2	7 289.2	20.9	6 924.0r	18.7r	7 496.8	17.7	8 733.5	17.5
Total imports, all products	31 880.3	100.0	34 829.7	100.0	37 494.0r	100.0	42 332.3r	100.0	49 937.7	100.0

p Preliminary; r Revised.

Table 17. Canada, value of exports of crude minerals and fabricated mineral products, by main groups and destination, 1978[p]

	United Kingdom	United States	Other Countries	Total
	($ million)			
Ferrous materials and products	75.6	2 010.4	463.3	2 549.3
Nonferrous materials and products	476.8	2 644.1	1 788.0	4 908.9
Nonmetallic mineral materials and products	54.8	954.0	744.2	1 753.0
Mineral fuels, materials and products	8.0	4 527.7	755.7	5 291.4
Total	615.2	10 136.2	3 751.2	14 502.6
Percentage of total mineral exports	4.2	69.9	25.9	100.0

[p] Preliminary.

Table 18. Canada, value of imports of crude minerals and fabricated mineral products, by main groups and origin, 1978[p]

	United Kingdom	United States	Other Countries	Total
	($ million)			
Ferrous materials and products	144.7	1 292.6	625.4	2 062.7
Nonferrous materials and products	36.7	901.3	487.7	1 425.7
Nonmetallic mineral materials and products	25.4	528.0	206.6	760.0
Mineral fuels, materials and products	4.0	1 385.6	3 095.5	4 485.1
Total	210.8	4 107.5	4 415.2	8 733.5
Percentage of total mineral imports	2.4	47.0	50.6	100.0

[p] Preliminary.

Table 19. Canada, value of exports of crude minerals and fabricated mineral products, by commodity and destination, 1978[p]

	U.S.A.	United Kingdom	E.F.T.A.[1]	E.E.C.[2]	Japan	Other Countries	Total
				($ 000)			
Aluminum	706 269	4 809	7 177	12 182	212 304	254 484	1 197 225
Asbestos	178 924	37 094	13 658	122 490	37 644	205 394	595 204
Copper	218 386	113 343	34 057	124 828	241 526	98 107	830 247
Fuels	4 527 650	8 026	21 018	47 774	596 997	89 943	5 291 408
Iron ore	546 569	57 225	1 548	137 062	27 380	13 009	782 793
Lead	67 929	29 971	1 772	14 079	36 840	11 752	162 343
Molybdenum	19 984	12 036	689	44 431	53 443	6 389	136 972
Nickel	503 189	134 647	81 401	65 703	7 577	67 089	859 606
Primary ferrous metals	172 154	6 791	901	44 309	18 095	39 885	282 135
Uranium	163 911	39 106	—	3 348	791	—	207 156
Zinc	242 635	42 809	4 416	112 664	31 656	72 850	507 030
All other minerals	2 788 583	129 316	17 013	144 747	99 351	471 460	3 650 470
Total	10 136 183	615 173	183 650	873 617	1 363 604	1 330 362	14 502 589

[1] European Free Trade Association, includes Austria, Norway, Portugal, Sweden. Switzerland, Finland and Iceland. [2] European Economic Community, includes Belgium and Luxembourg, France, Italy, Netherlands, West Germany, Denmark and Ireland, and excludes United Kingdom.
[p] Preliminary; — Nil.

Table 20. Canada, apparent consumption[1] of some minerals and relation to production[2], 1975-78

	Unit of Measure	1975 Apparent Consumption	1975 Production	1975 Consumption as % of Production	1976 Apparent Consumption	1976 Production	1976 Consumption as % of Production
Asbestos	t	. .	1 055 667	. .	44 116[r]	1 536 091	2.9
Cement	t	9 679 433[r]	10 193 984	95.0	8 909 101[r]	9 515 452[r]	93.6
Gypsum	t	2 083 113	5 719 451	36.4	2 258 681	6 002 154	37.6
Iron ore	t	13 677 126[r]	44 892 530	30.5	13 751 609	55 416 346	24.8
Lime	t	1 255 267	1 459 202	86.0	1 657 915	1 930 388[r]	85.9
Quartz (silica)	t	3 497 448	2 491 715	140.4	3 810 533	2 520 476	151.2
Salt	t	5 533 450[e]	5 122 573	108.0	6 093 580[r]	5 994 020	101.7

	Unit of Measure	1977 Apparent Consumption	1977 Production	1977 Consumption as % of Production	1978[p] Apparent Consumption	1978[p] Production	1978[p] Consumption as % of Production
Asbestos	t	106 228	1 517 360	7.0	. .	1 380 000	. .
Cement	t	8 622 839	9 639 679	89.5	9 362 317	10 777 000	86.9
Gypsum	t	2 263 650	7 233 931	31.3	2 781 391	7 889 000	35.3
Iron ore	t	11 065 909	53 621 097	20.6	12 378 916	39 622 000	31.2
Lime	t	1 564 486	1 899 546	82.4	1 621 570	2 069 000	78.4
Quartz (silica)	t	3 362 788	2 316 680	145.2	3 159 571	1 983 000	159.3
Salt	t	6 002 545	6 039 483	99.4	5 943 926	6 222 000	95.5

[1] Apparent consumption is production, plus imports, less exports. [2] Production refers to producers' shipments.
[p] Preliminary; [r] Revised; [e] Estimated; . . Not available.

Table 21. Canada, reported consumption of minerals

	Unit of Measure	1975 Consumption	1975 Production	1975 Consumption as % of Production	1976 Consumption	1976 Production	1976 Consumption as % of Production
Metals							
Aluminum	t	293 280	878 056	33.4	322 206	628 137	51.3
Antimony	kg	454 164	. .	. .	437 998	. .	. .
Bismuth	kg	29 267	156 605	18.7	21 105	129 578	16.3
Cadmium	kg	38 209	1 191 674	3.2	53 815	1 313 723	4.1
Chromium (chromite)	t	36 790	—	. .	30 783	—	. .
Cobalt	kg	123 002	1 354 213	9.1	160 492	1 356 337	11.8
Copper	t	185 198[1]	733 826	25.2	206 205[1]	730 930	28.2
Lead	t	89 193[2]	349 133	25.6	107 654[2]	256 323	42.0
Magnesium	t	5 404	3 826	141.2	4 230	6 092	69.4
Manganese ore	t	160 976	—	. .	238 629	—	. .
Mercury	kg	32 869	413 676	8.0	26 039	—	. .
Molybdenum (Mo content)	kg	1 436 883	13 323 144[r]	10.8[r]	1 260 329	14 618 607	8.6
Nickel	t	11 308	242 180	4.7	9 972	240 825	4.1
Selenium	kg	9 933	182 385	5.5	11 212	109 649	10.2
Silver	kg	642 089	1 234 642	52.0	551 212	1 281 437	43.0
Tellurium	kg	614	19 854	3.1	589	48 698	1.2
Tin	t	4 315	319	1 352.7	4 849	274	1 769.7
Tungsten (W content)	kg	451 336	1 447 731	30.5	337 345	2 168 153	15.6
Zinc	t	98 280[2]	1 055 151	9.3	98 897[2]	982 057	10.1
Nonmetals							
Barite	t	40 229	81 356	49.5	58 066	100 266	57.9
Feldspar	t	5 630	—	. .	4 053	—	. .
Fluorspar	t	202 126	90 883[r]	222.4[r]	128 352	113 061[r]	113.5[r]
Mica	kg	3 717 643	. .	. .	5 023 989	. .	. .
Nepheline syenite	t	103 774	468 427	22.2	103 241	540 121	19.1
Phosphate rock	t	2 095 368	—	. .	1 582 861	—	. .
Potash (K_2O)	t	206 813[3]	4 673 425	4.4	242 077[3]	5 215 435	4.6
Sodium sulphate	t	256 385	472 196	54.3	265 608	460 193	57.7
Sulphur	t	832 702	4 078 780	20.4	651 032	4 029 427	16.2
Talc, etc.	t	40 532	66 029	61.4	43 595	68 834	63.3
Fuels							
Coal	t	26 126 654	25 258 956	103.4	28 219 804	25 476 044	110.8
Natural gas	000 m^3	37 526 031[4]	87 519 740	42.9	38 834 918[4]	87 683 816	44.3
Oil, crude	m^3	98 739 939[5]	82 802 176	119.3	98 326 624[5]	76 075 000	129.2

Note: Unless otherwise stated, consumption refers to reported consumption of refined metals or nonmetallic minerals by consumers. Production of metals, in most cases, refers to production in all forms, and includes the recoverable content of ores, concentrates, matte, etc., and metal content of primary products recoverable at domestic smelters and refineries. Production of nonmetals refers to producers' shipments. For fuels, production is equivalent to actual output, less waste.

[1] Producers' domestic shipments of refined metal. [2] Includes primary and secondary refined metal. [3] Consumption of potash fertilizers for year ended June 30. [4] Domestic sales. [5] Refinery receipts.

[p] Preliminary; — Nil; . . Not available; [r] Revised.

and relation to production, 1975-78

1977			1978p		
Consumption	Production	Consumption as % of Production	Consumption	Production	Consumption as % of Production
332 393	973 106	34.2	380 290	1 048 469	36.3
370 867	. .	. .	347 906	. .	. .
25 016	164 685	15.2	15 004	158 000	9.5
50 369	1 185 446	4.3	47 523	965 000	4.9
30 299	—	. .	27 472	—	. .
146 763	1 484 669	9.9	162 495	1 163 000	14.0
200 372[1]	759 423	26.4	228 694[1]	657 521	34.8
106 962[2]	280 955	38.1	100 762[2]	308 327	32.7
6 222	7 633	81.5	12 371	8 269	149.6
182 157	—	. .	201 320	—	. .
30 447	—	. .	29 904	—	. .
1 149 738r	16 567 555	6.9	1 257 602	14 068 000	8.9
9 033	232 512	3.9	11 790	130 055	9.1
12 476	161 308	7.7	14 364	123 000	11.7
298 724	1 313 685	22.7	329 320	1 251 576	26.3
291	35 116	0.8	. .	27 000	. .
5 286	328	1 611.6	4 922	375	1 312.5
449 365	2 284 409	19.7	390 759	2 885 619	13.5
105 412[2]	1 070 515	9.9	123 477[2]	1 032 358	12.0
53 508	116 950	45.8	64 593	105 741	61.1
4 271	—	. .	4 586	—	. .
119 991	95 354r	125.8	143 039	—	. .
4 221 132	. .	. .	. .	. .	. .
86 014	574 558	15.0	88 806	579 000	15.3
1 671 399	—	. .	1 833 796	—	. .
234 232[3]	5 764 181	4.1	. .	6 375 000	. .
254 872	394 795	64.6	227 766	378 000	60.3
687 381	5 207 028	13.2	645 745	5 868 000	11.0
41 884	72 400	57.9	43 119	67 000	64.4
30 895 999	28 681 759	107.7	31 738 310	30 476 855	104.1
40 547 055	91 147 120	44.5	41 745 254	88 324 075	47.3
104 238 897[5]	76 447 000	136.4	103 746 001[5]	76 001 000	136.5

Table 22. Canada, domestic consumption of principal refined metals in relation to refinery production[1], 1969-78

	Unit of Measure	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978[p]
Copper											
Domestic consumption[2]	t	205 279	215 834	200 536	207 661	230 982	247 985	185 194	206 205	200 372	228 694
Production	t	407 536	493 261	477 545	495 944	497 581	559 125	529 199	510 469	508 767	446 278
Consumption of production	%	50.4	43.8	42.0	41.9	46.4	44.4	35.0	40.4	39.4	51.2
Zinc											
Domestic consumption[3]	t	110 150	98 306	109 380	125 019	116 386	117 619	98 280	98 897	105 412	..
Production	t	423 072	413 196	372 529	476 423	532 556	437 725	426 902	472 316	494 938	495 420
Consumption of production	%	26.0	23.8	29.4	26.2	21.9	26.9	23.0	20.9	21.3	..
Lead											
Domestic consumption[3]	t	96 084	84 765	85 835	78 559	108 349	99 734	89 192	107 654	110 763	..
Production	t	169 773	185 637	168 332	186 860	186 891	126 460	171 517	175 720	187 457	194 054
Consumption of production	%	56.6	45.7	51.0	42.0	58.0	78.9	52.0	61.3	59.1	..
Aluminum											
Domestic consumption[4]	t	244 057	250 150	292 188	302 591	331 782	359 790	293 280	332 206	322 393	..
Production	t	978 596	962 541	1 002 116	907 130	930 210	1 006 632	878 056	628 049[r]	973 524	1 048 469
Consumption of production	%	24.9	26.0	29.2	33.4	35.7	35.7	33.4	51.3[r]	34.1	..

[1] Production of refined metal from all sources, including metal derived from secondary materials at primary refineries. [2] Producers' domestic shipments of refined metal. [3] Consumption of primary and secondary refined metal, reported by consumers. [4] Consumption of primary refined metal, reported by consumers.
[p] Preliminary; [r] Revised; .. Not available.

Table 23. Average annual prices[1] of main metals, 1974-78

	Unit of Measure	1974	1975	1976	1977	1978
Aluminum, major U.S. producer	cents/lb	34.133	39.786	44.341	51.339	53.075
Antimony, New York dealer	cents/lb	207.070	149.425	156.105	123.716	114.461
Bismuth, major producer	$/lb	8.410	7.715	7.500	6.010	3.378
Cadmium, U.S. producer	cents/lb	407.800	335.500	266.200	296.200	245.000
Calcium, metal crowns	$/lb	1.071	1.315	1.335	1.482	1.680
Chrome, U.S. metal, 9% carbon	$/lb	1.900	2.570	2.640	2.900	3.080
Cobalt metal, shot/cathode/ 250 kg	$/lb	3.474	3.979	4.508	5.633	12.246
Columbite, spot ore	$/lb	. .	1.800-1.900	2.500-2.800	2.637-3.500	2.883-3.521
Copper, U.S. producer refinery	cents/lb	76.649	63.535	68.824	65.808	65.510
Gold, Royal Canadian Mint buying price	$ Cdn./troy oz	41.180	43.220	39.850	43.490	. .
London free market[2]	$ Cdn./troy oz	155.670	163.780	123.070	157.089	220.407
Iridium, major producer	$/troy oz	401.67-409.17	475.00-485.00	316.66-326.66	300.00-310.00	300.00-310.00
Iron ore						
Non-Bessemer						
Mesabi	$/long ton	14.000	17.890	18.500-19.670	21.103-21.180	21.647
Old Range	$/long ton	14.260	18.140	18.750-19.920	21.353-21.430	21.897
Lead, U.S. producer	cents/lb	22.533	21.529	23.102	30.703	33.653
Manganese, U.S. metal, regular	cents/lb	41.771	54.000	55.333-57.000	58.000	58.000
Magnesium, U.S. primary ingot	cents/lb	60.548	82.000	89.537	97.487	100.500
Mercury, New York	$/flask (76 lb)	281.690	158.115	121.302	135.710	153.322
Molybdenum, climax concentrate	$/lb	2.057	2.493	2.999	3.730	4.644

Table 23. (cont'd)

	Unit of Measure	1974	1975	1976	1977	1978
Nickel, major producer cathode	cents/lb	173.500	207.300	225.600	236.000	209.100
Osmium, major producer	$/troy oz	200.00-225.00	200.00-225.00	200.00-225.00	170.00-184.00	150.00-155.00
Palladium, major producer	$/troy oz	133.220	92.702	50.928	59.702	70.873
Platinum, major producer	$/troy oz	180.850	164.005	161.729	162.544	237.250
Rhenium, U.S. producer, powder	$/lb	737.500	570.520	540.000	468.540	357.160
Rhodium, major producer	$/troy oz	335.58-342.92	337.50-347.50	350.00-364.166	441.666-453.750	516.667-650.00
Ruthenium, major producer	$/troy oz	60.00-65.00	60.00-65.00	60.00-65.00	60.00-65.00	60.00-65.00
Selenium, major producer commercial	$/lb	16.33	18.00	18.00	17.00	15.00
Silver, Handy & Harman, N.Y.	cents/troy oz	470.798	441.852	435.346	462.302	540.089
Tantalum, U.S. rod	$/lb	41.25-56.17	46.75-60.50	52.00-80.00	52.00-80.00	47.30-85.87
Tellurium, major producer, slab	$/lb	8.330	9.333	10.500-11.083	17.416-17.666	20.000-22.500
Tin, New York market	cents/lb	396.266	320.345	349.241	499.381	587.032
Titanium, U.S. sponge	$/lb	1.850	2.554	2.700	2.671-2.784	3.105
Titanium, rutile ore	$/short ton	469.167	710.000	526.666	485.000	317.500
Tungsten, U.S. hydrogen red metal	$/lb	8.06-9.75	10.210-12.010	10.087-12.337	14.065-15.050	13.900-15.500
Vanadium, pentoxide metal	$/lb	..	2.980-3.060	2.600-3.229	2.750-3.350	2.950-3.810
Zinc, U.S. prime western	cents/lb	35.945	38.959	37.010	34.392	30.971

[1]These prices, except for gold, are in United States currency and are quoted from *Metals Week*. [2]Average of a.m. and p.m. fixings of the London Gold Market, converted to Canadian dollars.

. . Not available.

Table 24. Canada, wholesale price indexes of minerals and mineral products, 1975-78 (1935-39 = 100)

	1975	1976	1977	1978[p]
Iron and products	519.9	563.4	596.2	648.3
Pig iron	748.8	814.0	796.2	848.0
Rolling mill products	507.2	540.7	567.4	614.3
Iron foundries and pipe and tubing	557.1	604.4	657.0	713.6
Wire	620.6	667.7	692.6	731.0
Scrap iron and steel	529.7	532.4	466.0	536.7
Tinplate and galvanized steel	420.2	481.0	529.7	584.9
Nonferrous metal and products				
Total (including gold)	417.4	441.3	497.9	537.4
Total (excluding gold)	606.2	647.1	732.7	785.1
Copper and products	541.4	521.8	495.6	533.0
Lead and products	420.5	379.3	472.5	552.3
Silver	1 176.7	1 061.2	1 056.4	1 345.5
Tin	704.4	819.1	1 026.7	1 312.8
Zinc and products	842.0	763.8	654.3	629.8
Nonmetallic minerals and products	392.1	432.4	474.9	510.3
Clay and clay products	422.0	476.6	530.7	573.7
Pottery	493.4	533.7	564.5	652.3
Petroleum products	394.3	452.4	515.4	553.9
Asphalt	516.2	589.4	671.1	678.0
Asphalt shingles	216.9	. .	. .	. .
Plaster	276.3	301.2	337.5	369.1
Lime	625.2	686.4	761.1	883.9
Cement	322.8	377.5	405.5	445.2
Sand and gravel	327.3	349.6	377.0	404.3
Crushed stone	271.2	314.7	353.8	374.8
Building stone	364.8	415.2	490.5	518.8
Asbestos	679.4	790.0	853.2	896.3
General wholesale price index				
(all products)	491.6	512.4	559.5	610.2

[p] Preliminary; . . Not available.

Table 25. Canada, general wholesale price index, and wholesale price indexes of mineral and nonmineral products, 1954-78 (1935-39 = 100)

	Mineral Products			Nonmineral Products					General Wholesale Price Index
	Iron Products	Nonferrous Metal Products	Nonmetallic Mineral Products	Vegetable Products	Animal Products	Textile Products	Wood Products	Chemical Products	
1954	213.4	167.5	177.0	196.8	236.0	231.1	286.8	176.4	217.0
1955	221.4	187.6	175.2	195.1	226.0	226.2	295.7	177.0	218.9
1956	239.8	199.2	180.8	197.3	227.7	230.2	303.7	180.1	225.6
1957	252.7	176.0	189.3	197.0	238.4	236.0	299.4	182.3	227.4
1958	252.6	167.3	188.5	198.1	250.7	229.0	298.5	183.0	227.8
1959	255.7	174.6	186.5	199.5	254.3	228.0	304.0	187.0	230.6
1960	256.2	177.8	185.6	203.0	247.6	229.8	303.8	188.2	230.9
1961	258.1	181.6	185.2	203.1	254.7	234.5	305.1	188.7	233.3
1962	256.2	192.1	189.1	211.6	262.5	241.2	315.9	190.5	240.0
1963	253.6	197.5	189.5	227.8	255.6	248.0	323.4	189.3	244.6
1964	256.4	205.9	190.9	223.3	250.8	248.4	330.9	191.2	245.4
1965	264.5	217.6	191.6	218.4	270.7	246.4	334.0	200.2	250.3
1966	268.0	229.9	193.7	225.9	296.2	251.5	337.8	207.1	259.5
1967	274.4	240.2	199.2	230.9	293.1	252.7	346.3	212.6	264.1
1968	276.8	250.8	206.0	230.8	294.6	256.5	367.9	213.7	269.9
1969	285.8	264.0	210.0	237.9	322.4	256.7	389.4	219.7	282.4
1970	305.1	281.0	215.7	238.4	326.0	257.0	377.5	225.7	286.4
1971	316.4	260.1	225.8	237.1	326.0	261.9	394.4	237.8	289.9
1972	325.0	262.9	233.6	249.2	371.8	278.3	436.0	245.5	310.3
1973	354.3	326.5	254.1	354.9	455.3	337.7	504.1	263.3	376.9
1974	447.7	417.7	331.2	485.6	493.0	423.1	563.1	325.3	461.3
1975	519.9	417.4	392.1	469.6	537.5	404.9	639.3	383.9	491.6
1976	563.4	441.3	432.4	449.9	551.9	442.5	687.9	389.0	512.5
1977	596.2	497.9	474.9	493.8	578.4	471.9	790.6	408.3	559.5
1978[p]	648.3	537.4	510.3	502.4	677.4	501.5	888.8	437.0	610.2

[p] Preliminary.

Table 26. Canada, mineral products industries, selling price indexes, 1975-78 (1971 = 100)

	1975	1976	1977	1978[p]
Iron and steel products industries				
Agricultural implements industry	155.2	165.7	177.6	188.6
Hardware, tool and cutlery manufacturers	137.9	147.3	162.6	179.1
Heating equipment manufacturers	137.3	146.9	156.5	169.7
Primary metal industries	160.8	169.9	190.5	207.7
Iron and steel mills	162.0	177.2	187.9	203.9
Steel pipe and tube mills	162.9	179.1	197.8	217.7
Iron foundries	168.4	181.0	189.6	199.5
Wire and wire products manufacturers	158.3	171.0	175.4	185.8
Nonferrous metal products industries				
Aluminum rolling, casting and extruding	145.4	155.8	173.6	191.5
Copper and alloy, rolling, casting and extruding	131.6	138.4	144.5	153.0
Jewellery and silverware manufacturers	234.1	235.2	277.8	336.2
Metal rolling, casting and extruding, nes	171.8	181.0	216.3	239.8
Nonmetallic mineral products industries				
Abrasives manufacturers	140.5	167.5	194.7	223.6
Cement manufacturers	146.3	171.1	186.7	207.5
Clay products manufacturers from imported clay	151.0	161.7	164.7	173.5
Glass and glass products manufacturers	127.1	138.6	150.4	162.1
Lime manufacturers	181.7	204.3	228.7	252.9
Concrete products manufacturers	152.0	161.5	173.7	187.7
Clay products from domestic clay	157.1	169.6	182.8	196.4
Petroleum and coal products industries	183.7	210.2[r]	244.5	275.4
Petroleum refineries	184.5	211.5	246.7	278.7
Mixed fertilizers	204.0	176.9	180.2	191.0

Note: Industry selling price indexes reflect wholesale price trends of products or groups of products sold by the industries listed.
[p] Preliminary; nes Not elsewhere specified; [r] Revised.

Table 27. Canada, principal statistics of the mining industry[1], 1976

		Mining Activity							Total Activity[2]		
		Production and Related Workers			Costs						
	Establishments	Employees	Man-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Metals											
Gold quartz	19	4 200	8 540	56 571	7 583	38 738	159 995	113 674	5 051	70 221	113 749
Copper-gold-silver	34	11 105	23 055	174 323	53 324	580 417	1 235 386	601 645	15 322	246 361	600 677
Silver-lead-zinc	26	5 345	11 133	75 099	19 977	278 899	543 749	244 873	7 351	111 994	233 678
Nickel-copper	7	14 793	27 790	200 884	27 198	529 742	1 437 179	880 239	18 727	283 096	880 080
Iron	18	10 627	22 797	194 687	113 229	396 082	1 259 231	749 921	16 765	320 145	732 118
Misc. metal mines	13	3 764	7 327	57 936	14 643	78 909	358 367	264 815	5 053	80 529	270 105
Total	117	49 834	100 641	759 499	235 954	1 902 787	4 993 908	2 855 167	68 269	1 112 346	2 838 407
Nonmetals											
Asbestos	11	6 115	14 466	99 266	30 587	94 618	496 308	371 103	7 900	131 429	373 206
Feldspar, quartz and nepheline syenite	11	346	767	4 662	1 784	4 633	24 976	18 558	434	6 257	18 454
Gypsum	9	498	1 055	5 251	1 369	5 472	22 675	15 834	591	6 529	15 753
Peat	50	933	1 861	7 856	1 060	6 147	29 876	22 669	1 168	10 441	23 726
Potash	9	2 484	5 256	37 410	21 190	41 818	323 255	260 246	3 270	51 771	262 052
Salt	9	950	1 973	13 105	5 162	13 812	89 125	70 152	1 418	21 126	70 671
Sand and gravel	142	1 793	4 062	24 922	8 122	28 941	134 613	97 551	2 468	36 609	99 014
Stone	123	2 619	6 091	36 960	10 861	50 730	170 266	108 674	3 217	45 858	110 988
Misc. nonmetals	18	709	1 361	8 550	5 719	5 491	35 185	23 974	868	10 823	23 899
Total	382	16 447	36 892	237 982	85 854	251 662	1 326 279	988 761	21 334	320 843	997 763
Fuels											
Coal	27	7 777	15 534	108 528	19 790	124 525	619 801	475 486	8 995	128 461	474 338
Oil, crude and natural gas	718	4 931	10 360	79 176	60 300	159 697	7 238 022	7 018 025	19 096	341 032	7 050 003
Total	745	12 708	25 894	187 704	80 090	284 222	7 857 823	7 493 511	28 091	469 493	7 524 341
Total mining industry	1 244	78 989	163 426	1 185 184	401 899	2 438 672	14 178 010	11 337 439	117 694	1 902 682	11 360 511

[1] Cement manufacturing, lime manufacturers, clay and clay products (domestic clays) are included in the mineral manufacturing industries. Industry coverage is the same as in Tables 29, 31 and 33. [2] Total activity includes sales and head offices.

Table 28. Canada, principal statistics of the mineral manufacturing industries[1], 1976

	Mineral Manufacturing Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establishments	Employees	Man-hours Paid	Wage	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Primary metal industries											
Iron and steel mills	46	40 573	84 213	611 758	174 469	1 888 374	3 460 059	1 468 650	51 978	832 503	1 498 808
Steel pipe and tube mills	25	4 656	9 941	66 566	8 783	347 184	498 267	147 567	5 546	81 655	148 786
Iron foundries	110	8 639	17 947	107 302	14 085	197 355	440 079	237 751	10 365	135 538	241 893
Smelting and refining	28	23 294	45 150	314 963	156 870	505 255	1 443 307	781 182	34 246	511 696	812 654
Aluminum rolling, casting and extruding	59	4 778	10 448	63 170	10 369	382 646	534 428	149 495	6 255	88 493	149 366
Copper and alloy rolling, casting and extruding	39	2 731	5 575	35 491	5 440	294 183	372 306	73 056	3 297	44 518	71 429
Metal rolling, casting and extruding, nes	75	4 268	8 846	42 643	5 923	170 746	280 586	110 435	5 354	58 726	113 332
Total	382	88 939	182 120	1 241 893	375 939	3 785 743	7 029 032	2 968 136	117 041	1 753 129	3 036 268
Nonmetallic mineral products industries											
Cement manufacturers	27	2 993	6 286	47 686	83 545	77 330	403 631	249 503	4 517	76 645	249 142
Lime manufacturers	15	619	1 284	7 693	16 474	7 348	53 798	30 012	804	10 645	30 041
Concrete products manufacturers	413	8 495	18 005	104 407	13 395	182 752	465 135	274 669	10 773	140 199	282 089
Ready-mix concrete manufacturers	348	7 232	15 489	102 125	18 365	344 736	633 490	271 448	9 128	133 282	282 614
Clay products manufacturers (domestic)	59	2 317	4 918	26 355	11 878	20 557	98 253	65 395	2 784	33 955	65 881
Clay products manufacturers (imported)	30	1 614	3 365	16 128	2 344	17 872	59 007	38 596	2 007	21 144	39 078

Table 28. (cont'd)

	Mineral Manufacturing Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Estab-lishments	Employees	Man-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Refractories manufacturers	16	796	1 594	11 547	3 961	29 982	66 183	34 292	1 330	19 002	44 393
Stone products manufacturers	89	807	1 673	7 394	734	11 156	27 847	16 373	988	9 950	16 282
Glass and glass products manufacturers	83	9 306	19 672	112 669	29 802	166 158	481 472	293 256	11 836	153 267	292 471
Abrasive manufacturers	19	1 935	4 062	22 913	13 016	63 149	130 892	55 951	2 535	31 063	55 076
Other nonmetallic mineral products industries	83	5 158	10 678	70 349	20 911	172 463	421 609	234 026	8 319	118 276	270 215
Total	1 182	41 272	87 026	529 266	214 425	1 093 503	2 841 317	1 563 521	55 021	747 428	1 627 282
Petroleum and coal products industries											
Petroleum refining industry	39	6 084	13 070	115 166	61 354	5 798 853	6 725 221	944 843	15 105	298 260	945 816
Manufacture of lubricating oils & greases	13	326	678	4 130	904	72 960	105 492	30 921	602	8 602	32 635
Other petroleum and coal products industries	46	689	1 498	8 298	3 206	47 594	92 085	41 447	982	13 454	45 749
Total	98	7 099	15 246	127 594	65 464	5 919 407	6 922 798	1 017 211	16 689	320 316	1 024 200
Total mineral manufacturing industries	1 662	137 310	284 392	1 898 753	655 828	10 798 653	16 793 147	5 548 868	188 751	2 820 873	5 687 750

[1] Industry coverage is the same as in Tables 30, 32 and 34. [2] Includes sales and head offices.
nes Not elsewhere specified.

Table 29. Canada, principal statistics of the mining industry[1], 1971-76

	Mining Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Estab-lishments	Employees	Man-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
1971	1 662	76 701	158 835	646 900	164 332	1 223 982	5 198 173	3 809 859	110 410	1 015 661	3 826 264
1972	1 716	73 044	150 929	666 505	175 562	1 210 445	5 652 775	4 266 767	107 322	1 068 783	4 292 465
1973	1 626	75 165	156 960	751 878	215 096	1 551 560	8 030 314	6 263 659	111 443	1 214 871	6 288 935
1974	1 438	79 928	165 999	894 538	285 767	2 004 476	11 187 764	8 897 522	118 730	1 450 330	8 929 981
1975	1 345	77 091	159 431	1 030 009	319 496	2 214 191	12 240 016	9 706 329	115 715	1 655 278	9 750 032
1976	1 244	78 989	163 426	1 185 184	401 899	2 438 672	14 178 010	11 337 439	117 694	1 902 682	11 360 511

[1] Cement manufacturing, lime manufacturers, clay and clay products (domestic clays) are included in the mineral manufacturing industries. Industry coverage is the same as in Tables 27, 31 and 33. [2] Includes sales and head offices.

Table 30. Canada, principal statistics of the mineral manufacturing industries[1], 1971-76

		Mineral Manufacturing Activity							Total Activity[2]		
		Production and Related Workers			Costs						
	Establishments	Employees	Man-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
1971	1 813	131 044	276 629	1 063 861	288 016	4 192 544	7 551 959	3 097 001	181 122	1 595 437	3 166 347
1972	1 783	132 067	282 307	1 172 977	304 705	4 667 819	8 299 939	3 353 101	182 454	1 753 069	3 436 258
1973	1 749	138 177	295 213	1 347 918	349 521	5 735 529	9 914 174	3 934 216	188 498	1 970 456	4 039 415
1974	1 708	145 209	309 481	1 582 014	463 395	8 809 583	14 003 237	5 110 117	197 220	2 315 107	5 236 626
1975	1 680	140 195	290 264	1 712 892	541 650	9 724 522	15 205 070	5 183 708	193 526	2 580 313	5 316 534
1976	1 662	137 310	284 392	1 898 753	655 828	10 798 653	16 793 147	5 548 868	188 751	2 820 873	5 687 750

[1] Industry coverage is the same as in Tables 28, 33 and 34. [2] Includes sales and head offices.

Table 31. Canada, consumption of fuel and electricity in the mining industry[1], 1976

	Unit	Metals	Nonmetals	Fuels	Total
Coal and coke	000 t	247	11	. . .	258
	$000	5 403	121	1	5 525
Gasoline	000 litres	29 462	35 264	7 119	71 845
	$000	4 767	5 544	954	11 265
Fuel oil, kerosene, coal oil	000 litres	1 332 297	393 005	72 424	1 797 726
	$000	95 998	36 691	7 543	140 230
Liquefied petroleum gas	000 litres	85 067	4 273	4 383	93 724
	$000	7 181	482	256	7 919
Natural gas	000 m^3	339 398	640 488	103 180	1 083 067
	$000	15 273	19 617	3 261	38 151
Other fuels[2]	$000	15	—	—	15
Total value of fuels	$000	128 637	62 453	12 015	203 105
Electricity purchased	million kWh	11 326	1 959	2 770	16 055
	$000	107 318	23 401	68 075	198 794
Total value of fuels and electricity purchased, all reporting companies	$000	235 955	85 854	80 090	401 899

[1] Cement and lime manufacturing and manufacturers of clay products (domestic clays) are included under mineral manufacturing, Tables 32 and 34. Industry coverage is the same as in Tables 27, 29 and 33. [2] Includes wood, manufactured gas, steam purchased and other miscellaneous fuels.
Note: Figures may not add to totals due to rounding. — Nil; . . . Amount too small to be expressed.

Table 32. Canada, consumption of fuel and electricity in the mineral manufacturing industries[1], 1976

	Unit	Primary Metals Industries	Nonmetallic Mineral Products Industries	Petroleum and Coal Products Industries	Total
Coal and coke	000 t	359	389	2	750
	$ 000	28 532	12 870	8	41 410
Gasoline	000 litres	16 320	57 522	3 791	77 633
	$ 000	2 460	8 656	605	11 721
Fuel oil, kerosene, diesel oil	000 litres	1 179 847	891 725	22 458	2 094 030
	$ 000	73 590	59 095	1 912	134 597
Liquefied petroleum gas	000 litres	36 792	14 834	145	51 771
	$ 000	3 384	1 586	12	4 982
Natural gas	000 m^3	2 199 766	1 816 384	814 251	4 830 401
	$ 000	110 060	78 923	25 047	214 030
Other fuels	$ 000	6 902	1 182	2 890	10 974
Total value of fuels	$ 000	224 928	162 312	30 474	417 714
Electricity purchased	million kWh	16 497	4 137	3 010	23 644
	$ 000	151 011	52 113	34 988	238 112
Total value of fuels and electricity purchased, all reporting companies	$ 000	375 939	214 425	65 462	655 826

[1] Industry coverage is the same as in Tables 28, 30 and 34.

Table 33. Canada, cost of fuel and electricity used in the mining industry[1], 1969-76

	Unit	1969	1970	1971	1972[r]	1973	1974	1975	1976
Metals									
Fuel	$000	27 070	33 370	39 887	40 505	54 430	90 596	107 808	128 637
Electricity purchased	million kWh	7 073	7 995	8 692	8 807	10 032	10 282	10 259	11 326
	$000	46 002	52 257	56 847	58 103	68 089	77 669	85 063	107 318
Total cost of fuel and electricity	$000	73 072	85 627	96 734	98 608	122 519	168 265	192 871	235 955
Electricity generated for own use and for sale	million kWh	476	459	359	446	. .	. .	. .	. .
Nonmetals[2]									
Fuel	$000	19 793	20 029	22 951	25 277	29 101	42 209	46 561	62 453
Electricity purchased	millio kWh	1 473	1 468	1 584	1 642	1 782	2 015	1 763	1 959
	$000	12 728	13 980	14 474	15 080	16 593	20 065	20 049	23 401
Total cost of fuel and electricity	$000	32 521	34 009	37 425	40 357	45 694	62 274	66 610	85 854
Electricity generated for own use and for sale	million kWh	173	161	178	194	. .	. .	. .	. .
Fuels									
Fuels	$000	739	2 072	2 635	4 103	4 600	5 755	11 352	12 015
Electricity purchased	million kWh	1 265	1 540	1 763	2 154	2 792	2 972	2 539	2 770
	$000	20 244	23 320	27 528	32 494	42 283	49 473	48 663	68 075
Total cost of fuel and electricity	$000	20 983	25 392	30 163	36 597	46 883	55 228	60 015	80 090
Electricity generated for own use and for sale	million kWh	—	—	—	—	—	—	—	—
Total mining industry									
Fuel	$000	47 602	55 470	65 473	69 885	88 131	138 560	165 721	203 105
Electricity purchased	million kWh	9 811	11 003	12 039	12 603	14 606	15 267	14 560	16 055
	$000	78 974	90 558	98 849	105 677	126 965	147 207	153 775	198 794
Total cost of fuel and electricity	$000	126 576	146 028	164 322	175 562	215 096	285 767	319 496	401 899
Electricity generated for own use and for sale	million kWh	649	620	537	640	. .	. .	. .	. .

[1]Cement and lime manufacturing and manufacture of clay products (domestic clays) are included in mineral manufacturing, Tables 32 and 34. Industry coverage is the same as in Tables 27, 29 and 31. [2]Includes structural materials.
[r]Revised; . . Not available; — Nil.

Table 34. Canada, cost of fuel and electricity used in the mineral manufacturing industries[1], 1969-76

	Unit	1969	1970	1971	1972	1973	1974	1975	1976
Primary metals									
Fuel	$000	69 185	83 034	92 903	90 850	103 321	153 468	187 846	224 928
Electricity purchased	million kWh	15 370	14 539	15 028	15 678	16 584	17 727	16 544	16 497
	$000	73 114	87 656	90 512	95 447	108 575	122 567	129 750	151 011
Cost of fuel and electricity for small establishments[2]	$000	202	—	—	—	—	—	—	—
Total cost of fuel and electricity	$000	142 501	170 690	183 415	186 297	211 896	276 035	317 596	375 939
Nonmetallic mineral products									
Fuel	$000	47 310	49 451	57 249	65 166	75 144	112 531	133 016	162 312
Electricity purchased	million kWh	3 182	3 270	3 279	2 280	4 080	4 106	3 723	4 137
	$000	23 297	24 507	25 932	29 367	34 624	38 671	41 258	52 113
Cost of fuel and electricity for small establishments[2]	$000	1 231	—	—	—	—	—	—	—
Total cost of fuel and electricity	$000	71 838	73 958	83 181	94 533	109 768	151 202	174 274	214 425
Petroleum and coal products									
Fuel	$000	5 450	4 749	5 346	6 431	7 796	13 275	21 758	30 474
Electricity purchased	million kWh	1 980	2 171	2 326	2 475	2 683	2 715	2 904	3 010
	$000	13 059	14 430	16 074	17 444	20 061	22 885	28 028	34 988
Cost of fuel and electricity for small establishments[2]	$000	13	—	—	—	—	—	—	—
Total cost of fuel and electricity	$000	18 522	19 179	21 420	23 875	27 857	36 160	49 786	65 462
Total mineral manufacturing industries									
Fuel	$000	121 945	137 234	155 498	162 447	186 261	279 274	342 620	417 714
Electricity purchased	million kWh	20 532	19 980	20 633	20 433	23 347	24 548	23 171	23 644
	$000	109 470	126 593	132 518	142 258	163 260	184 123	199 036	238 112
Cost of fuel and electricity for small establishments[2]	$000	1 446	—	—	—	—	—	—	—
Total cost of fuel and electricity	$000	232 861	263 827	288 016	304 705	349 521	463 397	541 656	655 826

[1] Industry coverage is the same as in Tables 28, 30 and 33. [2] Total cost of fuel and electricity purchased by small establishments without detail.
— Nil.

Table 35. Canada, employment, salaries and wages in the mining industry[1], 1969-76

	Unit	1969	1970	1971	1972	1973	1974	1975	1976
Metals									
Production and related workers	Number	46 023	51 102	50 121	46 257	47 984	50 886	50 319	49 834
Salaries and wages	$000	341 495	421 893	434 222	430 919	494 631	580 185	685 562	759 499
Annual average salary and wage	$	7 420	8 256	8 664	9 316	10 308	11 402	13 624	15 241
Administrative and office workers	Number	14 527	15 488	15 891	15 737	18 150	19 152	18 842	18 435
Salaries and wages	$000	137 756	158 653	178 640	189 669	238 454	282 348	320 873	352 847
Annual average salary and wage	$	9 483	10 244	11 242	12 052	13 138	14 732	17 030	19 140
Total metals									
Employees	Number	60 550	66 590	66 012	61 994	66 134	70 038	69 161	68 269
Salaries and wages	$000	479 251	580 546	612 862	620 588	733 085	862 533	1 006 435	1 112 346
Annual average salary and wage	$	7 915	8 718	9 284	10 011	11 085	12 315	14 552	16 294
Nonmetals									
Production and related workers	Number	15 933	16 245	16 155	15 911	16 332	17 767	15 397	16 447
Salaries and wages	$000	107 622	114 345	122 355	131 371	147 027	180 962	188 956	237 982
Annual average salary and wage	$	6 755	7 039	7 574	8 257	9 002	10 185	12 272	14 470
Administrative and office workers	Number	4 081	4 415	4 278	4 109	4 335	4 628	4 688	4 887
Salaries and wages	$000	34 980	39 533	40 222	43 030	47 092	57 243	69 208	82 861
Annual average salary and wage	$	8 571	8 954	9 402	10 472	10 863	12 369	14 763	16 955
Total nonmetals									
Employees	Number	20 014	20 660	20 433	20 020	20 667	22 395	20 085	21 334
Salaries and wages	$000	142 602	153 878	162 577	174 401	194 119	238 205	258 164	320 843
Annual average salary and wage	$	7 125	7 448	7 957	8 711	9 393	10 637	12 854	15 039
Fuels									
Production and related workers	Number	9 412	9 861	10 425	10 876	10 849	11 275	11 375	12 708
Salaries and wages	$000	64 591	77 846	90 324	104 215	110 220	133 392	155 491	187 704
Annual average salary and wage	$	6 863	7 894	8 664	9 582	10 160	11 831	13 670	14 771
Administrative and office workers	Number	12 112	12 983	13 540	14 432	13 793	15 022	15 094	15 383
Salaries and wages	$000	118 395	131 744	149 898	169 579	177 447	216 200	235 188	281 789
Annual average salary and wage	$	9 775	10 147	11 071	11 750	12 865	14 392	15 582	18 318
Total fuels									
Employees	Number	21 524	22 844	23 965	25 308	24 642	26 297	26 469	28 091
Salaries and wages	$000	182 986	209 590	240 222	273 794	287 667	349 592	390 679	469 493
Annual average salary and wage	$	8 502	9 175	10 024	10 818	11 674	13 294	14 760	16 713

Table 35. (cont'd)

	Unit	1969	1970	1971	1972	1973	1974	1975	1976
Total mining									
Production and related workers	Number	71 368	77 208	76 701	73 044	75 165	79 928	77 091	78 989
Salaries and wages	$000	513 708	614 084	646 901	666 505	751 878	894 538	1 030 009	1 185 184
Annual average salary and wage	$	7 198	7 954	8 434	9 125	10 003	11 192	13 361	15 004
Administrative and office workers	Number	30 720	32 886	33 709	34 278	36 278	38 802	38 624	38 705
Salaries and wages	$000	291 131	329 930	368 760	402 278	462 993	555 792	625 269	717 498
Annual average salary and wage	$	9 477	10 033	10 940	11 736	12 762	14 324	16 189	18 538
Total mining									
Employees	Number	102 088	110 094	110 410	107 322	111 443	118 730	115 715	117 694
Salaries and wages	$000	804 839	944 014	1 015 661	1 068 783	1 214 871	1 450 330	1 655 278	1 902 682
Annual average salary and wage	$	7 884	8 575	9 199	9 959	10 901	12 215	14 305	16 166

[1] According to the revised Standard Industrial Classification, 1970. Does not include cement and lime manufacturing and clay products (domestic clays) manufacturing. These industries are included in Table 36 under "Nonmetallic mineral products industries". See Table 27 for detail of industries.

Table 36. Canada, employment, salaries and wages in the mineral manufacturing industries[1], 1969-76

	Unit	1969	1970	1971	1972	1973	1974	1975	1976
Primary metal industries									
Production and related workers	Number	83 564	88 839	86 452	86 335	89 853	94 538	90 169	88 939
Salaries and wages	$000	583 498	680 779	714 600	781 209	897 353	1 052 519	1 119 159	1 241 893
Annual average salary and wage	$	6 983	7 663	8 266	9 049	9 987	11 133	12 412	13 963
Administrative and office workers	Number	27 389	27 706	27 862	27 623	26 609	27 681	30 161	28 102
Salaries and wages	$000	255 548	277 728	303 113	327 598	340 547	403 151	493 764	511 236
Average annual salary and wage	$	9 330	10 024	10 879	11 860	12 798	14 564	16 371	18 192
Total primary metal industries									
Employees	Number	110 953	116 545	114 314	113 958	116 462	122 219	120 330	117 041
Salary and wages	$000	839 046	958 507	1 017 713	1 108 807	1 237 900	1 455 671	1 612 923	1 753 128
Annual average salary and wage	$	7 562	8 224	8 903	9 730	10 629	11 910	13 404	14 979
Nonmetallic mineral products industries									
Production and related workers	Number	38 107	36 045	38 035	39 159	41 502	42 884	42 149	41 272
Salaries and wages	$000	246 196	244 201	281 046	316 033	366 028	424 096	471 466	529 264
Annual average salary and wage	$	6 461	6 775	7 389	8 071	8 820	9 889	11 186	12 824
Administrative and office workers	Number	13 781	13 383	13 256	13 928	14 447	14 682	13 783	13 749
Salaries and wages	$000	111 568	117 163	124 085	142 193	156 085	180 802	197 884	218 164
Annual average salary and wage	$	8 096	8 755	9 361	10 209	10 804	12 314	14 357	15 868
Total nonmetallic mineral products									
Employees	Number	51 888	49 428	51 291	53 087	55 949	57 566	55 932	55 021
Salaries and wages	$000	357 764	361 364	405 131	458 226	522 113	604 898	669 350	747 428
Annual average salary and wage	$	6 895	7 311	7 899	8 632	9 332	10 507	11 967	13 584
Petroleum and coal products industries									
Production and related workers	Number	6 590	6 686	6 557	6 583	6 822	7 787	7 877	7 099
Salaries and wages	$000	61 217	64 745	68 215	75 735	84 537	105 398	122 268	127 594
Annual average salary and wage	$	9 289	9 684	10 403	11 505	12 392	13 535	15 522	17 974
Administrative and office workers	Number	9 043	8 961	8 960	8 826	9 265	9 648	9 387	9 590
Salaries and wages	$000	90 436	95 908	104 378	110 301	125 906	149 140	175 772	192 722
Annual average salary and wage	$	10 001	10 703	11 649	12 497	13 589	15 458	18 725	20 096
Total petroleum and coal products									
Employees	Number	15 633	15 647	15 517	15 409	16 087	17 435	17 264	16 689
Salaries and wages	$000	151 653	160 653	172 593	186 036	210 443	254 539	298 040	320 316
Annual average salary and wage	$	9 701	10 267	11 123	12 073	13 082	14 599	17 264	19 193

Table 36 (cont'd)

	Unit	1969	1970	1971	1972	1973	1974	1975	1976
Total mineral manufacturing industries									
Production and related workers	Number	128 261	131 570	131 044	132 077	138 177	145 209	140 195	137 310
Salaries and wages	$000	890 911	989 725	1 063 861	1 172 977	1 347 918	1 582 014	1 712 892	1 898 751
Average annual salary and wage	$	6 946	7 522	8 118	8 881	9 755	10 895	12 218	13 828
Administrative and office workers	Number	50 213	50 050	50 078	50 377	50 321	52 011	53 331	51 441
Salaries and wages	$000	457 552	490 799	531 576	580 092	622 538	733 093	867 421	922 122
Average annual salary and wage	$	9 112	9 806	10 615	11 515	12 371	14 095	16 269	17 926
Total mineral manufacturing industries									
Employees	Number	178 474	181 620	181 122	182 454	188 498	197 220	193 526	188 751
Salaries and wages	$000	1 348 463	1 480 524	1 595 437	1 753 069	1 970 456	2 315 107	2 580 313	2 820 872
Average annual salary and wage	$	7 556	8 151	8 809	9 608	10 454	11 739	13 333	14 945

Note: See footnote Table 35. See Table 28 for details of industries covered.

Table 37. Canada, number of wage earners employed in the mining industry[1] (surface, underground and mill), 1973-76

	1973	1974	1975	1976
Metals				
Surface	15 060	16 229	16 230	16 143
Underground	20 336	21 045	20 555	20 043
Mill	12 588	13 612	13 534	13 648
Total	47 984	50 886	50 319	49 834
Nonmetals				
Surface	7 080	7 743	7 180	7 264
Underground	1 881	2 210	1 870	2 180
Mill	7 383	7 814	6 347	7 003
Total	16 344	17 767	15 397	16 447
Fuels				
Surface	7 820	8 443	8 789	9 705
Underground	3 029	2 832	2 586	3 003
Total	10 849	11 275	11 375	12 708
Total mining industry				
Surface	29 960	32 415	32 200	33 112
Underground	22 246	26 087	25 010	25 226
Mill	19 971	21 426	19 881	20 651
Total	75 177	79 928	77 091	78 989

[1] See Table 27 for coverage.

Table 38. Canada, labour costs in relation to tonnes mined, metal mines, 1974-76

Type of Metal Mine	Number of Wage Earners	Total Wages	Average Annual Wage	Tonnes of Ore Mined	Average Annual Tonnes Mined per Wage Earner	Wage Cost per Tonne Mined
		($000)	($)	(000 tonnes)	(tonnes)	($)
1976						
Auriferous quartz	4 200	56 571	13 469	5 921	1 410	9.55
Copper-gold-silver	11 105	174 323	15 698	103 600	9 329	1.68
Nickel-copper	14 793	200 884	13 580	21 462	1 451	9.36
Silver-lead-zinc	5 345	75 099	14 050	14 197	2 656	5.29
Iron ore	10 627	194 687	18 320	133 073	12 522	1.46
Miscellaneous metals	3 764	57 936	15 392	18 274	4 855	3.17
Total	49 834	759 500	15 241	296 527	5 951	2.56
1975						
Auriferous quartz	4 841	57 883	11 957	5 901	1 219	9.81
Copper-gold-silver	11 980	164 794	13 756	97 656	8 152	1.69
Nickel-copper	15 052	190 064	12 627	23 265	1 546	8.17
Silver-lead-zinc	5 339	71 656	13 421	16 094	3 014	4.45
Iron ore	9 990	159 107	15 927	101 482	10 158	1.57
Miscellaneous metals	3 117	42 059	13 493	19 820	6 359	2.12
Total	50 319	685 563	13 624	264 218	5 251	2.59
1974						
Auriferous quartz	4 716	47 597	10 093	5 629	1 194	8.46
Copper-gold-silver	13 878	169 800	12 235	111 381	8 026	1.52
Nickel-copper	15 125	148 335	9 807	25 303	1 673	5.86
Silver-lead-zinc	4 940	52 702	10 668	14 190	2 872	3.71
Iron ore	9 560	131 199	13 723	107 105	11 203	1.22
Miscellaneous metals	2 667	30 551	11 455	15 114	5 667	2.02
Total	50 886	580 184	11 402	278 722	5 477	2.08

Table 39. Canada, man-hours paid, production and related workers, tonnes of ore mined and rock quarried, metal mines and nonmetallic mineral operations, 1970-76

	Unit	1970	1971	1972	1973	1974	1975	1976
Metal mines[1]								
Ore mined	million tonnes	213.0	211.4	205.9	274.7	278.7	264.2	296.6
Man-hours paid[2]	million	108.2	102.1	93.8	98.4	104.0	102.4	100.6
Man-hours paid per tonne mined	number	0.51	0.48	0.46	0.36	0.37	0.39	0.34
Tonnes mined per man-hour paid	tonnes	1.97	2.07	2.20	2.79	2.68	2.58	2.95
Nonmetallic mineral operations[3]								
Ore mined and rock quarried	million tonnes	161.5	165.9	169.3	190.5	209.7	180.2	200.4
Man-hours paid[2]	million	28.6	27.5	27.4	28.6	30.5	25.6	29.0
Man-hours paid per tonne mined	number	0.18	0.17	0.16	0.15	0.15	0.15	0.14
Tonnes mined per man-hour paid	tonnes	5.65	6.03	6.18	6.66	6.88	7.04	6.91

[1]Excludes placer mining. [2]Man-hours paid for production and related workers only. [3]Excludes salt, cement, clay products, stone for cement and lime manufacture, and peat.

Table 40. Canada, average weekly wages and hours worked, hourly-rated employees in mining, manufacturing and construction industries, 1971-78

	1971	1972	1973	1974	1975	1976	1977	1978[p]
Mining								
Average hours per week	40.4	40.3	40.9	40.4	40.0	40.3	40.6	40.5
Average weekly wage ($)	163.22	174.94	196.89	225.25	260.74	298.44	328.79	354.51
Metals								
Average hours per week	39.3	39.0	39.6	39.4	39.4	39.6	39.8	39.4
Average weekly wage ($)	164.27	174.69	195.89	222.80	260.33	296.21	325.75	344.94
Mineral fuels								
Average hours per week	41.4	41.0	41.0	40.6	39.7	40.6	41.3	41.0
Average weekly wage ($)	161.46	176.36	198.08	231.51	264.98	309.24	329.89	367.34
Nonmetals								
Average hours per week	41.4	41.3	41.3	41.1	40.1	40.5	40.3	40.5
Average weekly wage ($)	151.52	158.30	173.10	191.51	230.84	273.56	301.93	326.16
Manufacturing								
Average hours per week	40.3	40.4	39.6	38.9	38.6	38.7	38.7	38.8
Average weekly wage ($)	130.22	141.53	152.77	170.03	195.12	222.79	245.13	265.06
Construction								
Average hours per week	39.2	40.1	39.5	39.1	39.0	38.9	38.7	39.0
Average weekly wage ($)	186.20	206.43	223.86	251.08	293.96	330.95	372.83	400.58

[p] Preliminary.

Table 41. Canada, average weekly wages of hourly-rated employees in the mining industry, in current and 1971 dollars, 1971-78

	1971	1972	1973	1974	1975	1976	1977	1978[p]
Current dollars								
All mining	163.22	174.94	196.89	222.25	260.74	298.44	329.45	354.51
Metals	164.27	174.69	195.89	222.80	260.33	296.21	325.75	344.94
Gold	124.61	131.92	151.73	192.78	219.97	251.23	280.34	301.35
Mineral fuels	161.46	176.36	198.08	231.51	264.98	309.24	333.51	367.34
Coal	144.26	158.18	181.29	212.56	243.01	274.00	303.53	323.45
Nonmetals, except fuel	151.52	158.30	173.10	191.51	230.84	273.56	301.92	326.16
1971 dollars								
All mining	163.22	166.93	174.70	177.80	188.26	200.43	204.88	202.35
Metals	164.27	166.69	173.82	178.24	187.96	198.93	202.58	196.88
Gold	124.61	125.88	134.63	154.22	158.82	168.72	174.34	172.00
Mineral fuels	161.46	168.27	175.76	185.21	191.32	207.68	207.41	209.67
Coal	144.26	150.94	160.86	170.05	175.46	184.02	188.76	184.62
Industrial minerals	151.52	151.05	153.59	153.21	166.67	183.72	187.76	186.16

[p] Preliminary.

Table 42. Canada, industrial fatalities per thousand workers, by industry groups, 1976-78

	Fatalities (number)			Number of Workers (000)			Rate per 1 000 Workers[2]		
	1976	1977[r]	1978[p]	1976[r]	1977[r]	1978[p]	1976[r]	1977[r]	1978[p]
Agriculture	18	16	5	142.0	143.0	132.0	0.13	0.11	0.05
Forestry	64	59	71	56.0	64.4	66.6	1.14	0.92	1.07
Fishing	27	18	14	7.5	7.6	10.4	3.60	2.37	1.35
Mining[1]	161	128	100	136.5	141.7	139.7	1.18	0.90	0.72
Manufacturing	195	180	142	1 772.8	1 775.4	1 803.6	0.11	0.10	0.08
Construction	189	171	133	454.7	466.6	436.3	0.42	0.37	0.31
Transportation	217	176	172	779.0	794.7	802.9	0.28	0.22	0.21
Trade	62	73	51	1 401.0	1 413.5	1 467.3	0.04	0.05	0.04
Finance	10	9	4	434.4	472.1	488.2	0.02	0.02	0.01
Service	61	64	41	2 358.5	2 470.0	2 544.5	0.03	0.03	0.02
Public administration	54	49	60	606.4	620.7	633.0	0.09	0.08	0.10
Total	1 058	943	794	8 148.8	8 369.7	8 524.5	0.13	0.11	0.09

Note: See footnotes, Table 43.
[1] Includes fatalities resulting from occupational chest diseases such as silicosis, lung cancer, etc. In 1978, 45 (1977, 51) fatalities of this type were reported. [2] The rates may be understated because only 80 per cent of workers in the Statistics Canada employment estimates are covered by workers' compensation.
[p] Preliminary; [r] Revised.

Table 43. Canada, industrial fatalities per thousand workers, by industry groups, 1969-78

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978p
Agriculture	0.24	0.12	0.16	0.24	0.25	0.27	0.10	0.13	0.11	0.05
Forestry	1.34	1.48	1.56	1.36	1.58	1.31	1.25	1.14	0.92	1.07
Fishing[1]	2.37	3.57	1.38	0.99	1.65	1.38	3.25	3.60	2.37	1.35
Mining[2]	1.42	1.22	1.34	1.41	1.43	1.52	1.20	1.18	0.90	0.72
Manufacturing	0.12	0.11	0.12	0.16	0.15	0.17	0.13	0.11	0.10	0.08
Construction	0.62	0.54	0.58	0.52	0.53	0.52	0.48	0.42	0.37	0.31
Transportation[3]	0.31	0.28	0.30	0.33	0.37	0.33	0.28	0.28	0.22	0.21
Trade	0.06	0.06	0.07	0.06	0.07	0.09	0.05	0.04	0.05	0.04
Finance[4]	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.01
Service[5]	0.03	0.03	0.04	0.06	0.05	0.05	0.04	0.03	0.03	0.02
Public administration	0.15	0.18	0.14	0.13	0.19	0.11	0.14	0.09	0.08	0.10
Total	0.17	0.16	0.17	0.17	0.18	0.18	0.15	0.13	0.11	0.09

[1] Includes trapping and hunting. [2] Includes quarrying and oil wells. [3] Includes storage, communication, electric power and water utilities, and highway maintenance. [4] Includes insurance and real estate. [5] Includes community, business and personal service.
p Preliminary.

Table 44. Canada, industrial fatalities by occupational injuries and illnesses, 1976-78

	Occupational Injuries			Occupational Illnesses			Total		
	1976	1977	1978p	1976	1977	1978p	1976	1977	1978p
Agriculture	18	16	6	0	0	0	18	16	6
Forestry	64	59	71	0	0	0	64	59	71
Fishing	27	18	14	0	0	0	27	18	14
Mining	84	77	55	77	51	45	161	128	100
Manufacturing	152	136	120	44	44	22	196	180	142
Construction	177	163	131	9	8	2	186	171	133
Transportation	218	174	170	2	2	2	220	176	172
Trade	62	73	50	0	0	1	62	73	51
Finance	10	9	4	0	0	0	10	9	4
Service	60	64	39	0	0	2	60	64	41
Public administration	54	49	58	0	0	2	54	49	60
Total	926	838	718	132	105	76	1 058	943	794

p Preliminary.

Table 45. Canada, number of strikes and lockouts by industries, 1977 and 1978

	1977			1978[p]		
	Strikes and Lockouts	Workers Involved	Duration in Man-days	Strikes and Lockouts	Workers Involved	Duration in Man-days
Agriculture	—	—	—	1	4	20
Forestry	6	949	22 170	19	5 446	67 810
Fishing and trapping	4	1 379	14 960	1	600	1 200
Mines	28	11 217	91 050	39	31 147	1 699 460
Manufacturing	342	95 521	1 665 460	459	117 548	2 527 980
Construction	84	33 215	404 990	108	63 105	1 232 610
Transportation and utilities	98	32 650	527 100	126	74 332	945 480
Trade	70	4 851	128 470	91	10 618	245 950
Finance, insurance & real estate	7	544	10 720	16	924	7 520
Service	96	22 532	328 150	143	33 824	407 650
Public administration	68	14 699	114 810	55	64 140	257 140
All industries	803	217 557	3 307 880	1 058	401 688	7 392 820

[p] Preliminary; — Nil.

Table 46. Canada, number of strikes and lockouts in the mining and mineral manufacturing industries, 1977 and 1978

	1977			1978[p]		
	Strikes and Lockouts	Workers Involved	Duration in Man-days	Strikes and Lockouts	Workers Involved	Duration in Man-days
Mines	28	11 217	91 050	39	31 147	1 699 460
Metal	15	8 961	70 460	16	23 711	1 521 540
Mineral fuels	4	953	11 050	10	3 983	39 640
Nonmetals	6	1 232	4 470	12	3 443	137 550
Quarries	3	71	5 070	1	10	730
Mineral manufacturing	34	7 911	219 840	59	21 108	310 130
Primary metals	14	5 144	107 970	24	17 838	215 400
Nonmetallic mineral products	19	2 714	109 860	31	2 480	92 020
Petroleum and coal products	1	53	2 010	4	790	2 710

[p] Preliminary.

Table 47. Canada, ore mined and rock quarried in the mining industry, 1974-76

	1974	1975	1976
		(tonnes)	
Metals			
Gold quartz	5 628 780	5 900 860	5 920 845
Copper-gold-silver	111 380 587	97 656 374	103 599 508
Silver-cobalt	105 761	75 020	112 426
Silver-lead-zinc	14 189 710	16 094 171	14 197 435
Nickel-copper	25 302 458	23 264 576	21 462 226
Iron	107 104 902	101 482 119	133 072 912
Miscellaneous metals[1]	15 008 660	19 744 630	18 161 907
Total	278 720 858	264 217 750	296 527 259
Nonmetals			
Asbestos	85 541 458	61 709 522	84 233 640
Feldspar, nepheline syenite	647 616	596 787	550 217
Quartz (excluding sand)	1 273 667	1 268 565	1 144 657
Gypsum	6 916 833	5 578 241	5 977 803
Talc, soapstone	90 756	75 051	77 369
Rock salt	4 290 820	3 626 984	5 080 030
Other nonmetallics	22 432 148	22 030 535	20 559 514
Total	121 193 298	94 885 685	117 623 230
Structural materials			
Stone, all kinds quarried[2]	92 833 055	88 920 782	87 875 936
Stone used to make cement	14 947 658	13 653 506	13 350 220
Stone used to make lime	3 391 122	2 979 661	3 441 932
Total	111 171 835	105 553 949	104 668 088
Total ore mined and rock quarried	511 085 991	464 657 384	518 818 577

[1] Includes uranium ore. [2] Excludes stone used to manufacture cement and lime.

Table 48. Canada, ore mined and rock quarried in the mining industry, 1941-76

	Metals	Nonmetals[1]	Total
		(million tonnes)	
1941	39.0	19.5	58.5
1942	38.5	19.6	58.1
1943	35.1	18.7	53.8
1944	32.0	17.5	49.5
1945	28.3	18.6	46.9
1946	26.2	22.4	48.6
1947	30.2	27.5	57.7
1948	33.4	30.3	63.7
1949	39.2	29.8	69.0
1950	41.6	37.9	79.5
1951	44.2	39.7	83.9
1952	47.4	40.0	87.4
1953	49.3	42.8	92.1
1954	53.5	55.7	109.2
1955	62.7	57.6	120.3
1956	70.2	66.2	136.4
1957	76.4	74.5	150.9
1958	71.4	71.2	142.6
1959	89.9	82.2	172.1
1960	92.1	88.7	180.8
1961	90.1	96.7	186.8
1962	103.6	103.8	207.4
1963	112.7	120.4	233.1
1964	128.0	134.1	262.1
1965	151.0	146.5	297.5
1966	147.6	171.8	319.4
1967	169.1	177.5	346.6
1968	186.9	172.7	359.6
1969	172.0	178.8	350.8
1970	213.0	179.1	392.1
1971	211.5	185.8	397.3
1972	206.0	189.7	395.7
1973	274.8	212.8	487.6
1974	278.7	232.4	511.1
1975	264.2	200.5	464.7
1976	296.5	222.3	518.8

[1] Includes nonmetallic mineral mining and all stone quarried, including stone used to make cement and lime. Excludes coal. Coverage is the same as in Table 47.

Table 49. Canada, exploration and capital expenditures in the mining industry[1], by provinces and territories, 1976-78

		Capital						Repair						
		Construction												
		On-property Exploration	On-property Development	Structures	Total	Machinery and Equipment	Total Capital	Construction	Machinery and Equipment	Total Repair	Total Capital and Repair	Outside or General Exploration	Land and Mining Rights	Total all Expenditures
		($ million)												
Atlantic Provinces	1976	1.9	17.9	31.7	51.5	43.6	95.1	7.2	128.0	135.2	230.3	15.0	0.2	245.5
	1977	1.7	20.0	16.9	38.6	46.5	85.1	11.4	126.8	138.2	223.3	20.3	0.7	244.3
	1978p	1.3	20.4	12.1	33.8	59.4	93.2	8.5	110.0	118.5	211.7	17.6	1.0	230.3
Quebec	1976	7.3	109.4	193.0	309.7	162.8	472.5	14.6	178.4	193.0	665.5	21.1	5.5	692.1
	1977	(2)	(2)	(2)	318.3	211.9	530.2	15.8	184.5	200.3	730.5	29.3	10.5	770.3
	1978p	16.1	73.8	36.5	126.4	48.1	174.5	17.3	178.2	195.5	370.0	39.9	2.4	412.3
Ontario	1976	10.0	120.9	67.2	198.1	112.1	310.2	26.9	182.6	209.5	519.7	24.6	(2)	(2)
	1977	10.2	125.8	52.0	188.0	96.1	284.1	24.8	194.3	219.1	503.2	30.1	1.6	534.9
	1978p	7.9	100.2	21.0	129.1	77.2	206.3	18.6	168.9	187.5	393.8	21.0	(2)	(2)
Manitoba	1976	(2)	(2)	(2)	21.2	8.4	29.6	2.2	31.3	33.5	63.1	5.6	(2)	(2)
	1977	(2)	(2)	(2)	23.6	11.5	35.1	3.4	29.1	32.5	67.6	8.2	0.1	75.9
	1978p	(2)	(2)	(2)	45.8	28.1	73.9	2.0	25.9	27.9	101.8	11.8	(2)	(2)
Saskatchewan	1976	(2)	(2)	(2)	10.8	56.1	66.9	3.2	41.9	45.1	112.0	11.9	0.5	124.4
	1977	(2)	(2)	(2)	37.3	74.0	111.3	3.8	53.2	57.0	168.3	15.1	0.3	183.7
	1978p	(2)	(2)	(2)	58.6	78.5	137.1	5.7	58.6	64.3	201.4	27.9	1.7	231.0
Alberta	1976	0.7	6.6	20.0	27.3	65.4	92.7	5.3	23.8	29.1	121.8	4.3	1.3	127.4
	1977	(2)	(2)	(2)	53.1	47.9	101.0	5.5	38.9	44.4	145.4	3.0	2.6	151.0
	1978p	0.5	6.4	16.5	23.4	44.8	68.2	2.4	36.1	38.5	106.7	7.0	2.3	116.0
British Columbia	1976	8.1	58.9	44.0	111.0	55.3	166.3	10.9	132.7	143.6	309.9	22.9	4.5	337.3
	1977	21.2	65.6	61.5	148.3	71.1	219.4	12.8	155.8	168.6	388.0	26.0	1.1	415.1
	1978p	16.3	55.7	33.0	105.0	43.9	148.9	10.8	167.1	177.9	326.8	32.5	1.0	360.3
Yukon and Northwest Territories	1976	3.7	15.4	10.2	29.3	16.2	45.5	11.2	29.1	40.3	85.8	25.7	0.3	111.8
	1977	3.8	13.1	17.5	34.4	18.8	53.2	6.4	27.3	33.7	86.9	38.0	—	124.9
	1978p	5.1	13.1	6.1	24.3	16.8	41.1	6.6	29.8	36.4	77.5	37.2	0.3	115.0
Canada	1976	35.4	351.5	372.0	758.9	519.9	1 278.8	81.5	747.8	829.3	2 108.1	131.1	13.8	2 253.0
	1977	73.8	363.2	404.6	841.6	577.8	1 419.4	83.9	809.9	893.8	2 313.2	170.0	16.9	2 500.1
	1978p	54.2	324.1	168.1	546.4	396.8	943.2	71.9	774.6	846.5	1 789.7	194.9	11.0	1 995.6

[1] Excludes the petroleum and natural gas industries and the smelting and refining industries. (2) Confidential, figures are included in "Canada".
p Preliminary; — Nil.

Table 50. Canada, exploration and capital expenditures[1], in the mining industry, by type of mining, 1976-78

		Capital						Repair						
		Construction												
		On-property Exploration	On-property Development	Structures	Total	Machinery and Equipment	Total Capital	Construction	Machinery and Equipment	Total Repair	Total Capital and Repair	Outside or General Exploration	Land and Mining Rights	Total all Expenditures
		($ million)												
Metal mining														
Gold	1976	1.6	12.8	2.9	17.3	4.5	21.8	0.7	11.4	12.1	33.9	(2)	—	(3)
	1977	2.8	15.8	1.7	20.3	4.5	24.8	1.3	12.5	13.8	38.6	0.4	(3)	(3)
	1978p	4.2	21.8	3.0	29.0	4.6	33.6	2.0	15.8	17.8	51.4	1.1	—	52.5
Copper-gold-silver	1976	6.5	72.2	49.7	128.4	69.5	197.9	12.5	133.2	145.7	343.6	4.8	0.2	348.6
	1977	10.2	53.0	44.5	107.7	74.2	181.9	14.1	136.5	150.6	332.5	5.2	(3)	(3)
	1978p	8.6	43.0	27.5	79.1	52.0	131.1	11.7	144.4	156.1	287.2	5.0	(3)	(3)
Silver-lead-zinc	1976	3.2	33.6	18.3	55.1	22.7	77.8	10.8	36.4	47.2	125.0	2.6	(3)	(3)
	1977	6.6	29.0	18.3	53.9	23.1	77.0	5.8	32.3	38.1	115.0	6.2	(3)	(3)
	1978p	7.6	19.8	14.8	42.2	19.9	62.1	5.6	32.9	38.5	100.6	3.1	(3)	(3)
Iron	1976	(2)	(2)	(2)	277.3	149.1	426.4	14.2	226.0	240.2	666.6	1.0	—	667.6
	1977	(2)	(2)	(2)	265.8	(2)	(2)	18.8	225.1	243.9	(2)	(4)	(3)	(4)
	1978p	(2)	(2)	(2)	71.1	32.5	103.6	17.7	196.0	213.7	317.3	(4)	—	(4)
Other metal mining	1976	12.7	155.5	220.0	110.9	58.5	169.4	23.3	114.5	137.8	307.2	14.2	(3)	(3)
	1977	26.0	163.0	247.1	170.3	247.4	417.7	22.8	130.1	152.9	1 080.3	9.7	0.1	1 090.1
	1978p	13.7	143.4	43.8	129.8	49.5	179.3	16.7	98.4	115.1	294.4	14.5	1.5	310.4
Total metal mining	1976	24.0	274.1	290.9	589.0	304.3	893.3	61.5	521.5	583.0	1 476.3	22.6	1.5	1 500.4
	1977	45.6	260.8	311.6	618.0	349.2	967.2	62.8	536.5	599.3	1 566.5	(4)	2.2	(4)
	1978p	34.1	228.0	89.1	351.2	158.5	509.7	53.7	487.5	541.2	1 050.9	(4)	2.4	(4)
Nonmetal mining														
Asbestos	1976	(6)	43.2	22.7	65.9	29.0	94.9	5.9	69.8	75.7	170.6	0.2	(5)	(5)
	1977	2.0	43.8	20.6	66.4	37.3	103.7	7.5	73.1	80.6	184.3	(4)	(5)	(4)
	1978p	1.5	43.9	26.6	72.0	31.0	103.0	5.8	88.3	94.1	197.1	(4)	(5)	(4)
Other non-metal mining	1976	(6)	37.8	57.6	95.4	185.6	281.0	14.1	156.4	170.5	451.5	8.9	(5)	(5)
	1977	18.7	57.7	72.0	148.4	188.5	336.9	13.3	200.1	213.4	550.3	5.8	(5)	(4)
	1978p	11.5	51.7	52.1	115.3	205.5	320.8	12.4	198.7	211.1	531.9	9.5	(5)	(5)

Table 50 (cont'd)

		Capital						Repair						
		Construction												
		On-property Exploration	On-property Development	Structures	Total	Machinery and Equipment	Total Capital	Construction	Machinery and Equipment	Total Repair	Total Capital and Repair	Outside or General Exploration	Land and Mining Rights	Total all Expenditures
		($ million)												
Total non-metal mining	1976	8.0	73.0	80.3	161.3	214.6	375.9	20.0	226.2	246.2	622.1	9.1	6.9	638.1
	1977	20.7	101.5	92.6	214.8	225.8	440.6	20.8	273.2	294.0	734.6	(4)	10.9	(4)
	1978[p]	13.0	95.6	78.7	187.3	236.5	423.8	18.2	287.0	305.2	729.0	(4)	4.2	(4)
Metal and non-metal mining exploration	1976	3.4	4.4	0.8	8.6	1.0	9.6	—	0.1	0.1	9.7	99.4	5.4	114.5
	1977	7.5	0.9	0.4	8.8	2.8	11.6	0.3	0.2	0.5	12.1	141.5	3.8	157.4
	1978[p]	7.1	0.5	0.3	7.9	1.8	9.7	—	0.1	0.1	9.8	160.5	4.4	174.7
Total mining	1976	35.4	351.5	372.0	758.9	519.9	1 278.8	81.5	747.8	829.3	2 108.1	131.1	13.8	2 253.0
	1977	73.8	363.2	404.6	841.6	577.8	1 419.4	83.9	809.9	893.8	2 313.2	170.0	16.9	2 500.1
	1978[p]	54.2	324.1	168.1	546.4	396.8	943.2	71.9	774.6	846.5	1 789.7	194.9	11.0	1 995.6

[1]Excludes expenditures in the petroleum and natural gas industries. (2) Confidential, included in "Other metal mining". (3) Confidential, included in "Total metal mining". (4) Confidential, included in "Total mining". (5) Confidential, included in "Total nonmetal mining". (6) Confidential, included in "On-property development".
[p]Preliminary; — Nil.

Table 51. Canada, diamond drilling in the mining industry, by mining companies with own equipment and by drilling contractors, 1975 and 1976

		1975			1976		
		Exploration	Other	Total	Exploration	Other	Total
		(metres)					
Metal mining							
Gold quartz	Own equipment	25 105	11 289	36 394	—	2 749	2 749
	Contractors	170 413	9 351	179 764	72 532	6 627	79 159
	Total	195 518	20 640	216 158	72 532	9 376	81 908
Copper-gold-silver	Own equipment	77 482	7 489r	84 971r	99 715	16 492	116 207
	Contractors	185 524	24 334	209 858	170 179	11 069	181 248
	Total	263 006	31 823r	294 829r	269 894	27 561	297 455
Nickel-copper	Own equipment	201 098	—	201 098	184 285	—	184 285
	Contractors	37 064	—	37 064	25 780	—	25 780
	Total	238 162	—	238 162	210 065	—	210 065
Silver-lead-zinc and silver-cobalt	Own equipment	30 892r	13 139	44 031r	34 505	12 172	46 677
	Contractors	139 382	790	140 172	118 237	1 452	119 689
	Total	170 274r	13 929	184 203r	152 742	13 624	166 366
Iron mines	Own equipment	—	—	—	—	—	—
	Contractors	17 103	—	17 103	19 486	—	19 486
	Total	17 103	—	17 103	19 486	—	19 486
Miscellaneous metal mining	Own equipment	12 193	—	12 193	4 921	—	4 921
	Contractors	68 675	—	68 675	73 328	—	73 328
	Total	80 868	—	80 868	78 249	—	78 249
Total metal mining	Own equipment	346 770r	31 917r	378 687r	323 426	31 413	354 839
	Contractors	618 161	34 475	652 636	479 542	19 148	498 690
	Total	964 931r	66 392r	1 031 323r	802 968	50 561	853 529

Table 51. (cont'd)

		1975			1976		
		Exploration	Other	Total	Exploration	Other	Total
		(metres)					
Nonmetal mining							
Asbestos	Own equipment	—	—	—	—	—	—
	Contractors	9 615	—	9 615	13 847	58	13 905
	Total	9 615	—	9 615	13 847	58	13 905
Feldspar and quartz	Own equipment	—	—	—	—	—	—
	Contractors	1 034	—	1 034	—	—	—
	Total	1 034	—	1 034	—	—	—
Gypsum	Own equipment	—	—	—	—	—	—
	Contractors	549	—	549	1 881	—	1 881
	Total	549	—	549	1 881	—	1 881
Salt	Own equipment	1 088	—	1 088	1 308	—	1 308
	Contractors	—	—	—	—	—	—
	Total	1 088	—	1 088	1 308	—	1 308
Miscellaneous nonmetal mining	Own equipment	3 100	—	3 100	3 865	—	3 865
	Contractors	—	—	—	—	—	—
	Total	3 100	—	3 100	3 865	—	3 865
Total nonmetal mining	Own equipment	4 188	—	4 188	5 173	—	5 173
	Contractors	11 198	—	11 198	15 728	58	15 786
	Total	15 386	—	15 386	20 901	58	20 959
Total mining industry	Own equipment	350 958ʳ	31 917ʳ	382 875ʳ	328 599	31 413	360 012
	Contractors	629 359	34 475	663 834	495 270	19 206	514 476
	Total	980 317ʳ	66 392ʳ	1 046 709ʳ	823 869	50 619	874 488

— Nil; ʳ Revised.

Table 52. Canada, total diamond drilling, metal deposits, 1963-76

	Gold-Quartz Deposits	Copper-Gold-Silver and Nickel-Copper Deposits	Silver-Lead-Zinc and Silver-Cobalt Deposits	Other Metal Bearing Deposits[1]	Total Metal Deposits
			(metres)		
1963	529 958	977 257	288 204	148 703	1 944 122
1964	458 933	709 588	401 099	104 738	1 674 358
1965	440 020	779 536	331 294	275 917	1 826 767
1966	442 447	729 148	292 223	164 253	1 628 071
1967	391 347	947 955	230 182	120 350	1 689 834
1968	375 263	935 716	198 038	56 780	1 565 797
1969	274 410	923 452	197 670	109 592	1 505 124
1970	214 717	1 132 915	375 019	99 373	1 822 024
1971	193 291	1 089 103	308 798	83 851	1 675 043
1972	229 771	967 640	240 195	50 225	1 487 831
1973	243 708	713 134	185 946	57 730	1 200 518
1974	250 248	798 564	197 322	83 484	1 329 618
1975	216 158	532 991[r]	184 203[r]	97 971	1 031 323[r]
1976	81 908	507 520	166 366	97 735	853 529

Note: Nonproducing companies not included since 1964.
[1] Includes iron, titanium, uranium, molybdenum and other metal deposits.
[r] Revised.

Table 53. Canada, exploration diamond drilling, metal deposits, 1963-76

	Mining Companies with Own Personnel and Equipment	Diamond Drill Contractors	Total
		(metres)	
1963	361 180	1 169 292	1 530 472
1964	143 013	1 072 985	1 215 998
1965	209 002	1 176 996	1 385 998
1966	163 379	1 044 860	1 208 239
1967	93 164	1 123 137	1 216 301
1968	159 341	990 690	1 150 031
1969	135 311	1 072 328	1 207 639
1970	62 147	1 228 061	1 290 208
1971	86 838	1 053 330	1 140 168
1972	251 651	839 753	1 091 404
1973	321 333	742 899	1 064 232
1974	357 823	892 557	1 250 380
1975	346 770[r]	618 161	964 931[r]
1976	323 426	479 542	802 968

Note: Nonproducing companies are not included since 1964. See footnote to Table 54.
[r] Revised.

Table 54. Canada, diamond drilling, other than for exploration, metal deposits, 1963-76

	Mining Companies with Own Personnel and Equipment	Diamond Drill Contractors	Total
		(metres)	
1963	388 228	25 422	413 650
1964	385 765	72 594	458 359
1965	393 947	46 822	440 769
1966	227 968	191 863	419 831
1967	186 463	287 071	473 534
1968	122 851	292 914	415 765
1969	87 552	209 933	297 485
1970	290 363	241 453	531 816
1971	295 966	238 910	534 876
1972	304 523	91 903	396 426
1973	77 162	59 124	136 286
1974	54 353	24 885	79 238
1975	31 917[r]	34 475	66 392[r]
1976	31 413	19 148	50 561

Note: Nonproducing companies not included since 1964. The total depth drilled shown in Tables 53 and 54 equals the total depth drilled reported in Table 52.
[r] Revised.

Table 55. Canada, total contract diamond drilling operations[1], 1963-76

	Metres Drilled	Income from Drilling	Average Number of Employees	Total Salaries and Wages
		($ million)		($ million)
1963	1 738 020	20.1	2 201	9.0
1964	1 974 828	23.7	2 401	11.2
1965	2 256 993	30.7	2 776	14.1
1966	2 275 717	33.7	2 887	15.1
1967	2 120 575	31.3	2 669	14.9
1968	2 321 105	38.7	2 985	18.8
1969	2 367 368	44.8	3 109	21.3
1970	2 324 859	53.2	3 207	24.3
1971	1 888 453	38.1	2 514	18.9
1972	1 578 218	35.9	2 083	16.6
1973	1 596 967	39.1	2 123	18.7
1974	1 689 598	51.6	2 317	22.6
1975	1 536 115	62.6	1 899	25.1
1976	1 350 575	58.3	1 548	25.3

[1] Includes contract diamond drilling in mining and in other industries.

Table 56. Canada, contract drilling for oil and natural gas, 1965-76

	Metres Drilled				Gross Income from Drilling	Number of Employees	Total Salaries and Wages
	Rotary	Cable	Diamond	Total	($ million)		($ million)
1965	4 875 969	103 737	—	4 979 706	100.2	4 648	31.7
1966	4 082 617	64 039	—	4 146 656	95.8	4 428	33.9
1967	3 876 269	51 217	—	3 927 486	94.7	4 249	32.9
1968	4 054 073	70 239	—	4 124 312	109.5	4 434	36.9
1969	3 974 024	85 442	—	4 059 466	115.5	4 821	39.5
1970	3 505 457	50 304	—	3 555 761	112.6	4 267	37.9
1971	3 551 027	41 002	—	3 592 029	109.5	4 093	38.0
1972	4 332 240	42 362	—	4 374 602	154.6	4 817	53.5
1973	4 881 533	24 045	—	4 905 578	213.3	5 680	75.5
1974	4 380 546	17 372	—	4 397 918	206.1	5 054	74.4
1975	3 927 744	39 075	—	3 966 819	193.2	5 096	75.1
1976	5 561 234	40 746	—	5 601 980	285.2	5 486	108.1

— Nil.

Table 57. Canada, crude minerals transported by Canadian railways, 1976 and 1977

	1976	1977
	(000 tonnes)	
Metallic minerals		
Alumina and bauxite	1 174[r]	2 585
Copper ores and concentrates	1 956[r]	2 220
Iron ores and concentrates	57 837	57 295
Iron pyrite	24	24
Lead ores and concentrates	537	618
Lead-zinc ores and concentrates	38[r]	41
Manganese ores	9	10
Nickel-copper ores and concentrates	4 913	5 214
Nickel ores and concentrates	1 757	1 172
Tungsten ores and concentrates	21[r]	2
Zinc ores and concentrates	2 044	2 143
Metallic ores and concentrates, nes	59[r]	46
Total metallic minerals	70 369[r]	71 370
Nonmetallic minerals		
Abrasives, natural	109	69
Asbestos	855	789
Barite	61	63
Clay	575[r]	616
Gravel	982	926
Gypsum	3 665	4 359
Limestone, agricultural	149	83
Limestone, industrial	325	311
Limestone, nes	3 366	3 196
Nepheline syenite	154	402
Phosphate rock	1 849	1 884
Potash (KCl)	7 864	8 719
Refractory materials, nes	27	14
Salt, rock	973[r]	986
Salt, nes	204	157
Sand, industrial	1 362[r]	1 283
Sand, nes	102	38
Silica	17	18
Sodium carbonate	273	389
Sodium sulphate	515[r]	455
Stone, building, rough	17	16
Stone, nes	1 058	487
Sulphur, liquid	1 215	1 340
Sulphur, nes	2 366	3 295
Nonmetallic minerals, nes	178[r]	258
Total nonmetallic minerals	28 261[r]	30 153
Mineral fuels		
Coal, anthracite	187	180
Coal, bituminous	16 661[r]	17 663
Coal, lignite	791	1 427
Coal, nes	7	6
Natural gas and other crude bituminous substances	12	19
Oil, crude	336	283
Total mineral fuels	17 994[r]	19 578
Total crude minerals	116 624[r]	121 101
Total revenue freight moved by Canadian railways	238 468[r]	246 974
Per cent crude minerals of total revenue freight	48.9	49.0

nes Not elsewhere specified; [r] Revised.

Table 58. Canada, crude minerals transported by Canadian railways, 1968-77

	Total Revenue Freight	Total Crude Minerals	Crude Minerals as % of Total Revenue Freight
	(million tonnes)		
1968	195.4	86.7	44.4
1969	189.0	81.9	43.4
1970	211.6	97.5	46.1
1971	214.5	95.6	44.6
1972	215.8	89.4	41.4
1973	241.2	113.1	46.9
1974	246.3	115.3	46.8
1975	226.0	110.6	49.0
1976	238.5[r]	116.6	48.9[r]
1977	246.9	121.1	49.0

[r] Revised.

Table 59. Canada, fabricated mineral products transported by Canadian railways, 1976 and 1977

	1976	1977
	(000 tonnes)	
Metallic mineral products		
Ferrous mineral products		
Ferroalloys	177	128
Pig iron	59	63
Ingots, blooms, billets, slabs of iron and steel	282	258
Other primary iron and steel	38	38
Castings and forgings, iron and steel	252	236
Bars and rods, steel	643	654
Plates, steel	315	343
Sheet and strip, steel	1 112	1 139
Structural shapes and sheet piling, iron and steel	354	332
Rails and railway track material	165	135
Pipes and tubes, iron and steel	482r	397
Wire, iron or steel	33	35
Iron and steel scrap	1 654r	1 454
Slag, dross, etc.	190	99
Total ferrous mineral products	5 756r	5 311
Nonferrous mineral products		
Aluminum paste, powder, pigs, ingots, shot	82	118
Aluminum and aluminum alloy fabricated material, nes	272	278
Copper matte and precipitates	3	2
Copper and alloys, in primary forms	392	436
Copper and alloys, nes	137	69
Lead and alloys	151	162
Nickel and nickel-copper matte	150	137
Nickel and alloys	48	34
Zinc and alloys	457	395
Other nonferrous base metals and alloys	15r	15
Nonferrous metal scrap	152	87
Total nonferrous mineral products	1 859r	1 733
Total metallic mineral products	7 615r	7 044

Table 59. (cont'd)

	1976	1977
	(000 tonnes)	
Nonmetallic mineral products		
Natural stone basic products, chiefly structural	217r	200
Bricks and tiles, clay	59	57
Fire brick and similar shapes	111	117
Dolomite and magnesite, calcined	73	82
Refractories, nes	35	32
Glass basic products	130	140
Asbestos and asbestos-cement basic products	23	20
Portland cement, standard	1 832	1 931
Concrete pipe	72r	38
Cement and concrete basic products, nes	343	378
Plaster	28	25
Gypsum wallboard and sheathing	68	62
Gypsum basic products, nes	1	3
Lime, hydrated and quick	435r	438
Nonmetallic mineral basic products, nes	751r	747
Fertilizers and fertilizer materials, nes	1 529	1 952
Total nonmetallic mineral products	5 707r	6 222
Mineral fuel products		
Gasoline	1 773	1 773
Aviation turbine fuel	68	87
Diesel fuel	3 374	3 216
Kerosene	6	5
Fuel oil, nes	967	1 220
Lubricating oils and greases	363	373
Petroleum coke	447r	511
Coke, nes	814	918
Refined and manufactured gases, fuel type	3 082	3 146
Asphalts and road oils	216	124
Bituminous pressed or molded fabricated material	1	2
Other petroleum and coal products	1 056	1 034
Total mineral fuel products	12 167r	12 409
Total fabricated mineral products	25 489r	25 675
Total revenue freight moved by Canadian railways	238 468r	246 974
Fabricated mineral products as a per cent of total revenue freight	10.7	10.4

nes Not elsewhere specified; r Revised.

Table 60. Canada, crude and fabricated minerals transported through the St. Lawrence Seaway, 1977 and 1978

	Montreal-Lake Ontario Section		Welland Canal Section	
	1977r	1978	1977r	1978
	(tonnes)			
Crude minerals				
Coal	215 973	940 399	6 734 292	5 408 206
Iron ore	20 205 603	13 542 178	19 926 871	15 679 922
Aluminum ores and concentrates	103 906	130 900	103 906	130 900
Clay and bentonite	313 203	18 725	333 665	18 698
Gravel and sand	28 839	15 167	289 440	84 801
Stone, ground or crushed	97 733	106 349	1 013 004	1 315 535
Stone, rough	326	4 237	307	5 671
Salt	783 692	746 982	1 489 847	1 386 969
Phosphate rock	5 279	54 869	—	19
Sulphur	14 309	7 214	14 309	7 214
Other crude minerals	1 239 328	1 030 381	553 413	984 398
Total crude minerals	23 008 191	16 597 401	30 459 054	25 022 333
Fabricated mineral products				
Coke	2 026 038	2 486 639	2 101 577	2 525 771
Gasoline	52 772	108 884	110 003	105 257
Fuel oil	2 015 025	1 887 976	958 025	910 793
Lubricating oils and greases	145 492	145 368	157 266	146 943
Other petroleum products	158 420	227 483	112 287	134 783
Tar, pitch and creosote	35 745	32 314	53 762	49 474
Pig iron	160 155	242 424	148 565	231 298
Iron and steel: bars, rods, slabs	203 078	360 910	151 638	332 878
Iron and steel: nails, wire	39 191	38 901	34 040	36 360
Iron and steel: manufactured	4 730 629	3 239 842	4 529 274	3 075 751
Scrap iron and steel	348 673	639 829	354 157	590 828
Cement	3 051	23 008	222 796	412 708
Total fabricated minerals	9 918 269	9 433 578	8 933 390	8 522 844
Total crude and fabricated minerals	32 926 460	26 030 979	39 392 444	33 575 177
Total all products	57 457 309	56 942 680	65 078 545	65 670 992
Crude and fabricated minerals as a per cent of total	57.3	45.7	60.5	51.1

r Revised; — Nil.

Table 59. (cont'd)

	1976	1977
	(000 tonnes)	
Nonmetallic mineral products		
Natural stone basic products, chiefly structural	217[r]	200
Bricks and tiles, clay	59	57
Fire brick and similar shapes	111	117
Dolomite and magnesite, calcined	73	82
Refractories, nes	35	32
Glass basic products	130	140
Asbestos and asbestos-cement basic products	23	20
Portland cement, standard	1 832	1 931
Concrete pipe	72[r]	38
Cement and concrete basic products, nes	343	378
Plaster	28	25
Gypsum wallboard and sheathing	68	62
Gypsum basic products, nes	1	3
Lime, hydrated and quick	435[r]	438
Nonmetallic mineral basic products, nes	751[r]	747
Fertilizers and fertilizer materials, nes	1 529	1 952
Total nonmetallic mineral products	5 707[r]	6 222
Mineral fuel products		
Gasoline	1 773	1 773
Aviation turbine fuel	68	87
Diesel fuel	3 374	3 216
Kerosene	6	5
Fuel oil, nes	967	1 220
Lubricating oils and greases	363	373
Petroleum coke	447[r]	511
Coke, nes	814	918
Refined and manufactured gases, fuel type	3 082	3 146
Asphalts and road oils	216	124
Bituminous pressed or molded fabricated material	1	2
Other petroleum and coal products	1 056	1 034
Total mineral fuel products	12 167[r]	12 409
Total fabricated mineral products	25 489[r]	25 675
Total revenue freight moved by Canadian railways	238 468[r]	246 974
Fabricated mineral products as a per cent of total revenue freight	10.7	10.4

nes Not elsewhere specified; [r] Revised.

Table 62. Canada, crude minerals loaded and unloaded at Canadian ports in international shipping trade, 1976 and 1977

	1976		1977	
	Loaded	Unloaded	Loaded	Unloaded
	(tonnes)			
Metallic minerals				
Alumina, bauxite ore	—	1 848 004	21 470	3 705 030
Copper ores and concentrates	747 099	—	816 235	—
Iron ore and concentrates	45 675 427	3 885 409	44 229 617	2 654 560
Lead ore and concentrates	167 437	—	97 693	15 571
Manganese ore	13 623	221 197	77 593	175 454
Nickel-copper ore and concentrates	74 520	21 979	108 219	29 548
Titanium ore	270 585	—	104 106	—
Zinc ore and concentrates	1 139 442	—	897 889	—
Ores and concentrates, nes	25 712	113 021	51 233	157 609
Iron and steel scrap	328 291	1 694	141 599	465
Nonferrous metal scrap	5 768	1 343	3 558	—
Slag, dross, residue	724 044	44 094	596 311	43 261
Total metals	49 171 948	6 136 741	47 145 523	6 781 498
Nonmetallic minerals				
Asbestos	447 117	5 162	269 620	2 313
Barite	56 514	—	74 569	—
Bentonite	1 999	196 972	—	259 813
China clay	—	21 795	—	32 428
Clay materials, nes	18	42 938	166	36 182
Dolomite	878 849	—	874 670	—
Fluorspar	25 524	156 580	10 990	122 477
Gypsum	4 057 951	51 728	4 940 953	16 419
Limestone	819 511	2 949 456	899 270	2 890 795
Phosphate rock	—	1 071 821	—	1 281 826
Potash (KCl)	1 514 650	21 532	1 397 449	18 623
Salt	1 418 527	1 106 345	1 282 034	950 145
Sand and gravel	9 149	1 287 573	11 641	1 264 920
Stone, crude, nes	71 500	9 614	41 415	13 339
Sulphur	2 244 080	13 165	2 649 403	12 031
Crude, nonmetallic minerals, nes	57 090	22 165	109 877	29 587
Total nonmetals	11 602 479	6 956 846	12 562 057	6 930 898
Mineral fuels				
Coal bituminous	9 812 549	14 178 421	9 952 375	15 302 598
Coal, nes	9 807	220 914	—	297 743
Oil, crude	930 504	16 939 895	597 273	16 402 728
Total fuels	10 752 860	31 339 230	10 549 648	32 003 069
Total crude minerals	71 527 287	44 432 817	70 257 228	45 715 465
Total, all commodities	114 815 138	56 475 039	119 770 049	58 882 220
Crude minerals as a per cent of all commodities	62.3	78.7	58.6	77.6

— Nil; nes Not elsewhere specified.

Table 61. Canada, crude minerals loaded and unloaded in coastwise shipping, 1977

	Loaded				Unloaded			
	Atlantic	Great Lakes	Pacific	Total	Atlantic	Great Lakes	Pacific	Total
				(tonnes)				
Metallic minerals								
Alumina, bauxite ores	17 377	—	—	17 377	17 377	—	—	17 377
Copper ore and concentrates	28 964	—	—	28 964	28 964	—	—	28 964
Iron ore and concentrates	4 248 781	3 114 499	—	7 363 280	579 995	6 783 285	—	7 363 280
Lead ore and concentrates	4 911	—	—	4 911	4 911	—	—	4 911
Titanium ore	2 325 833	—	—	2 325 833	2 325 833	—	—	2 325 833
Zinc ore and concentrates	46 910	—	10 168	57 078	46 910	—	10 168	57 078
Ores and concentrates, nes	48	—	275	323	48	—	275	323
Iron and steel scrap	6 430	—	1 613	8 043	6 430	—	1 613	8 043
Nonferrous metal scrap	72	—	373	445	72	—	373	445
Total metals	6 679 326	3 114 499	12 429	9 806 254	3 010 540	6 783 285	12 429	9 806 254
Nonmetallic minerals								
Asbestos	1 361	—	—	1 361	1 361	—	—	1 361
Clay materials, nes	633	—	—	633	633	—	—	633
Dolomite	—	4 929	—	4 929	4 929	—	—	4 929
Fluorspar	135 920	—	—	135 920	128 118	7 802	—	135 920
Gypsum	687 066	—	12 882	699 948	586 231	100 835	12 882	699 948
Limestone	30 012	1 855 644	355 580	2 241 236	30 012	1 855 644	355 580	2 241 236
Salt	290 345	1 245 351	35 429	1 571 125	882 944	652 752	35 429	1 571 125
Sand and gravel	52 065	16 329	2 184 405	2 252 799	52 065	16 329	2 184 405	2 252 799
Stone, crude, nes	14 534	377 147	5 897	397 578	67 650	324 031	5 897	397 578
Sulphur	73	14 307	11 481	25 861	14 380	—	11 481	25 861
Crude nonmetallic minerals, nes	189	—	2 131	2 320	189	—	2 131	2 320
Total nonmetals	1 212 198	3 513 707	2 607 805	7 333 710	1 768 512	2 957 393	2 607 805	7 333 710
Mineral fuels								
Coal, bituminous	557 054	188 434	144 557	890 045	193 406	696 639	—	890 045
Oil, crude	100 545	—	—	100 545	—	100 545	—	100 545
Total mineral fuels	657 599	188 434	144 557	990 590	193 406	797 184	—	990 590
Total crude minerals	8 549 123	6 816 640	2 764 791	18 130 554	4 972 458	10 537 862	2 620 234	18 130 554
Total, all commodities	21 552 253	24 750 336	12 006 598	58 309 187	28 535 774	17 918 448	11 854 965	58 309 187
Crude minerals as a per cent of all commodities	39.7	27.5	23.0	31.1	17.4	58.8	22.1	31.1

— Nil; nes Not elsewhere specified.

Table 63. Canada, fabricated mineral products loaded and unloaded at Canadian ports in international shipping trade, 1976 and 1977

	1976		1977	
	Loaded	Unloaded	Loaded	Unloaded
	(tonnes)			
Metallic products				
Aluminum	212 709	1 185	248 141	5 183
Copper and alloys	55 688	4 863	89 210	4 173
Ferroalloys	5 013	9 265	32 087	50 669
Iron and steel, primary	68 867	22 041	70 719	52 927
Iron, pig	440 297	2 497	439 057	7 418
Iron and steel, other				
bars and rods	80 551	170 300	20 411	199 474
castings and forgings	23 089	10 990	15 657	39 756
pipe and tubes	23 953	76 679	12 331	101 059
plate and sheet	273 601	245 905	174 364	327 742
rails and track material	79 961	17 756	27 651	6 606
structural shapes	77 465	197 208	51 943	226 255
wire	2 752	11 812	2 773	13 438
Lead and alloys	33 557	1 088	34 922	2
Nickel and alloys	4 997	37 713	2 982	998
Zinc and alloys	66 012	11 958	56 632	8 219
Nonferrous metals, nes	2 999	7 410	1 274	5 960
Metal fabricated basic products	11 631	27 925	7 218	18 501
Total metals	1 463 142	856 595	1 287 372	1 068 380
Nonmetallic products				
Asbestos basic products	834	689	937	77
Building brick, clay	45	—	2	178
Bricks and tiles, nes	7 753	3 050	9 259	5 533
Cement	1 009 400	84 129	1 069 330	61 425
Cement basic products	1 514	186	2 684	1 133
Drain tiles and pipes	—	—	—	5
Glass basic products	6 695	14 539	2 001	5 864
Lime	1 227	602	4 292	463
Nonmetallic mineral basic products	8 104	13 291	6 102	6 776
Fertilizers, nes	88 261	155 928	130 759	185 974
Total nonmetals	1 123 833	272 414	1 225 366	267 428
Mineral fuel products				
Asphalts, road oils	965	4 536	169	16 439
Coal tar, pitch	1 821	65 271	64	81 104
Coke	503 656	694 851	233 622	873 014
Fuel oil	2 379 101	1 175 438	2 596 932	1 612 211
Gasoline	393 117	4 162	362 460	432
Lubricating oils and greases	2 015	23 145	571	20 403
Petroleum and coal products, nes	244 206	115 425	272 044	94 336
Total fuels	3 524 881	2 082 828	3 465 862	2 697 939
Total fabricated mineral products	6 111 856	3 211 837	5 978 600	4 033 747
Total, all commodities	114 815 138	56 475 039	119 770 049	58 882 220
Fabricated mineral products as a per cent of all commodities	5.3	5.7	5.0	6.9

— Nil; nes Not elsewhere specified.

Table 64. Canada, financial statistics of corporations in the mining industry[1],

	Corporations		Assets	
	(number)	(%)	($ million)	(%)
Metal mines				
Reporting corporations				
50% and over nonresident	46	23.2	5 047	40.9
Under 50% nonresident	91	46.0	6 682	54.2
Government business enterprise	3	1.5	602	4.9
Other corporations	58	29.3	3	. . .
Total, all corporations	198	100.0	12 335	100.0
Minerals fuels				
Reporting corporations				
50% and over nonresident	238	24.3	9 306	67.3
Under 50% nonresident	292	29.7	3 684	26.6
Government business enterprise	6	0.6	816	5.9
Other corporations	446	45.4	29	0.2
Total, all corporations	982	100.0	13 837	100.0
Other mining (including mining services)				
Reporting corporations				
50% and over nonresident	194	6.9	2 180	55.4
Under 50% nonresident	969	34.4	1 538	39.1
Government business enterprise	4	0.2	87	2.2
Other corporations	1 647	58.5	129	3.3
Total, all corporations	2 814	100.0	3 934	100.0
Total mining				
Reporting corporations				
50% and over nonresident	478	12.0	16 533	54.9
Under 50% nonresident	1 352	33.8	11 905	39.6
Government business enterprise	13	0.3	1 506	5.0
Other corporations	2 151	53.9	162	0.5
Total, all corporations	3 994	100.0	30 105	100.0

Note: Footnotes for Table 65 apply to this table. Figures may not add to totals due to rounding.
[1]Classification of the industry is the same as in Table 27.
— Nil; . . . Amount too small to be expressed; . . Not available.

by degree of nonresident ownership, 1976

Equity ($ million)	Equity (%)	Sales ($ million)	Sales (%)	Profits ($ million)	Profits (%)	Taxable Income ($ million)	Taxable Income (%)
2 215	38.3	2 342	45.3	197	25.5	. .	. .
3 377	58.3	2 768	53.5	569	73.7	183.9	78.3
195	3.4	60	1.2	6	0.8	—	—
−1	. . .	—	—	. . .	. . .	. .	. .
5 787	100.0	5 169	100.0	772	100.0	. .	100.0
5 121	68.3	6 757	83.0	1 752	80.9	1 368.5	87.8
2 034	27.1	1 138	14.0	359	16.6	186.7	12.0
363	4.8	230	2.8	56	2.6	—	—
−15	−0.2	18	0.2	−1	−0.1	2.8	0.2
7 503	100.0	8 143	100.0	2 166	100.0	1 558.0	100.0
1 247	61.5	1 212	54.5	269	80.6	. .	. .
726	35.8	900	40.4	67	20.0	65.4	23.4
37	1.8	12	0.6	−1	−0.3	—	—
18	0.9	101	4.5	−1	−0.3	. .	. .
2 027	100.0	2 226	100.0	333	100.0	. .	100.0
8 583	56.0	10 310	66.4	2 218	67.8	1 625.7	78.4
6 137	40.1	4 806	30.9	995	30.4	436.0	21.0
595	3.9	302	1.9	61	1.9	—	—
2	. . .	120	0.8	−3	−0.1	11.2	0.6
15 317	100.0	15 538	100.0	3 271	100.0	2 072.9	100.0

Table 65. Canada, financial statistics of corporations in the mineral

	Corporations[2]		Assets[5]	
	(number)	(%)	($ million)	(%)
Primary metal products				
Reporting corporations[2]				
50% and over nonresident	58	11.1	1 142	14.6
under 50% nonresident	238	45.8	6 232	79.7
Government business enterprises[3]	2	0.4	..	..
Other[4]	222	42.7	..	..
Total, all corporations	520	100.0	7 816	100.0
Nonmetallic mineral products				
Reporting corporations[2]				
50% and over nonresident	120	9.5	2 405	68.4
under 50% nonresident	538	42.5	1 049	29.9
Government business enterprises[3]	1	0.1	..	..
Others[4]	607	47.9	..	..
Total, all corporations	1 266	100.0	3 514	100.0
Petroleum and coal products				
Reporting corporations[2]				
50% and over nonresident	20	39.2	11 342	91.7
under 50% nonresident	18	35.3	..	..
Government business enterprises[3]	—	—	—	—
Other[4]	13	25.5	..	..
Total, all corporations	51	100.0	12 368	100.0
Total mineral manufacturing industries				
Reporting corporations[2]				
50% and over nonresident	198	10.8	14 889	62.8
under 50% nonresident	794	43.2	..	..
Government business enterprises[3]	3	0.2	..	..
Other[4]	842	45.8	..	..
Total, all corporations	1 837	100.0	23 698	100.0

[1]Classification of industries is the same as in Table 28. [2]Corporations reporting under the Corporations and Labour Unions Returns Act. A corporation is considered to be foreign controlled if 50% or more of its voting rights are known to be held outside Canada, and/or by one or more Canadian corporations which are, in turn, foreign controlled. Each corporation is classified according to the percentage of its voting rights which are owned by nonresidents, either directly or through other Canadian corporations, and the whole of the corporation is assigned to this particular degree of foreign ownership. [3]Nontaxable federal and provincial Crown Corporations and municipally owned corporations. [4]Corporations exempt from reporting under the Corporations and Labour Unions Returns Act. These include corporations reporting under other acts, small companies and corporations and nonprofit organizations. [5]Included are cash, marketable securities, accounts receivable, inventories, fixed assets, investments in affiliated corporations and other assets. The amounts tabulated are those shown on the balance sheets of corporations after deducting allowances for doubtful accounts, amortization, depletion and depreciation. [6]Equity represents the shareholders' interest in the net assets of the corporation and includes the total amount of all issued and paid-up share capital, earnings retained in the business and other surplus accounts such as contributed and capital surplus. For nonfinancial corporations, sales are gross revenues from nonfinancial operations. For financial corporations, sales include income from financial as well as nonfinancial sources. [8]The net earnings from operations, investment income and net capital gains. Profits are tabulated after deducting allowances for amortization, depletion and depreciation, but before income tax provisions or declaration of dividends. [9]Taxable income figures are as reported by corporations prior to assessment by the Department of National Revenue. They include earnings in the reference year after the deduction of applicable losses of other years.

— Nil; .. Not available; ... Amount too small to be expressed.

manufacturing industries[1], by degree of nonresident ownership, 1976

Equity[6]		Sales[7]		Profits[8]		Taxable Income[9]	
($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)
712	21.2	1 257	19.5	108	48.4	280.2	58.2
2 693	80.4	4 976	77.1	191	85.6	183.9	38.2
..	..	..	..	..	..	—	—
..	..	..	..	..	..	17.6	3.6
3 350	100.0	6 457	100.0	223	100.0	481.7	100.0
1 183	72.9	1 854	58.6	172	67.5	114.0	63.7
423	26.1	1 224	38.7	81	31.8	60.6	33.9
..	..	..	..	..	..	—	—
..	..	..	..	..	..	4.2	2.4
1 623	100.0	3 166	100.0	255	100.0	178.8	100.0
6 253	95.7	12 235	95.7	1 417	99.5	788.2	99.6
..	..	..	..	..	..	3.0	0.4
—	—	—	—	—	—	—	—
..	..	..	..	..	..	0.1	...
6 536	100.0	12 787	100.0	1 424	100.0	791.3	100.0
8 148	70.8	15 346	68.5	1 697	89.2	1 182.4	81.4
..	..	..	..	..	..	247.5	17.1
..	..	..	..	..	..	—	—
..	..	..	..	..	..	21.9	1.5
11 509	100.0	22 410	100.0	1 902	100.0	1 451.8	100.0

Table 67. Canada, capital and repair expenditures in mining[1] and mineral manufacturing industries, 1977-79

	1977			1978[p]			1979[r]		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
	($ million)								
Mining industry									
Metal mines									
Gold	24.8	13.8	38.6	32.1	15.5	47.6	39.1	15.6	54.7
Silver-lead-zinc	77.0	38.1	115.1	71.6	42.4	114.0	84.9	47.0	131.9
Copper-gold-silver	181.9	150.6	332.5	136.3	161.7	298.0	172.5	171.6	344.1
Iron	450.9	243.9	694.8	152.2	203.1	355.3	165.5	243.3	408.8
Other metal mines	244.2	153.4	397.6	209.2	92.5	301.7	245.7	106.4	352.1
Total metal mines	978.8	599.8	1 578.6	601.4	515.2	1 116.6	707.7	583.9	1 291.6
Nonmetal mines									
Asbestos	103.7	80.6	184.3	97.1	96.1	193.2	107.2	101.9	209.1
Other nonmetal mines[2]	336.9	213.4	550.3	345.9	214.8	560.7	286.9	230.4	517.3
Total nonmetal mines	440.6	294.0	734.6	443.0	310.9	753.9	394.1	332.3	726.4
Mineral fuels									
Oil, crude and gas[3]	2 445.5	419.5	2 865.0	2 747.8	440.1	3 187.9	3 304.2	462.5	3 766.7
Total mining industries	3 864.9	1 313.3	5 178.2	3 792.2	1 266.2	5 058.4	4 406.0	1 378.7	5 784.7
Mineral manufacturing									
Primary metal industries									
Iron and steel mills	392.2	441.1	833.7	333.7	522.6	856.3	324.1	569.3	893.4
Steel pipe and tube mills	18.1	29.4	47.5	35.4	36.9	72.3	48.2	42.7	90.9
Iron foundries	25.3	29.4	54.7	36.8	35.4	72.2	39.1	37.6	76.7
Smelting and refining	249.2	216.0	465.2	222.8	179.8	402.6	361.3	187.4	548.7
Aluminum rolling, casting and extruding	11.8	15.8	27.6	24.5	17.4	41.9	24.6	18.0	42.6
Other primary metal industries	23.7	16.4	40.1	24.3	16.5	40.8	19.6	17.3	36.9
Total primary metal industries	720.3	748.1	1 468.4	677.5	808.6	1 486.1	816.9	872.3	1 689.2

Table 67 (cont'd)

	1977			1978[p]			1979[f]		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
					($ million)				
Nonmetallic mineral products									
Cement	105.2	44.7	149.9	73.6	51.0	124.6	106.9	59.0	165.9
Stone products	1.1	0.7	1.8	1.5	0.8	2.3	1.2	1.0	2.2
Concrete products	24.8	28.9	53.7	17.6	24.6	42.2	17.4	26.9	44.3
Ready-mix concrete	28.4	43.8	72.2	22.9	34.7	57.6	22.3	38.3	60.6
Clay products	12.6	9.2	21.8	3.5	4.9	8.4	7.6	5.0	12.6
Glass and glass products	16.5	10.9	27.4	62.2	20.0	82.2	49.1	20.7	69.8
Abrasives	5.5	11.1	16.6	7.6	11.9	19.5	9.2	14.0	23.2
Lime	11.8	4.2	16.0	6.5	4.7	11.2	8.6	6.4	15.0
Other nonmetallic mineral products	72.9	32.1	105.0	70.7	35.1	105.8	94.6	36.7	131.3
Total nonmetallic mineral products	278.8	185.6	464.4	266.1	187.7	453.8	316.9	208.0	524.9
Petroleum and coal products	366.6	171.5	538.1	325.9	169.0	494.9	239.9	189.1	429.0
Total mineral manufacturing industries	1 365.7	1 105.2	2 470.9	1 269.5	1 165.3	2 434.8	1 373.7	1 269.4	2 643.1
Total mining and mineral manufacturing industries	5 230.6	2 418.5	7 649.1	5 061.7	2 431.5	7 493.2	5 779.7	2 648.1	8 427.8

[1] Does not include cement, lime and clay products (domestic clay) manufacturing, smelting and refining. [2] Includes coal mines, gypsum, salt, potash and miscellaneous nonmetal mines and quarrying. [3] The total of capital expenditures shown under "petroleum and gas" is equal to the total capital expenditure under the column entitled "petroleum and natural gas extraction" and under the column "Natural gas processing plants" of Table 70.
[p] Preliminary; [f] Forecast.

Table 66. Canada, financial statistics of corporations in nonfinancial

	Agriculture, Forestry, Fishing and Trapping		Mining		Manufacturing	
	1975	1976p	1975	1976p	1975	1976p
Number of corporations						
Foreign control	106	103	499	478	2 472	2 437
Canadian control	3 489	4 126	1 297	1 365	10 630	11 496
Other corporations	7 250	7 774	2 118	2 151	14 407	15 300
Total corporations	10 845	12 003	3 914	3 994	27 509	29 233
			($ million)			
Assets						
Foreign control	294	295	14 849	16 533	44 563	46 982
Canadian control	2 113	..	11 030	13 410	35 365	39 203
Other corporations	699	..	161	162	1 152	1 218
Total corporations	3 106	3 615	26 040	30 105	81 080	87 403
Equity						
Foreign control	141	141	7 521	8 583	21 865	23 595
Canadian control	655	..	5 890	6 732	13 904	15 065
Other corporations	169	..	12	2	321	329
Total corporations	965	1 158	13 423	15 317	36 090	38 989
Sales						
Foreign control	221	255	9 054	10 310	59 981	66 304
Canadian control	1 807	..	4 324	5 108	43 566	49 186
Other corporations	636	..	110	120	2 047	2 157
Total corporations	2 664	3 193	13 488	15 538	105 594	117 647
Profits						
Foreign control	15	24	1 849	2 218	5 011	4 961
Canadian control	82	..	1 032	1 055	2 576	2 343
Other corporations	34	..	−5	−2	65	48
Total corporations	131	191	2 876	3 271	7 652	7 352

Note: Figures may not add to totals due to rounding.
p Preliminary; .. Not available.

industries, by major industry group and by control, 1975 and 1976

Construction		Transportation, Communication and Other Utilities		Trade		Services		Total	
1975	1976p	1975	1976p	1975	1976p	1975	1976p	1975	1976p
202	191	298	299	2 052	2 087	587	598	6 216	6 193
9 192	10 540	3 348	3 761	24 410	27 526	9 025	10 625	61 391	69 439
23 948	26 330	8 982	9 613	52 133	56 631	39 155	44 033	147 993	161 832
33 342	37 061	12 628	13 673	78 595	86 244	48 767	55 256	215 600	237 464
				($ million)					
1 812	1 991	4 977	5 475	9 798	9 960	3 073	3 315	79 367	84 550
10 127	. .	60 226	67 838	27 794	31 206	8 940	10 946	155 594	177 013
1 630	. .	647	694	3 768	4 157	2 442	2 741	10 498	11 545
13 569	15 652	65 850	74 007	41 360	45 323	14 455	17 002	245 459	273 108
410	488	1 723	1 916	3 314	3 685	1 143	1 276	36 117	39 685
2 209	. .	17 151	18 045	8 449	9 634	2 510	2 985	50 768	56 023
493	. .	176	184	1 241	1 297	713	772	3 124	3 297
3 112	3 746	19 050	20 145	13 004	14 616	4 366	5 033	90 009	99 005
2 762	3 195	2 323	2 846	21 676	23 381	3 056	3 529	99 074	109 820
14 376	. .	19 176	23 346	70 340	79 740	8 325	9 914	161 915	185 243
3 162	. .	944	1 032	7 884	8 480	3 479	3 917	18 260	19 857
20 300	22 356	22 443	27 224	99 900	111 601	14 860	17 360	279 249	314 920
151	165	361	389	742	753	339	376	8 468	8 887
814	. .	1 568	1 802	2 828	2 872	575	688	9 474	9 704
148	. .	28	33	288	259	193	207	751	709
1 113	1 107	1 957	2 224	3 858	3 884	1 107	1 271	18 693	19 300

Table 68. Canada, capital and repair expenditures in the mining industry[1], 1969-79

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978[p]	1979[f]
						($ million)					
Metal mines											
Capital											
Construction	295.1	335.6	590.8	345.7	357.1	409.6	499.6	597.6	626.8	405.3	498.0
Machinery	98.2	150.3	239.8	313.0	241.3	157.9	215.3	305.3	352.0	196.1	209.7
Total	393.3	485.9	830.6	658.7	598.4	567.5	714.9	902.9	978.8	601.4	707.7
Repair											
Construction	35.7	36.6	38.9	26.4	48.0	58.7	63.7	61.5	63.1	61.4	75.8
Machinery	160.9	220.2	240.9	242.4	299.7	383.4	446.7	521.6	536.7	453.8	508.1
Total	196.6	256.8	279.8	268.8	347.7	442.1	510.4	583.1	599.8	515.2	583.9
Total capital and repair	589.9	742.7	1 110.4	927.5	946.1	1 009.6	1 225.3	1 486.0	1 578.6	1 116.6	1 291.6
Nonmetal mines[2]											
Capital											
Construction	128.1	107.9	84.6	59.8	67.5	116.0	112.8	161.3	214.8	190.0	189.4
Machinery	113.9	115.9	105.6	81.3	79.7	125.7	209.6	214.6	225.8	253.0	204.7
Total	242.0	223.8	190.2	141.1	147.2	241.7	322.4	375.9	440.6	443.0	394.1
Repair											
Construction	10.4	7.1	7.9	6.2	6.5	13.1	23.8	20.0	20.8	27.0	28.2
Machinery	64.7	99.9	107.1	116.4	135.2	167.0	184.3	226.2	273.2	283.9	304.1
Total	75.1	107.0	115.0	122.6	141.7	180.1	208.1	246.2	294.0	310.9	332.3
Total capital and repair	317.1	330.8	305.2	263.7	288.9	421.8	530.5	622.1	734.6	753.9	726.4
Mineral fuels											
Capital											
Construction	465.3	552.6	639.4	729.3	851.7	1 060.9	1 355.7	1 598.0	1 998.0	2 423.5	2 943.1
Machinery	76.6	86.2	101.3	91.2	83.4	165.3	219.0	564.1	447.5	324.3	361.1
Total	541.9	638.8	740.7	820.5	935.1	1 226.2	1 574.7	2 162.1	2 445.5	2 747.8	3 304.2

Table 68 (cont'd)

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978[p]	1979[f]
						($ million)					
Repair											
Construction	73.7	93.5	102.7	106.8	138.0	159.0	215.2	287.4	318.3	327.2	343.3
Machinery	19.0	22.5	28.7	35.6	54.2	62.3	68.5	82.9	101.2	112.9	119.2
Total	92.7	116.0	131.4	142.4	192.2	221.3	283.7	370.3	419.5	440.1	462.5
Total capital and repair	634.6	754.8	872.1	962.9	1 127.3	1 447.5	1 858.4	2 532.4	2 865.0	3 187.9	3 766.7
Total mining											
Capital											
Construction	888.5	996.1	1 314.8	1 134.8	1 276.3	1 586.5	1 968.1	2 356.9	2 839.6	3 018.8	3 630.5
Machinery	288.7	352.4	446.7	485.5	404.4	448.9	643.9	1 084.0	1 025.3	773.4	775.5
Total	1 177.2	1 348.5	1 761.5	1 620.3	1 680.7	2 035.4	2 612.0	3 440.9	3 864.9	3 792.2	4 406.0
Repair											
Construction	119.8	137.2	149.5	139.4	192.5	230.8	302.7	368.9	402.2	415.6	447.3
Machinery	244.6	342.6	376.7	394.4	489.1	612.7	699.5	830.7	911.1	850.6	931.4
Total	364.4	479.8	526.2	533.8	681.6	843.5	1 002.2	1 199.6	1 313.3	1 266.2	1 378.7
Total capital and repair	1 541.6	1 828.3	2 287.7	2 154.1	2 362.3	2 878.9	3 614.2	4 640.5	5 178.2	5 058.4	5 784.7

[1] Does not include cement, lime and clay products (domestic clays) manufacturing, smelting and refining. [2] Includes coal mines, asbestos, gypsum, salt, potash, miscellaneous nonmetals, quarrying and sand pits.
[p] Preliminary; [f] Forecast.

Table 69. Canada, capital and repair expenditures in the mineral manufacturing industries[1], 1969-79

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978[p]	1979[f]
	($ million)										
Primary metal industries[2]											
Capital											
Construction	71.5	114.0	89.0	95.3	75.8	148.0	200.5	144.8	171.2	161.8	194.5
Machinery	221.4	311.2	312.4	276.6	328.5	549.7	614.4	496.1	549.1	515.7	622.4
Total	292.9	425.2	401.4	371.9	404.3	697.7	814.9	640.9	720.3	677.5	816.9
Repair											
Construction	22.6	28.6	28.4	35.3	38.8	51.6	66.8	63.2	85.3	89.1	96.4
Machinery	267.9	324.6	343.5	383.2	420.1	507.3	563.4	632.4	662.8	719.5	775.9
Total	290.5	353.2	371.9	418.5	458.9	558.9	629.2	695.6	748.1	808.6	872.3
Total capital and repair	583.4	778.4	773.3	790.4	863.2	1 256.6	1 444.1	1 336.5	1 468.4	1 486.1	1 689.2
Nonmetallic mineral products[3]											
Capital											
Construction	37.1	30.7	21.8	30.7	37.6	29.5	41.1	46.6	63.3	63.6	69.3
Machinery	84.0	104.3	58.5	99.2	151.1	144.7	158.0	195.4	215.5	202.5	247.6
Total	121.1	135.0	80.3	129.9	188.7	174.2	199.1	242.0	278.8	266.1	316.9
Repair											
Construction	7.2	5.4	7.0	8.5	7.5	11.3	14.4	15.4	16.1	17.0	18.7
Machinery	72.1	77.1	80.4	85.7	112.0	130.9	151.8	164.9	169.5	170.7	189.3
Total	79.3	82.5	87.4	94.2	119.5	142.2	166.2	180.3	185.6	187.7	208.0
Total capital and repair	200.4	217.5	167.7	224.1	308.2	316.4	365.3	422.3	464.4	453.8	524.9
Petroleum and coal products											
Capital											
Construction	116.9	213.7	211.3	214.0	229.7	321.7	337.5	255.9	268.2	230.3	159.7
Machinery	12.9	17.4	20.1	29.8	89.1	107.8	112.9	88.3	98.4	95.6	80.2
Total	129.8	231.1	231.4	243.8	318.8	429.5	450.4	344.2	366.6	325.9	239.9

Table 69 (cont'd)

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978[p]	1979[f]
						($ million)					
Repair											
Construction	52.1	51.0	51.3	61.3	71.1	83.8	96.1	101.2	125.7	121.9	136.8
Machinery	6.8	9.2	9.8	14.6	17.3	27.0	37.0	35.8	45.8	47.1	52.3
Total	58.9	60.2	61.1	75.9	88.4	110.8	133.1	137.0	171.5	169.0	189.1
Total capital and repair	188.7	291.3	292.5	319.7	407.2	540.3	583.5	481.2	538.1	494.9	429.0
Total mineral manufacturing industries											
Capital											
Construction	225.5	358.4	322.1	340.0	343.1	499.2	579.1	447.3	502.7	455.7	423.5
Machinery	318.3	432.9	391.0	405.6	568.7	802.2	885.3	779.8	863.0	813.8	950.2
Total	543.8	791.3	713.1	745.6	911.8	1 301.4	1 464.4	1 227.1	1 365.7	1 269.5	1 373.7
Repair											
Construction	81.9	85.0	86.7	105.1	117.4	146.7	176.3	179.8	227.1	228.0	251.9
Machinery	346.8	410.9	433.7	483.5	549.4	665.2	752.2	833.1	878.1	937.3	1 017.5
Total	428.7	495.9	520.4	588.6	666.8	811.9	928.5	1 012.9	1 105.2	1 165.3	1 269.4
Total capital and repair	972.5	1 287.2	1 233.5	1 334.2	1 578.6	2 113.3	2 392.9	2 240.0	2 470.9	2 434.8	2 643.1

[1] Industry groups are the same as in Table 28. [2] Includes smelting and refining. [3] Includes cement, lime and clay products manufacturing.
[p] Preliminary; [f] Forecast.

Table 70. Canada, capital expenditures in the petroleum, natural gas and allied industries[1], 1968-79

	Petroleum and Natural Gas Extraction[2]	Transportation Including Rail, Water and Pipelines	Marketing (chiefly outlets of oil companies)	Natural Gas Distribution	Petroleum and Coal Products Industries	Natural Gas Processing Plants	Total Capital Expenditures
				($ million)			
1968	374.3	247.9	87.6	117.4	127.6	91.1	1 045.9
1969	438.1	220.6	103.6	117.0	129.8	103.8	1 112.9
1970	449.3	246.5	100.0	100.4	231.1	189.5	1 316.8
1971	489.6	352.0	99.2	115.2	231.4	251.1	1 538.5
1972	690.2	440.9	111.8	141.7	243.8	130.3	1 758.7
1973	864.8	390.9	128.0	146.3	318.8	70.3	1 919.1
1974	1 087.8	262.4	144.7	191.7	429.5	138.4	2 254.5
1975	1 427.2	361.9	152.8	192.7	450.4	147.5	2 732.5
1976	1 998.8	337.3	164.9	182.3	344.2	163.3	3 190.8
1977	2 290.0	374.9	135.5	213.0	366.6	155.5	3 535.5
1978[p]	2 467.7	321.0	143.9	237.6	325.9	280.1	3 776.2
1979[f]	3 026.4	270.4	135.3	250.0	239.9	277.8	4 199.8

[1] The petroleum and natural gas industries in this table include all companies engaged in whole or in part in oil and gas activities. [2] Includes capital expenditures by oil and gas drilling contractors since 1968. Does not include expenditures for geological and geophysical operations. See also Footnote 3 to Table 67.

[p] Preliminary; [f] Forecast.

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